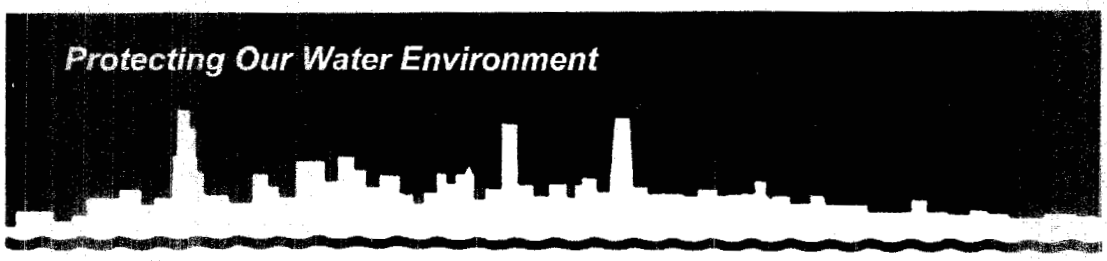

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

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GEOTECHNICAL CHARACTERIZATION OF BIOSOLIDS

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March 2003

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Research and Development Department
Richard Lanyon, Director

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GEOTECHNICAL CHARACTERIZATION

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SUBMITTED TO

RESEARCH AND DEVELOPMENT DEPARTMENT
METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

SEPTEMBER 2002

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EXECUTIVE SUMMARY

The Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) generates approximately 200,000 dry tons of biosolids annually. These biosolids are utilized beneficially and economically in a variety of projects. These projects include of protective vegetative layer of landfill final covers, soil substitute and conditioner for golf courses, parks, athletic fields, highway medians and embankments. The biosolids in these cases augment and/or replace conventional earthen materials thus providing beneficial and economical use for the biosolids.

The present study is intended to provide the geotechnical characterization of the biosolids so that guidelines can be developed for construction and management when biosolids are utilized.

The scope of the study required testing of six biosolids samples for various conventional geotechnical properties. The testing included Sieve/Hydrometer Analysis and determination of Atterberg Limits for classification purposes; bulk density, particle density and compaction tests to determine moisture-density relationships under various compactive energies; unconfined compression and triaxial shear tests to evaluate shear strength parameters that could be used in evaluating slope stability and bearing capacity; CBR tests to determine the properties required when biosolids are used as a soil substitute or conditioner in applications involving traffic loading. All tests were performed according to ASTM or IDOT methods.

The test results are analyzed to determine the effects of solids content and aging as well as source of biosolids on geotechnical properties of biosolids. Recommendations for applying biosolids in various applications such as embankment fill and landfill cover material are provided. In addition, recommendations concerning further evaluation of biosolids for various civil and environmental applications are made.

1 INTRODUCTION

The Metropolitan Water Reclamation District of Greater Chicago (District) generates approximately 200,000 dry tons of biosolids annually. Most of this biosolids is generated at the District's Calumet and Stickney water reclamation plants (WRP). Following anaerobic digestion of sewage sludge, biosolids are produced by taking the digested sludge through two main processing trains: by centrifugation (high solids processing train-HSPT) and by gravity thickening (low solids processing train-LSPT). Except for some of the centrifuge cake biosolids (25 percent solids) which are immediately applied to farmland, after generation, most of the biosolids are stored in lagoons for greater than 18 months (aged) or less than 18 months (under aged), then dried to approximately 65 percent solids before final utilization. The biosolids are used in a variety of beneficial reuse projects such as final cover at municipal solid waste landfills, construction of golf courses, parks, and athletic fields, and for reclamation of brownfields. In these projects, biosolids are utilized as a soil substitute or at relatively high application rates (usually greater than 25 percent of soil volume) as a soil amendment. Also, the biosolids are utilized as a fertilizer amendment to farmland.

Information on the geotechnical characteristics of biosolids is essential to adequately evaluate the suitability of biosolids for various applications, especially in civil engineering projects. For example, if biosolids are to be used as a fill material, properties such moisture-density relationships and shear strength need to be determined. If biosolids are considered as subbase or base course underneath pavements, geotechnical properties such as Illinois bearing ratio (IBR) and immediate bearing value (IBV) will be relevant. Index geotechnical properties such as grain size distribution and Atterberg Limits are needed to compare biosolids to natural soils.

2 OBJECTIVE AND SCOPE

The overall objective of the study is to determine relevant geotechnical properties of biosolids that can be used to determine the behavior or biosolids and to develop management guidelines when biosolids are used as a soil substitute, on slopes and embankments (example: roadsides, final covers on landfills), as subbase or backfill, or on recreational areas (example: parks and golf courses).

The scope of this study included characterization of six District biosolids samples by performing the following standard geotechnical tests:

- Moisture content
- Specific gravity (or particle density)
- Particle size analysis (based on combined sieve and hydrometer analyses)
- Atterberg limits
- Moisture-density relationship based on Standard and Modified Proctor tests
- Primary and secondary consolidation characteristics based on consolidation test
- Unconfined compression
- Triaxial unconsolidated undrained shear
- Triaxial consolidated undrained shear
- Illinois bearing ratio (IBR)
- Immediate bearing value (IBV)

3 EXPERIMENTAL METHODS

3.1 Biosolids Used In the Study

The biosolids samples used in this study were obtained from the Stickney and Calumet WRPs and were generated through the District's low solids (LS) and high solids (HS) processing trains, and were aged (greater than 18 months) or under-aged (Table 3-1).

Table 3-1 Description of Biosolids Used in the Study

Sample ID	Source[1]	Process
SALS	Stickney WRP	Low Solids, Aged
SAHS	Stickney WRP	High Solids, Aged
SULS	Stickney WRP	Low Solids, Under-aged
SUHS	Stickney WRP	High Solids, Under-aged
CAHS	Calumet WRP	High Solids, Aged
CALS	Calumet WRP	Low Solids, Aged

[1]WRP = Water Reclamation Plant.

3.2 Overview of Tests

The following tests were performed on six biosolids samples to determine their engineering parameters and to make recommendations concerning their use in civil engineering applications. Tests were performed according to the American Society for Testing and Materials (ASTM) and the Illinois Department of Transportation (IDOT) procedures.

3.2.1 Moisture Content

The moisture content of the biosolids was determined using ASTM D 2216, "Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock By Mass". The moisture content (or water content) is the ratio of the mass of water to the dry mass of biosolids in that volume. Moisture content, usually expressed as a percentage, can range from 0 to several hundred percent. Most soils will have natural moisture content well below 100%. Marine and organic soils can have moisture contents up to 500%.

3.2.2 Specific Gravity (Particle Density)

The specific gravity (particle density) of biosolids was measured using ASTM D 854, "Standard Test Method for Specific Gravity of Soil Solids by Water Pycnometer". Specific gravity is the ratio of the density of solid particles to the density of water. For most inorganic soils, the specific gravity ranges from 2.6 to 2.7. Organic soils possess lower specific gravity values as compared to inorganic soils.

3.2.3 Particle Size Analysis

The particle size distribution of biosolids samples was determined using ASTM D 422, "Standard Test Method for Particle-Size Analysis of Soils". Both sieve analysis and hydrometer analysis were performed to determine the distribution of coarser and finer fractions of the biosolids samples.

3.2.4 Atterberg Limits

Atterberg Limits of biosolids were determined using ASTM D 4318, "Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils". These limits define the consistency of biosolids. Liquid limits (LL) defines the threshold water content at which biosolids will change from plastic state to fluid state, while the plastic limit (PL) defines the threshold water content at which biosolids change from semi-plastic state to plastic state. Plasticity index (PI) is the difference between the liquid limit and the plastic limit (PI=LL-PL). These limits are useful for classification for engineering purposes and can be used for correlation with other engineering properties.

3.2.5 Moisture-Density Relationship (Compaction) Tests

Moisture-density relationship of biosolids was determined using both the Standard Proctor testing and the Modified Proctor testing procedures in accordance with: (a) ASTM D 698, "Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort", and (b) ASTM D 1557, "Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort". Compaction refers to the densification of materials by the application of mechanical energy. Compaction tests provide the optimum moisture content (OMC) at which maximum dry unit weight (density) will occur. The OMC and the maximum dry unit weight are used in establishing compaction criteria when the material is used in fill applications.

3.2.6 Consolidation Tests

Consolidation characteristics of biosolids were determined using ASTM D 2435, "Standard Test Method for One-Dimensional Consolidation Properties of Soils". Consolidation properties are required to calculate the primary consolidation (S_c) and secondary compression (S_s) components of the total settlement under applied load as given by:

$$S_t = S_i + S_c + S_s$$

Where S_i = the immediate or distortion settlement, S_c = the primary consolidation settlement, and S_s = the secondary compression. The immediate or distortion settlement is generally estimated using the elastic theory. The consolidation settlement is a phenomenon that is associated with saturated fine-grained materials which have a low coefficient of permeability. Rate of settlement of these soils depend on the rate of dissipation of porewater pressures created by the increased loading. Secondary compression, which is time-dependent process, occurs under constant effective pressure, with no changes in porewater pressures.

3.2.7 Shear Strength Tests

Shear strength of biosolids is the most important engineering property which determines the bearing capacity, slope stability, pavement design of structures built on or of biosolids. Shear strength can be defined as the ultimate or maximum shear stress the biosolids can withstand. Shear strength depends on consolidation and drainage conditions. The following tests were conducted to determine the shear strength of biosolids: (a) ASTM D 2166, "Standard Test Method for Unconfined Compressive Strength of Cohesive Soil", (b) ASTM D 2850, "Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils", and (c) ASTM D 4767, "Standard Test Method for Consolidated Undrained Triaxial Compression for Cohesive Soils".

3.2.8 Illinois Bearing Ratio (IBR) and Immediate Bearing Value (IBV)

Illinois Bearing Ratio (IBR) and Immediate Bearing Value (IBV) of biosolids were determined using IDOT's "Method of Determining the IBR and the IBV of Soils, Treated Soils and Aggregates" (Geotechnical Manual, IDOT 1999). IBR and IBV are useful to evaluate the suitability of biosolids for pavement construction.

3.3 Quality Control

Standard testing procedures were used in this study. Selected tests were conducted in replicates to determine the variability in the determined soil property. The tests were conducted by technicians under the direct supervision of an experienced geotechnical engineer. Laboratory test procedures were reviewed with the technicians before the start of the testing program and periodically thereafter. Data were reviewed for consistency and completeness.

4 RESULTS AND ANALYSIS

Test results are grouped, summarized and presented in various subsections. Test reports are included in appendices. Discussion and analysis of the test results is also presented. In addition to the test results from this study, results from a similar, previous study by Claude H. Hurley Company, Inc. (CHHI), Chicago, dated March,1994 on two biosolids samples are also summarized as applicable.

4.1 Index Properties

Table 4-1 summarizes the particle-size analysis, Atterberg Limits, Specific Gravity and Classification for the six biosolids samples tested as part of this study. Based on these results, the biosolids were classified according to the Unified Soil Classification System (USCS) and the American State Highway and Transportation Officials (AASHTO) system. The classification results are also shown in Table 4-1.

None of the samples contained gravel size particles. The amount of sand, silt size particles and clay size particles ranged from 39% to 49%, 46% to 52%, and 2% to 11%, respectively. Atterberg Limits tests conducted on air-dry biosolids indicated Liquid Limit (LL) ranging between 71 to 119 and Plasticity Index (PI) ranging between 17 and 53. Atterberg limits tests conducted on oven-dried biosolids indicated the material to be non-plastic. Specific Gravity of the biosolids varied from 1.81 to 2.17.

As can be seen from Table 4-1, the six biosolids samples are classified as fine-grained soil equivalent with the group symbol of "OH" according to the Unified Soil Classification System (USCS). The group name is "Sandy organic silt". Figure 4-1 shows a plot of the Atterberg Limits of all six samples on the Plasticity Chart. Figure 4-2 shows a combined grain-size distribution plots for the six samples and their replicates. The biosolids samples were also classified according to the American State Highway and Transportation Officials (AASHTO) system. This classification system indicates a soil's acceptability as a highway and road subgrade and base course. The six samples used in the study are classified as "A-7-6". CHHI(1994) results indicated a USCS classification of "Organic Silt" and a grain-size distribution with 2% clay, 84 to 86% silt and 12 to 14% sand. Liquid Limit, Plastic Limit and moisture content ranged between 85 to 88, 64 to 65 and 34 to 36%, respectively. Atterberg limits tests conducted by CHHI on oven-dry materials indicated that the bio-solids were non-plastic, a characteristic typical for organic soils. Specific gravity was between 1.93 and 2.01. The soils possessed a loss on ignition (LOI) of 32 to 34%.

TABLE 4-1 Index and Classification Properties of Biosolids Samples

Sample ID	Replicate No.	% Sand	%Silt size	%Clay size	Liquid Limit	Plastic Limit	Plasticity Index	Classification	Specific Gravity
SALS	1	45	47	8	108	74	34	OH	1.94
	2	39	50	11	96	71	25	OH	2.02
SAHS	1	49	48	4	119	66	53	OH	2.11
	2	49	48	3	71	54	17	OH	2.17
SULS	1	44	49	8	93	66	27	OH	2.15
	2	42	49	10	105	82	23	OH	1.88
SUHS	1	48	46	6	108	60	48	OH	1.92
	2	48	46	5	87	59	28	OH	1.83
CAHS	1	43	52	5	103	65	38	OH	1.81
	2	42	48	10	103	85	18	OH	1.82
CALS	1	49	45	5	91	70	21	OH	1.94
	2	49	49	2	105	83	22	OH	1.93

4.2 Moisture-Density Relationships

Table 4-2 summarizes the results of Standard and Modified Proctor tests performed on the six (6) biosolids samples. Detailed test reports are provided in Appendix B. The Standard and Modified Proctor tests result in compaction curves are essentially variations of dry density with moisture content. The optimum moisture content (OMC) is defined as the moisture content at which the dry density is a maximum.

The maximum dry density (γ_{dry}) for standard effort (Standard Proctor Test) ranged between 50 to 68 pcf and the optimum moisture content (OMC) ranged between 37 to 64%. For the modified effort (Modified Proctor Test), γ_{dry} ranged between 52 and 72 pcf and the OMC between 31 to 64%. The initial moisture content of the six biosolids samples as they were received by the lab ranged between 46 and 75% with an average of 56%.

Most maximum dry densities varied only by 2 to 4 pcf for the range of moisture contents used in testing. Inorganic clayey soils, in general, have a well-defined density-moisture curve. In the present study, due to the organic matter in the biosolids, the curves are almost "flat", a characteristic of organic soils, indicating that changes in moisture content of the biosolids does not significantly affect their compactibility. In addition, natural soils have a compacted dry density of more than twice that of the biosolids samples.

Figure 4-1 Atterberg Limits Summary

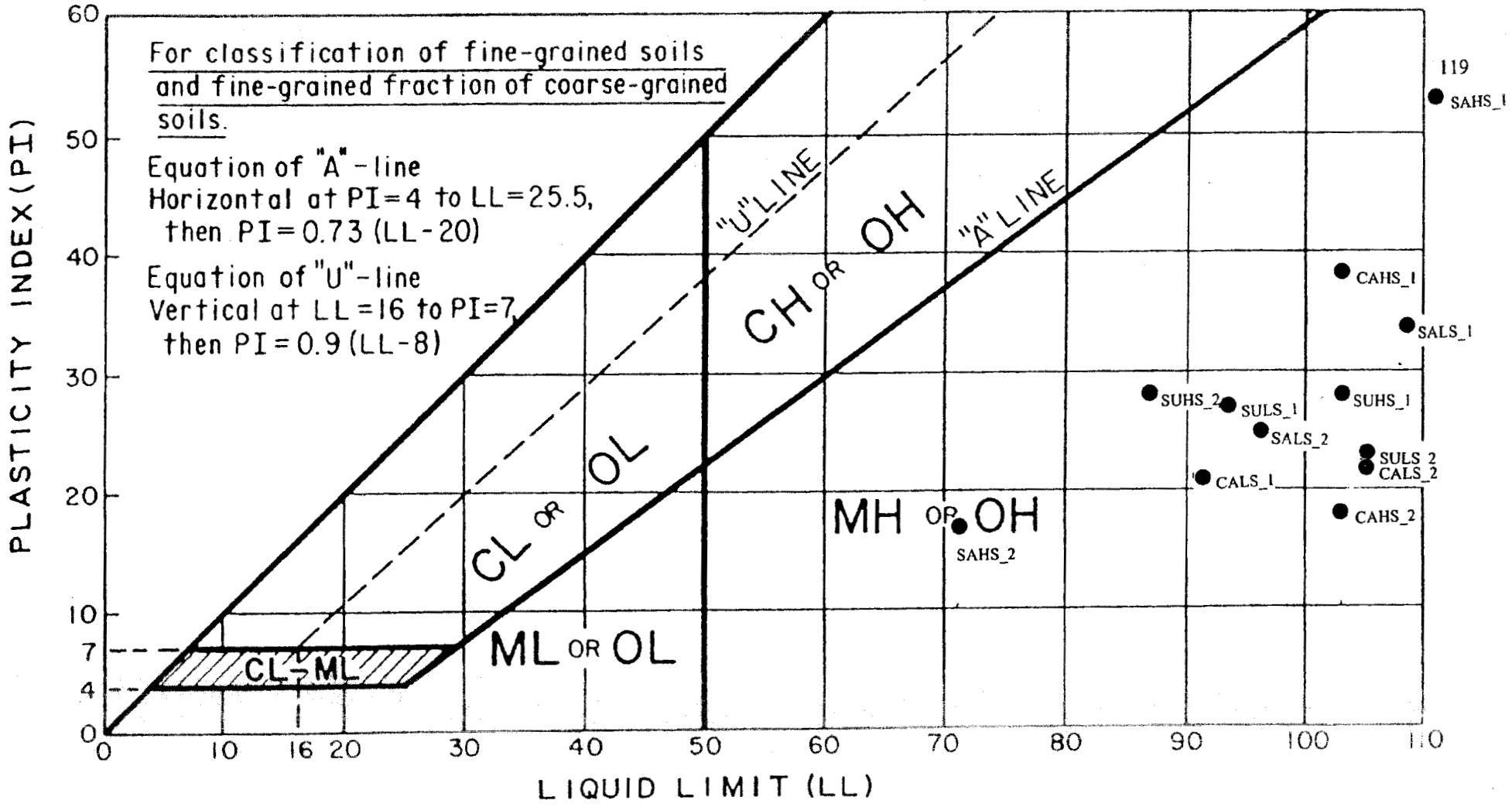

Figure 4-2 Grain Size Distribution Summary

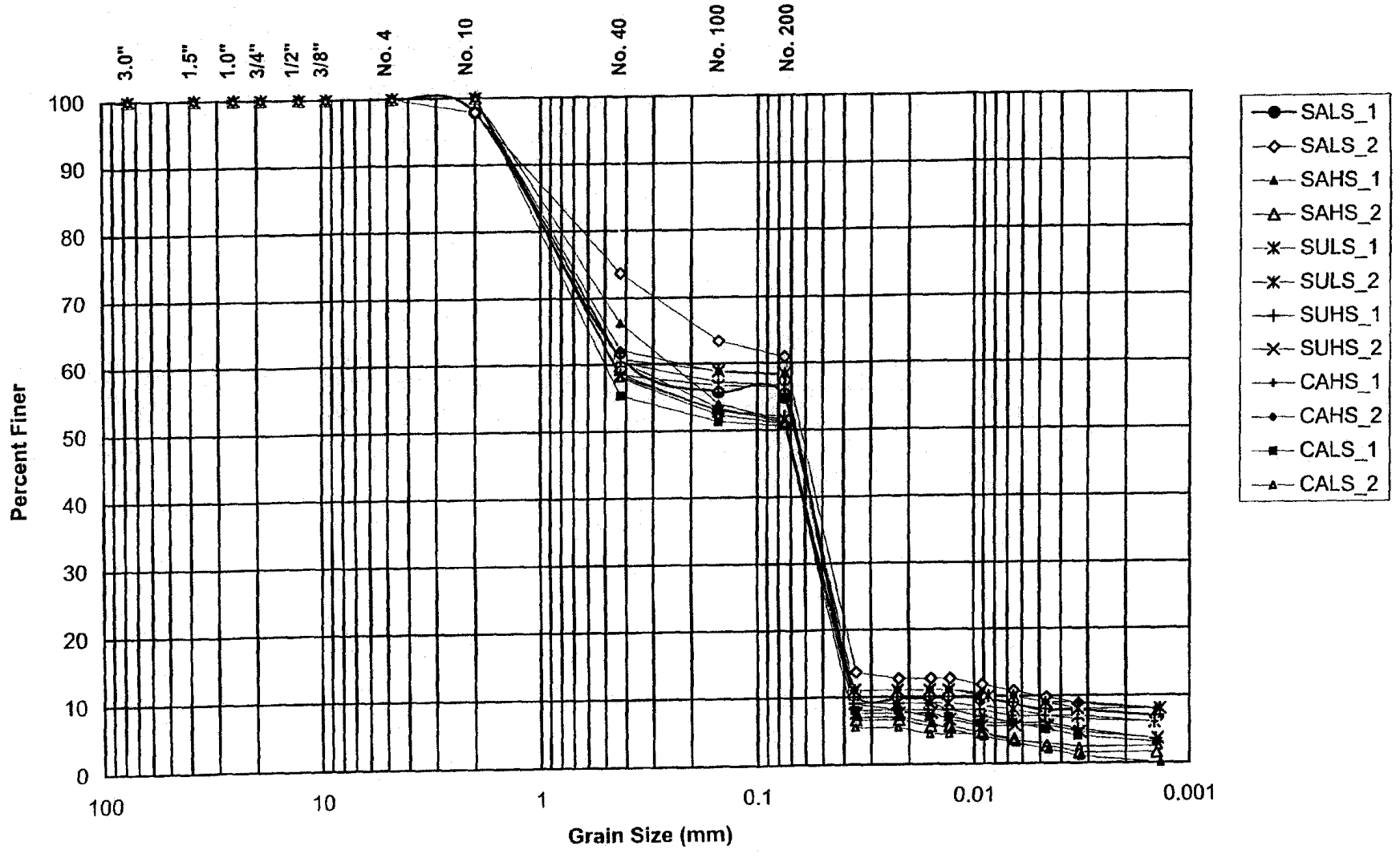

TABLE 4-2 Results of Moisture-Density Relationship (Proctor) Tests

Sample ID	Replicate No.	Standard Proctor		Modified Proctor		Initial Moisture Content (%)
		Max. Dry Density (pcf)	Optimum Moisture Cont. (%)	Max. Dry Density (pcf)	Optimum Moisture Cont. (%)	
SALS	1	59	49	58	48	46
	2	54	62	64	40	
SAHS	1	67	38	72	34	42
	2	68	37	72	31	
SULS	1	58	48	63	35	65
	2	50	70	56	54	
SUHS	1	61	42	68	30	75
	2	60	49	68	34	
CAHS	1	51	64	54	50	50
	2	50	64	52	64	
CALS	1	55	53	59	45	55
	2	56	51	61	45	

The high OMC is reflective of the organic matter present in the biosolids samples and is 2 to 3 times that of natural clayey soils. For most of the samples, the initial moisture content was higher than the OMC.

Standard and Modified Proctor tests were conducted in replicates. The results indicate that in general, the maximum dry density values between the replicates were close. The OMCs were close between replicates in most cases. However, for a few tests, the variation in OMC between replicates is significant. This can be attributed to the very "flat" nature of the compaction curve, making determination of OMC more subjective.

The OMC is the moisture content at which at which maximum dry density occurs under a specified compaction effort such as standard or modified. Modified compaction tests imparts approximately three times more energy compared to a standard compactive effort. In general, for natural soils, the OMC of Standard Proctor test is higher than that of the Modified Proctor test; the maximum dry density of Standard Proctor is lower than that of the Modified Proctor test. The test results for biosolids indicate similar pattern, however, the effect of moisture content on dry density is not as pronounced as that for natural soils. Higher compactive effort such as that in Modified Proctor test produces higher dry density, however, the increase is not significant. This implies that higher level of compactive effort need not pay itself in terms of achieving higher dry density.

The HS sample from the Stickney WRP exhibited higher maximum dry density and lower OMC compared to low solids (LS) samples. In general, aged samples resulted in slightly higher maximum dry densities compared under-aged samples. The effect of aging on the OMC, however, is less distinct.

For Calumet WRP samples, the maximum dry densities are lower and OMCs are higher than the Stickney WRP samples. Calumet aged high solids (CAHS) exhibited lower densities compared to Calumet Aged Low Solids (CALS) samples, which is contrary to the observations made for Stickney samples.

The CHHI(1994) study indicated maximum dry unit weights of 66 and 70 pcf and OMCs of 36.7% and 43% from Modified Proctor tests. These results fall within the range of results obtained in the present study.

4.3 Consolidation Test Results

Table 4-3 summarizes the results of consolidation tests performed on the six (6) biosolids samples. Test reports are included in Appendix C. The results from consolidation tests are plotted to yield effective normal stress versus void ratio plots. The compression index (Cc) is the slope of the straight line portion of the loading curve, while the recompression index (Cr) is the slope of the unloading curve.

TABLE 4-3 Results of Consolidation Tests.

Sample ID	Compression Index, Cc	Recompression Index, Cr
SALS	0.26	0.05
SAHS	0.37	0.03
SULS	0.44	0.10
SUHS	0.28	0.06
CAHS	0.48	0.08
CALS	0.50	0.08

The compression index (Cc) ranged from 0.26 to 0.50 with an average value of 0.39 and the recompression index (Cr) ranged from 0.03 to 0.10 with an average value of 0.07. For the biosolids tested, the secondary compression index (C_α) is calculated based on the slope of time-settlement curve beyond the primary consolidation. For all samples, C_α is found to be approximately 0.02. These values are in general agreement with those reported in the literature for organic silts and clays. C_c and C_r are essential to calculating consolidation settlement under any applied loading.

The CHHI(1994) study reports the compression index, C_c to range between 0.17 and 0.58, indicating wide range of compressibility of biosolids as observed in the present study.

4.4 Shear Strength

Table 4-4 summarizes the results of triaxial unconsolidated undrained (UU), triaxial consolidated undrained (CU) tests and unconfined compressive strength tests. Test reports are included in Appendix D. For each biosolids sample, a set of three UU triaxial tests were conducted at various confining pressures. Each test resulted in a stress versus strain plot. The maximum stress in each test defined the failure stress. The failure stress together with the confining pressure were plotted on an X-Y plot, as a "Mohr's Circle". Three such circles were drawn from the results of the three tests. A tangent line drawn to these circles defined the "failure envelope". The slope of this envelope is the Angle of Internal Friction, "ϕ", and the intercept with Y axis is the "Cohesion". The same procedure was followed for the CU Triaxial Tests. However, for CU Triaxial tests, pore water pressures within the specimen were also measured and later used to determine the effective stresses and corresponding ϕ and cohesion.

Triaxial UU tests indicated parameters of cohesion between 0 and 20 kPa (0 and 420 psf) and friction angle between 25 to 40 degrees. Specimens were tested as compacted.

Based on the triaxial CU test results, total and effective shear strength parameters were determined. The total shear strength parameters ranged from 0 to 40 kPa (0 to 840 psf) for cohesion and 21.1 to 29.7 degrees for friction angle. The effective shear strength parameters ranged between 0 and 50 kPa (0 and 1050 psf) for cohesion and 32 and 42 degrees for friction angle.

Unconfined compression tests indicated strengths ranging from 32 to 46 kPa (670 to 960 psf) with the exception of 126 kPa (2630 psf) for sample 'SAHS'. Strain at failure ranged between 4.0 and 5.2%.

The CHHI(1994) study reported UU triaxial test results ranging between 25 and 39 degrees friction angle and 30 and 78 kPa cohesion. These cohesion values seem to be much higher than those observed in the present study. Friction angle values are, however, fall within the range.

CU triaxial test results reported by CHHI(1994) ranged between 25 to 70 kPa for total cohesion and 0 kPa effective cohesion. Total Friction angle ranged between 23 to 33 degrees and effective friction angle ranged between 32 and 41 degrees.

TABLE 4-4 Results of Shear Strength Tests

Sample ID	CU Triaxial Test				UU Triaxial Test		Unconfined Compressive Strength Tests	
	Total Strength		Effective Strength					
	C (kPa)	ϕ (deg)	C (kPa)	ϕ (deg)	C (kPa)	ϕ (deg)	Unconf. Compressive Stength, Qu (kPa)	Strain at Faillure (%)
SALS	20	23.2	10	37.6	15	32.2	46	5.2
SAHS	0	29.7	0	40.6	0	32.2	126	5.0
SULS	15	26.6	0	42	10	31.0	36	4.7
SUHS	40	29.7	50	33.3	20	39.6	42	4.0
CAHS	10	25.2	10	32.2	0	37.6	23	5.1
CALS	40	21.1	30	32.2	20	24.6	36	4.9

4.5 Bearing Strength

Table 4-5 summarizes the results of the Illinois Bearing Ratio (IBR) and the Immediate Bearing Value (IBV) tests conducted on the biosolids samples. Test reports are included in Appendix E.

TABLE 4-5 Results of Bearing Strength Tests

Sample ID	IBR	IBV	Swell (%)
SALS	2.5	4.3	1.55
SAHS	4.8	6.8	0.93
SULS	2.0	3.6	3.37
SUHS	1.6	9.4	2.55
CAHS	1.6	2.2	1.73
CALS	1.8	6.0	2.45

The IBR for the biosolids ranged between 1.6 to 4.8 with an average of 2.4, and the IBV value ranged between 2.2 and 9.4 with an average value of 5.4. IBV test is performed on unsoaked specimens, while the IBR test is performed on soaked specimens. Swell is defined as a ratio of change in length to original length and expressed as a percentage. Swell measured for all the specimens after soaking ranged between 0.93 to 3.37%.

5 PRELIMINARY ASSESSMENT OF BENEFICIAL USE IN CIVIL AND ENVIRONMENTAL ENGINEERING APPLICATIONS

5.1 Assessment of Geotechnical Properties

Geotechnical engineering properties of biosolids that are of particular interest when biosolids are considered as substitute material for natural soils are particle size distribution, moisture-density relationship, consolidation characteristics, shear strength, bearing strength, and permeability. Based on the results of this study, the biosolids exhibit the following characteristics:

- As seen Table 4.1, biosolids are predominantly a silt-size material. As such, its particle size distribution falls essentially within the normally recognized limits for frost-susceptible soils. The fine particle sizing of biosolids, together with the relative uniformity of the gradation in the coarse silt range, makes it imperative that the biosolids be handled with sufficient water to prevent dusting. Since fine-grained soils can be fairly easily eroded, enough moisture must also be present to support compaction equipment and to permit the material to be well densified, in order to prevent or minimize erodibility.

- As seen from Table 4.2, the maximum dry density of biosolids ranges from 50 to 68 pcf which is one-half of the density of natural soils. Thus, biosolids may be used as lightweight fill material in earthfill projects. The compaction test results (Table 4-2) also showed that the compaction does not depend significantly on the moisture content, thus moisture adjustments may not be needed.

- As seen in Table 4.3, the consolidation characteristics of biosolids are similar to that of normally consolidated clays. Designs should consider total and differential settlements, depending on the application.

- As shown in Table 4.4, shear strength tests conducted on biosolids samples show that biosolids derive shear strength from internal friction and cohesion. The shear strength of biosolids depends on the solids content, aging as well as source. Biosolids possess a friction angle ranging from 21 to 39 degrees and a cohesion ranging from 0 to 40 kPa. These shear strength parameters are comparable to some natural soils.

- Bearing values indicate the suitability of using the materials for pavement applications. As shown in Table 4.5, IBR values for biosolids found to range from 1.6 to 4.8 percent in the soaked condition and IBV values ranged from 2.2 to 9.4 percent in the unsoaked condition. For naturally occurring soils, IBR values normally range from 3 to 15% for fine-grained materials (silts and clays) and from 10 to 40% for sand and sandy soils.

5.2 Assessment of Potential Uses

A preliminary assessment of beneficial use of biosolids in various civil and environmental applications was made. These applications included:

- Embankment fill
- Base, subbase and subgrade under pavements,
- Structural backfill
- Landfill intermediate or final cover material
- Landfill liner material
- Reactive media in permeable reactive barriers

These applications are briefly described below.

5.2.1 Embankment Fill

Biosolids possess relatively low unit weight that makes them as suitable lightweight fill material to construct embankments over soft or low bearing strength soils. The design of biosolids embankment is essentially the same as the design of an earthern embankment. However, there are certain special design considerations that should be considered when biosolids are used in embankment applications:

Embankment slopes should be stable. The basic principle of slope stability analysis is to compare the factors contributing to instability with those resisting failure. The principal resistance to failure is the shear strength of the embankment material.

- The ability of the top portion of a biosolids embankment to support a pavement structure depends on the bearing values. Based on the IBR/IBV results, biosolids are not suitable to support pavement with traffic loading. Therefore, the biosolids embankments can not be used to adequately support pavements unless it is blended with other materials that can enhance the bearing capacity.

- The design of embankment slopes should consider the potential for erodibility of biosolids by runoff, or even high winds. Erosion control on side slopes is usually provided by placing from 6 inches to 2 feet of soil cover on the slopes. An alternative approach is to build outside dikes of soil to contain the biosolids as the embankment is being constructed.

- Because of its predominance of silt-size particles, biosolids may tend to wick water into itself and become saturated, resulting in a loss of shear strength. An effective way to prevent capillary rise or the effects of seepage in biosolids emabankments is the placement of a drainage layer of well-drained granular material at the base of the embankment.

- The surface portion of biosolids embankment is subjected to frost heaving. Objections to the use of compacted biosolids within the frost depth can be overcome by substituting a soil that is not susceptible to frost within the frost zone.

- Biosolids may be potentially corrosive to metal pipes placed within an embankment. Each source of biosolids should be individually evaluated for its corrosivity potential. If protection of metal pipes is deemed necessary, the exterior of the pipes may be coated with tar or asphalt cement, the pipes may be wrapped with polyethylene sheeting, or the pipes can be backfilled with sand or an inert material.

Methods to construct biosolids embankments will be the same as that used to construct earthen embankments. Standard construction equipment can be used to construct biosolids embankment. The equipment includes a bulldozer for spreading the material, a compactor, a water truck to provide water for compaction (if needed) and to control dusting, and a motor grader, where final grade control is critical. To achieve the desired degree of compaction in the field, the biosolids should have moisture content close to optimum moisture content.

5.2.2 Base, Subbase and Subgrade Under Pavements

Figure 5-1 shows approximate correlation of soil ratings based on CBR values for use in design of light-traffic pavements. IBR values (same as CBR) for biosolids tested in this study ranged from 1.6 to 4.8. Clearly, the biosolids are rated as 'unacceptable' as base or subbase materials. They are rated as 'poor' as a subgrade material. It is possible that biosolids could be used as subgrade materials under very light traffic pavements. However, if the bearing strength could be improved by amending biosolids with soils, lime or flyash, they may be suitable as subgrade for light-traffic pavements.

5.2.3 Structural Backfill

Although the biosolids seem to have requisite shear strength, other issues such as settlement, frost and swell potential may restrict their use. Due to their lightweight, they could be considered as backfill for retaining structures. However, their drainage characteristics and aesthetics should be considered in such applications.

5.2.4 Intermediate or Final Cover Over Landfills

Landfill final cover slopes typically range from 5% (for drainage purposes) to 33% (3H:1V). Geotechnical properties that are necessary to evaluate the suitability of materials to use in final covers include shear strength parameters (c and ϕ) and hydraulic conductivity (k). Typically, a Factor of Safety (F.S.) of 1.5 is required against slope failure for the final cover slopes. The biosolids tested in this study have an effective friction angle ranging from 32 to 40 degrees when compacted to 95% of Modified Proctor density and optimum moisture content (OMC). Infinite slope analysis indicated that the final cover slopes would have sufficient factors of safety. Biosolids should be compacted to at least 95% of Modified Proctor Density at not more than 5% wet of

optimum moisture content. In landfill final cover type applications, the overburden pressure from protective cover soils on biosolids is not significant (typically less than 350 psf when natural soils are used). Preliminary calculations based on typical biosolids' compression indices and typical overburden pressures resulting from protective covers, the initial thickness should be 10 percent more than the desired final thickness. It appears that conventional compactors such as sheeps-foot roller and pneumatic tired roller would be suitable to achieve required densities and proper lift bonding between various lifts. Although, a potential application for biosolids, the use of biosolids in such applications should be thoroughly investigated with field scale pilot studies as several environmental and compactibility issues could not be assessed are addressed from laboratory studies.

Other potential applications include low height screening berms, temporary berms constructed to less than 1V:3H outslopes. These applications could be attractive particularly when embankments need to be built on soft soils. Due to their lightweight (only half of other natural soils), biosolids will lessen the severity of foundation and settlement issues inherent to such soils. Slope stability analyses should be performed to determine the available factors of safety for a particular application. Again, as mentioned above, field scale pilot tests should be under taken with monitoring slope movement and settlements to assess the suitability of biosolids in such application.

5.2.5 Landfill Liner Material

Conventionally landfill liners are designed to minimize the infiltration of leachates into the subsurface below the landfill, thus eliminating the potential for groundwater contamination. Clay liners, geomembranes and geosynthetic clay liners are commonly used for this purpose. Modified clay liners which consist of clays mixed with selected additives provide both hydraulic and chemical containment. Biosolids, because of their high organic content, may be used as an additive to modify the clays to provide chemical containment. Geosynthetics, such as geosynthetic clay liner composition could be also altered with the incorporation of biosolids to provide effective chemical containment.

5.2.6 Reactive Media in Permeable Reactive Barriers

Permeable reactive barriers (PRBs) are used for the treatment of groundwater under in-situ conditions. PRBs essentially involve placing reactive media in the path of a migrating contaminant plume, either in a trench or buried as a broad continuous wall. The reactive media reacts with the contaminants and converts them into nontoxic form such as by redox reactions or immobilization the contaminants by sorption processes. Due to high organic content, biosolids may function as an effective sorptive media for different types of contaminants in PRBs.

6 CONCLUSIONS AND RECOMMENDATIONS

Six biosolids samples were tested as part of this study. These samples were provided by the Metropolitan Water Reclamation District from its plants in the Chicago metropolitan area. The biosolids samples are termed as 'Aged Low Solids' or 'Aged High Solids' depending on the process through which they were generated. Based on the present study, the following conclusions are drawn.

6.1 Conclusions

1. The biosolids samples are classified as fine-grained soils with a group symbol of 'OH' as per USCS classification system. The group name for these soils is 'organic soil with sand'. The soils contained approximately 50% sand, 45% silt size and 5% clay size particles. All biosolids samples have high moisture content, Liquid Limit and Plasticity Indices that are comparable to common inorganic soils. Specific Gravity of the biosolids is approximately 2.0, which is substantially less than that natural soils (approximately 2.7).

2. The moisture-density relationship tests indicated that the compaction curve is "flat" and that maximum dry density varied only slightly with moisture content changes. The maximum dry density is half and the optimum moisture content is 2 to 3 times that of other natural inorganic soils. Therefore, biosolids may be used as a lightweight fill material.

3. Biosolids when compacted would possess reasonably good shear strength characteristics thus making them useful materials for several applications. embankments.

4. The biosolids can undergo medium to high consolidation under overburden pressure. This possibility precludes from being used underneath foundations where significant stresses occur.

5. The biosolids have relatively poor soil rating based on IBR (CBR) and high swell potential. They are unacceptable as base or subbase material and rated as poor for subgrade material for light-traffic pavements. They may be suitable as subgrade materials for very light traffic pathways such golf cart pathways.

6. The biosolids should be restricted from structural backfills due to settlement and swell potential. Potential backfill applications include behind retaining walls if hydraulic conductivity properties do not pose a limitation.

6.2 Recommendations

The following recommendations are offered regarding the use and further evaluation of biosolids in geotechnical applications:

1. All design issues such as strength, compressibility, factors of safety against failure, long-term maintenance and environmental effects should be properly considered.

2. Field scale pilot studies should be conducted to evaluate the performance of biosolids before full-scale use.

3. Additional studies involving stabilizing biosolids with soils, lime or fly-ash to improve their bearing strength and compactibility characteristics and reduce their potential for swell.

7 REFERENCES

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Appendix A

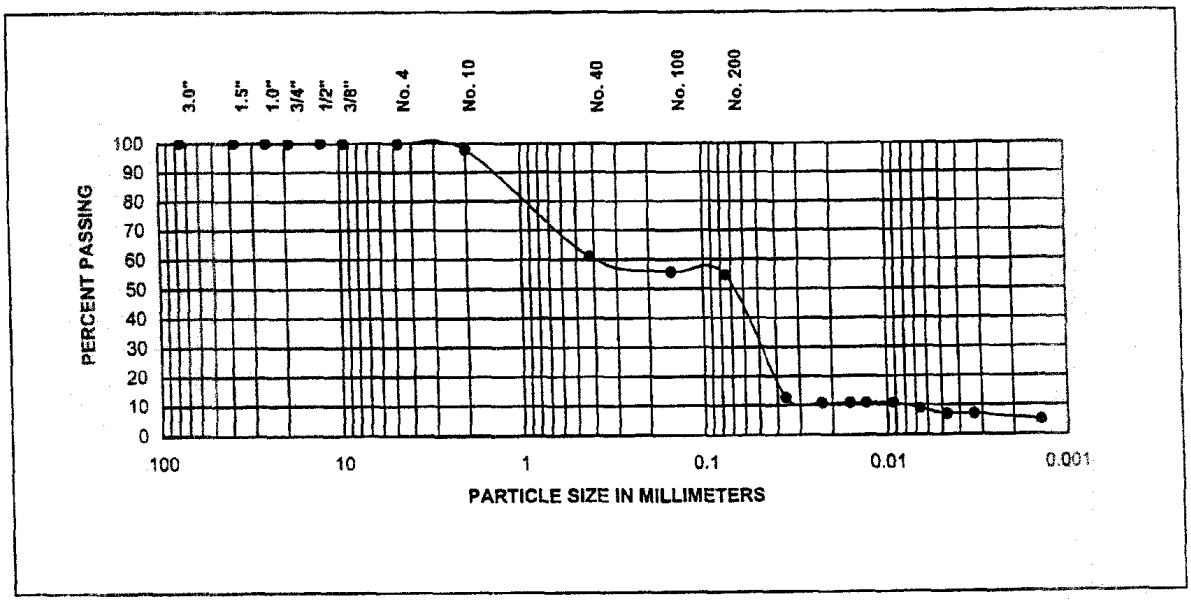
Index Properties

- Particle Size Analysis
- Atterberg Limits and Plasticity Index
- Specific Gravity (Particle Density)

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	GRAIN SIZE ANALYSIS (ASTM D422)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#1-SALS-1001-HYD-1	**Date Tested**	2/27/2002	**Tested by**	MC
						Qc by	SB

Sample Location	SWRP Lagoon-23 RASMA May/June Lift
Sample Description	Black aged solids



			Fines	
% + 3"	**% Gravel**	**% Sand**	**% Silt Size**	**% Clay Size**
0.0	0	45	47	8

For coarse-grained soils with <12% Fines	D60(mm)	D30(mm)	D10(mm)	Cu	Cc

Sieve Size	**Percent Passing**
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
No. 4	99.9
No. 10	97.8
No. 40	61.1
No. 100	55.8
No. 200	54.7

Liquid Limit, L_L	**Plastic Limit, PL**	**Plasticity Index, PI**
108	74	34

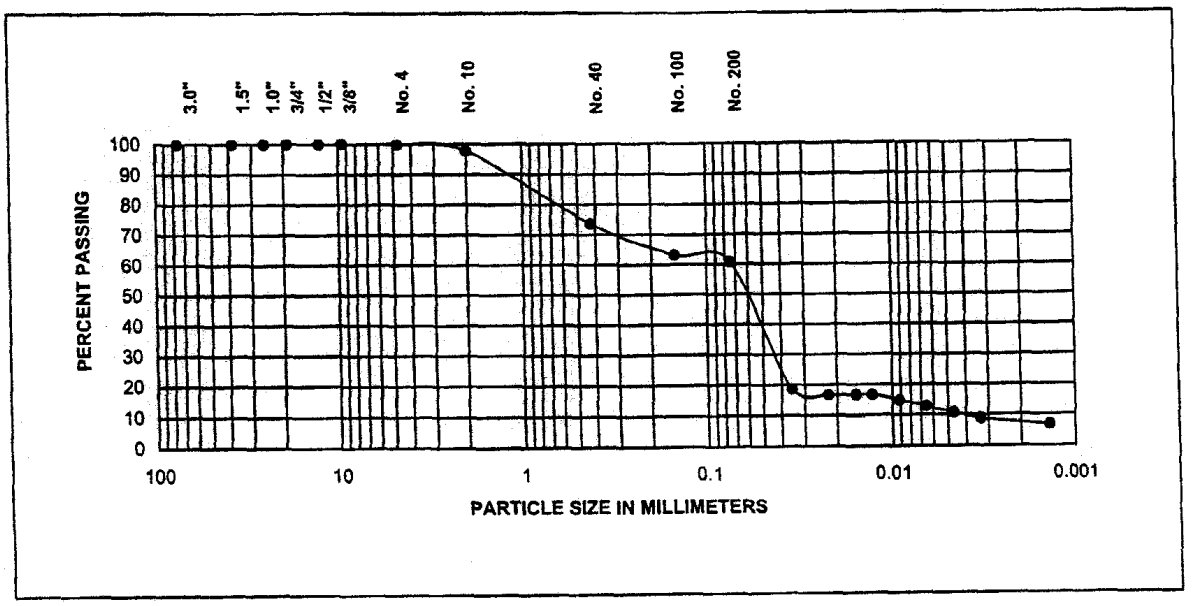
Soil Classification:	OH
Soil Description:	Sandy organic soil
System:	USCS

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	GRAIN SIZE ANALYSIS (ASTM D422)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#1-SALS-1001-HYD-2	**Date Tested**	2/28/2002	**Tested by**	AK
						Qc by	SB

Sample Location	SWRP Lagoon-23 RAMA May/June Lift
Sample Description	Black Aged Low Solids



			Fines	
% + 3"	**% Gravel**	**% Sand**	**% Silt Size**	**% Clay Size**
0.0	0	39	50	11

	D60(mm)	D30(mm)	D10(mm)	Cu	Cc
For coarse-grained soils with <12% Fines					

Sieve Size	Percent Passing
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
No. 4	99.9
No. 10	97.8
No. 40	73.7
No. 100	63.4
No. 200	60.9

Liquid Limit, L_L	Plastic Limit, PL	Plasticity Index, PI
96	71	25

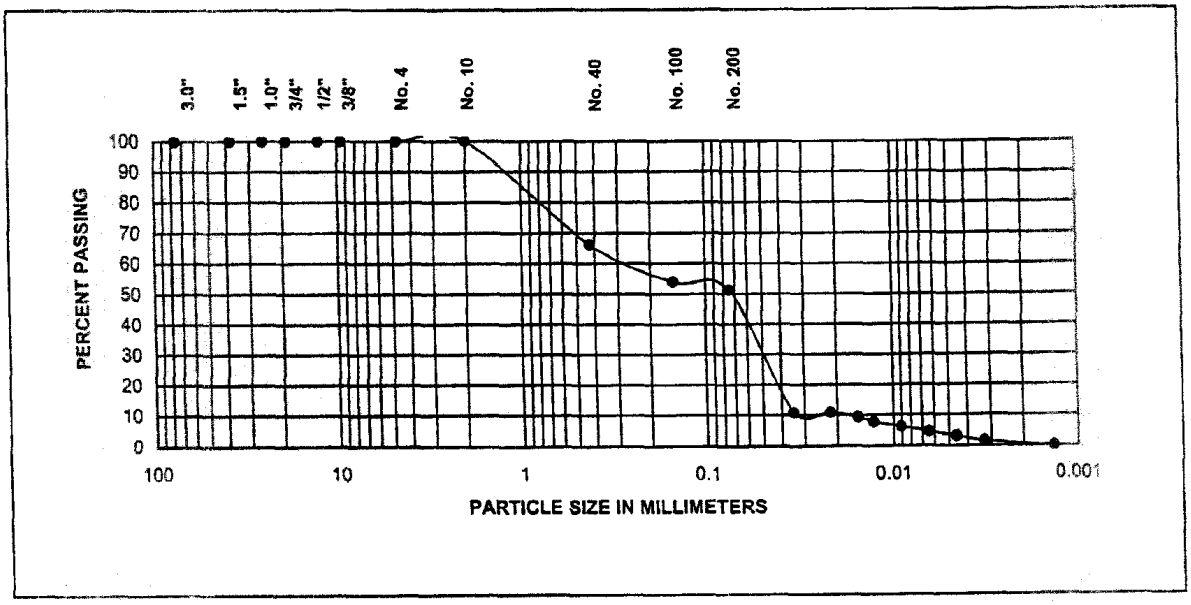
Soil Classification:	OH
Soil Description:	Sandy organic soil
System:	USCS

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	GRAIN SIZE ANALYSIS (ASTM D422)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#2-SAHS-1001-HYD-1	**Date Tested**	3/1/2002	**Tested by**	MC
						Qc by	SB

Sample Location	SWRP Lagoon-24-HASMA
Sample Description	Black Aged High Solids



			Fines	
% + 3"	**% Gravel**	**% Sand**	**% Silt Size**	**% Clay Size**
0.0	0	49	48	4

For coarse-grained soils with <12% Fines	D60(mm)	D30(mm)	D10(mm)	Cu	Cc

Sieve Size	**Percent Passing**
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
No. 4	100.0
No. 10	100.0
No. 40	66.2
No. 100	54.0
No. 200	51.3

Liquid Limit, L_L	**Plastic Limit, PL**	**Plasticity Index, PI**
119	66	53

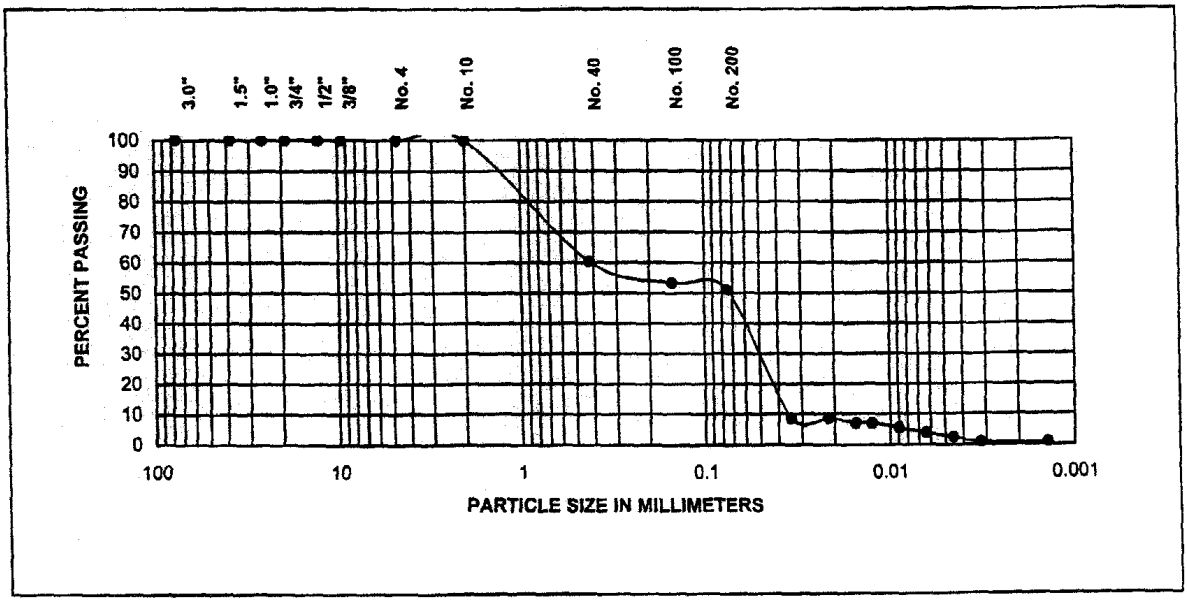
Soil Classification:	OH
Soil Description:	Sandy organic soil
System:	USCS

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	GRAIN SIZE ANALYSIS (ASTM D422)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#2-SAHS-1001-HYD-2	**Date Tested**	3/4/2002	**Tested by**	MC
						Qc by	SB

Sample Location	SWRP Lagoon-24-HASMA
Sample Description	Black Aged High Solids



			Fines	
% + 3"	**% Gravel**	**% Sand**	**% Silt Size**	**% Clay Size**
0.0	0	49	48	3

	D60(mm)	D30(mm)	D10(mm)	Cu	Cc
For coarse-grained soils with <12% Fines					

Sieve Size	Percent Passing
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
No. 4	100.0
No. 10	100.0
No. 40	60.5
No. 100	53.3
No. 200	51.1

Liquid Limit, L_L	**Plastic Limit, PL**	**Plasticity Index, PI**
71	54	17

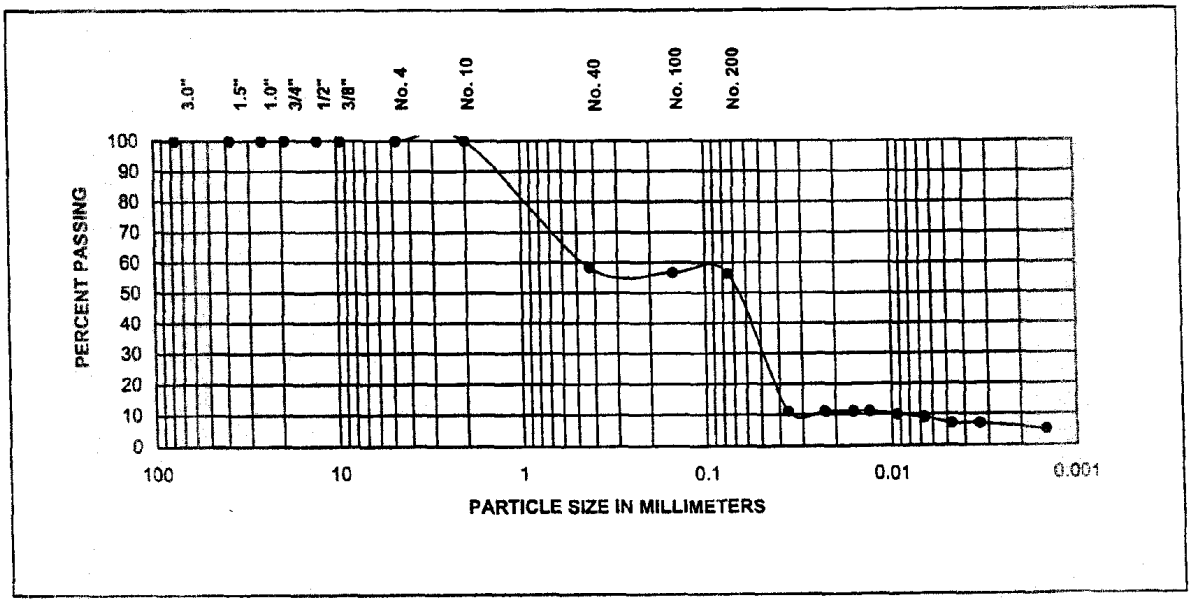
Soil Classification:	OH
Soil Description:	Sandy organic soil
System:	USCS

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	GRAIN SIZE ANALYSIS (ASTM D422)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#3-SULS-1001-HYD-1	**Date Tested**	2/27/2002	**Tested by**	MC
						Qc by	SB

Sample Location	SWRP Lagoon-16 Marathon
Sample Description	Black Under-aged Low Solids



			Fines	
% + 3"	**% Gravel**	**% Sand**	**% Silt Size**	**% Clay Size**
0.0	0	44	49	8

	D60(mm)	D30(mm)	D10(mm)	Cu	Cc
For coarse-grained soils with <12% Fines					

Sieve Size	Percent Passing
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
No. 4	100.0
No. 10	100.0
No. 40	58.4
No. 100	56.7
No. 200	56.4

Liquid Limit, L_L	Plastic Limit, PL	Plasticity Index, PI
93	66	27

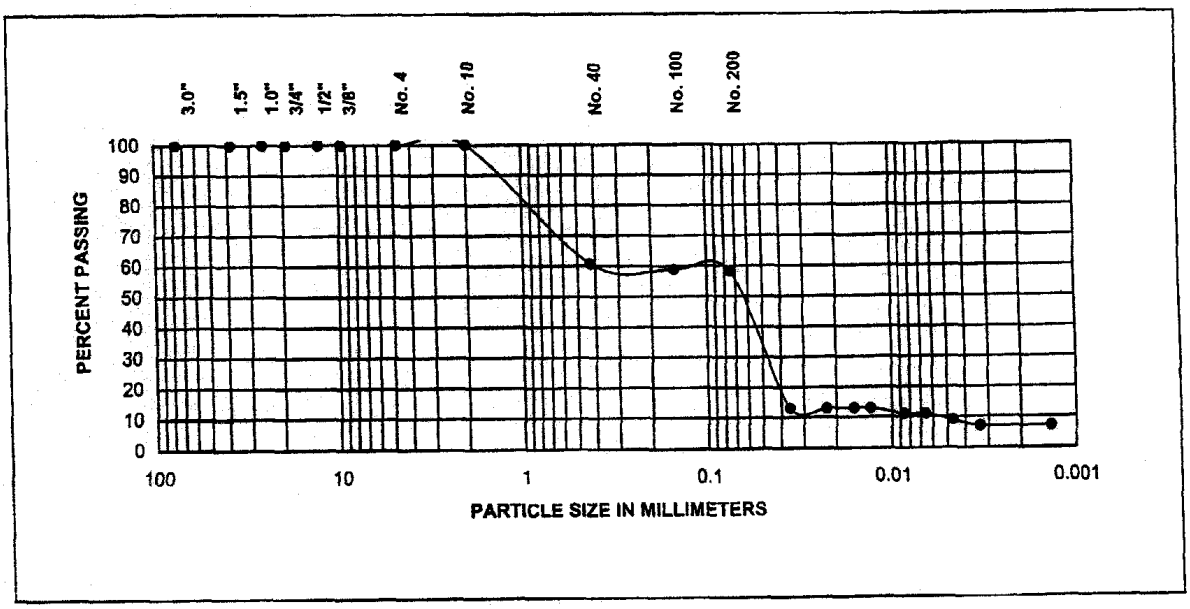
Soil Classification:	OH
Soil Description:	Sandy organic soil
System:	USCS

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	GRAIN SIZE ANALYSIS (ASTM D422)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#3-SULS-1001-HYD-2	**Date Tested**	2/28/2002	**Tested by**	AK
						Qc by	SB

Sample Location	SWRP Lagoon-16 Marathon
Sample Description	Black Under-aged Low Solids



			Fines	
% + 3"	**% Gravel**	**% Sand**	**% Silt Size**	**% Clay Size**
0.0	0	42	49	10

For coarse-grained soils with <12% Fines	D60(mm)	D30(mm)	D10(mm)	Cu	Cc

Sieve Size	**Percent Passing**
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
No. 4	100.0
No. 10	100.0
No. 40	60.7
No. 100	58.9
No. 200	58.4

Liquid Limit, L_L	**Plastic Limit, PL**	**Plasticity Index, PI**
105	82	23

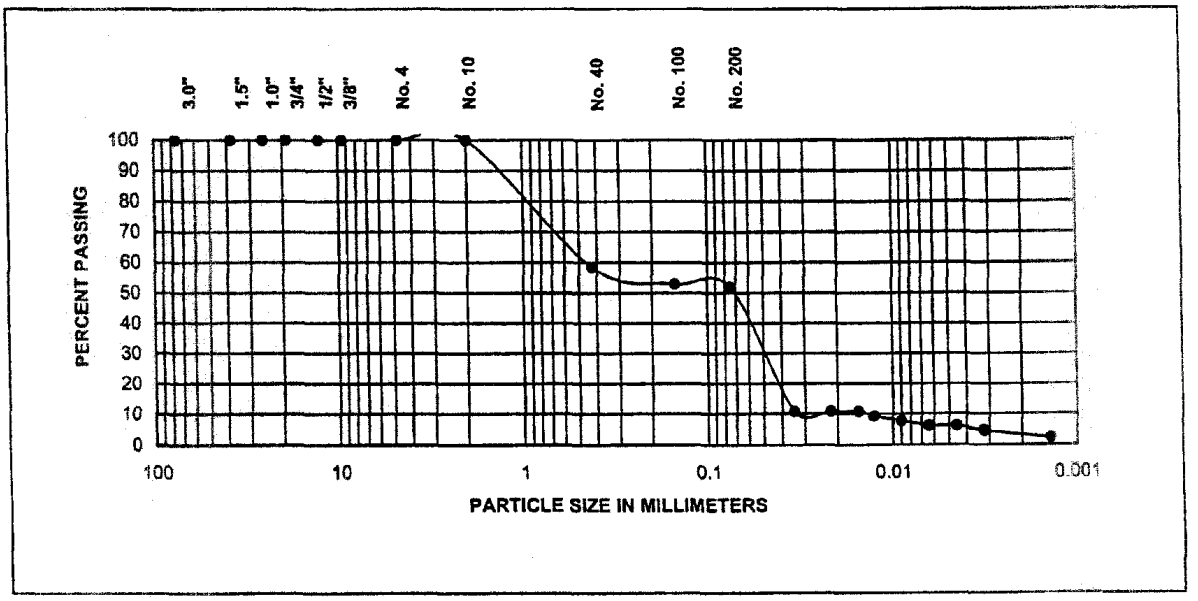
Soil Classification:	OH
Soil Description:	Sandy organic soil
System:	USCS

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	GRAIN SIZE ANALYSIS (ASTM D422)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	Sample #	Ref#4-SUHS-1001-HYD-1	Date Tested	3/1/2002	Tested by	MC
						Qc by	SB

Sample Location	SWRP 2001 Lift-Stoney Island
Sample Description	Black Under-aged High Solids



			Fines	
% + 3"	% Gravel	% Sand	% Silt Size	% Clay Size
0.0	0	48	46	6

For coarse-grained soils with <12% Fines	D60(mm)	D30(mm)	D10(mm)	Cu	Cc

Sieve Size	Percent Passing
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
No. 4	100.0
No. 10	100.0
No. 40	58.5
No. 100	53.0
No. 200	52.0

Liquid Limit, L_L	Plastic Limit, PL	Plasticity Index, PI
108	60	48

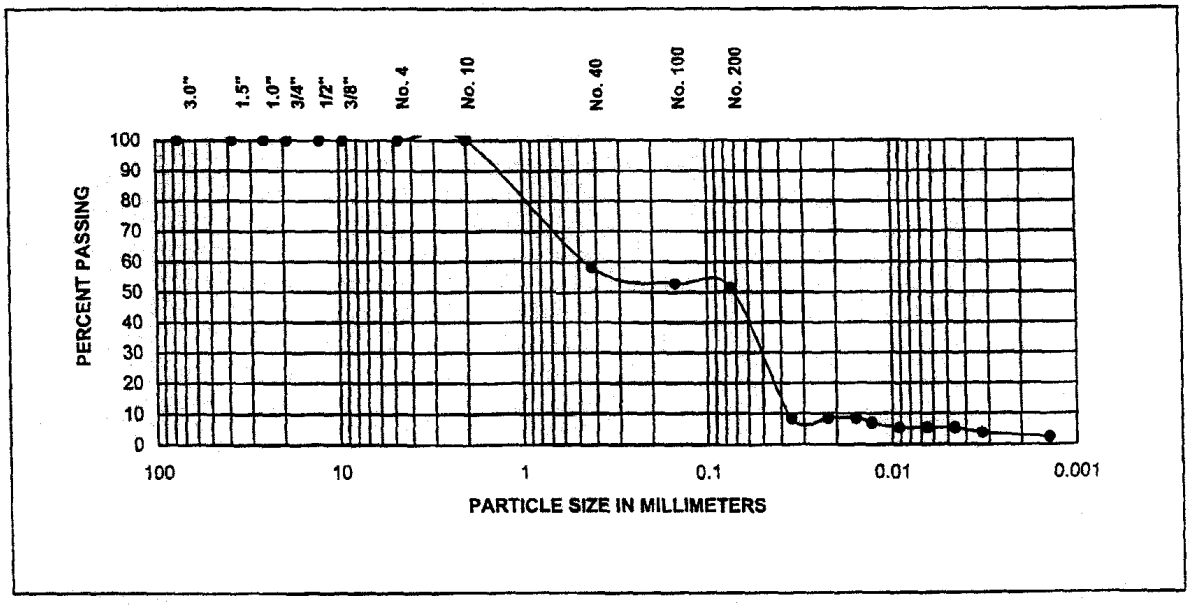
Soil Classification:	OH
Soil Description:	Sandy organic soil
System:	USCS

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	GRAIN SIZE ANALYSIS (ASTM D422)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#4-SUHS-1001-HYD-2	**Date Tested**	3/4/2002	**Tested by**	MC
						Qc by	SB

Sample Location	SWRP 2001 Lift-Stoney Island
Sample Description	Black Under-aged High Solids



			Fines	
% + 3"	**% Gravel**	**% Sand**	**% Silt Size**	**% Clay Size**
0.0	0	48	46	5

For coarse-grained soils with <12% Fines	D60(mm)	D30(mm)	D10(mm)	Cu	Cc

Sieve Size	**Percent Passing**
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
No. 4	100.0
No. 10	100.0
No. 40	58.2
No. 100	52.9
No. 200	51.6

Liquid Limit, L_L	**Plastic Limit, PL**	**Plasticity Index, PI**
87	59	28

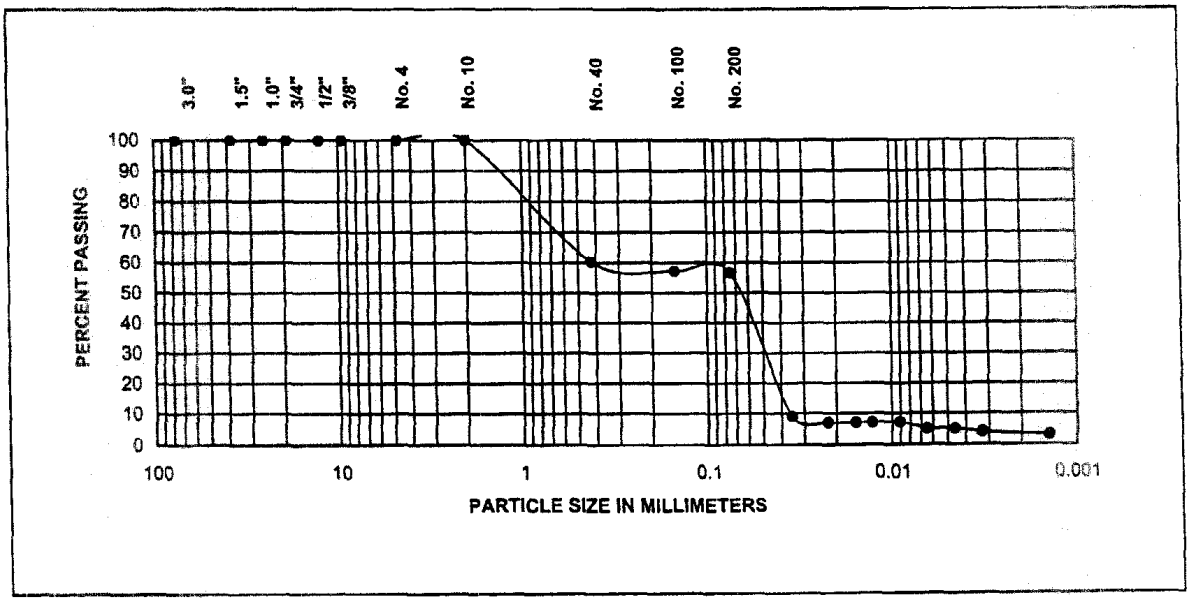
Soil Classification:	OH
Soil Description:	Sandy organic soil
System:	USCS

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	GRAIN SIZE ANALYSIS (ASTM D422)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#5 -CAHS-1001-HYD-1	**Date Tested**	2/27/2002	**Tested by**	AK
						Qc by	SB

Sample Location	CWRP -West
Sample Description	Black Aged High Soilds



			Fines	
% + 3"	**% Gravel**	**% Sand**	**% Silt Size**	**% Clay Size**
0.0	0	43	52	5

For coarse-grained soils with <12% Fines	D60(mm)	D30(mm)	D10(mm)	Cu	Cc

Sieve Size	**Percent Passing**
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
No. 4	100.0
No. 10	100.0
No. 40	60.3
No. 100	57.2
No. 200	56.7

Liquid Limit, L_L	**Plastic Limit, PL**	**Plasticity Index, PI**
103	65	38

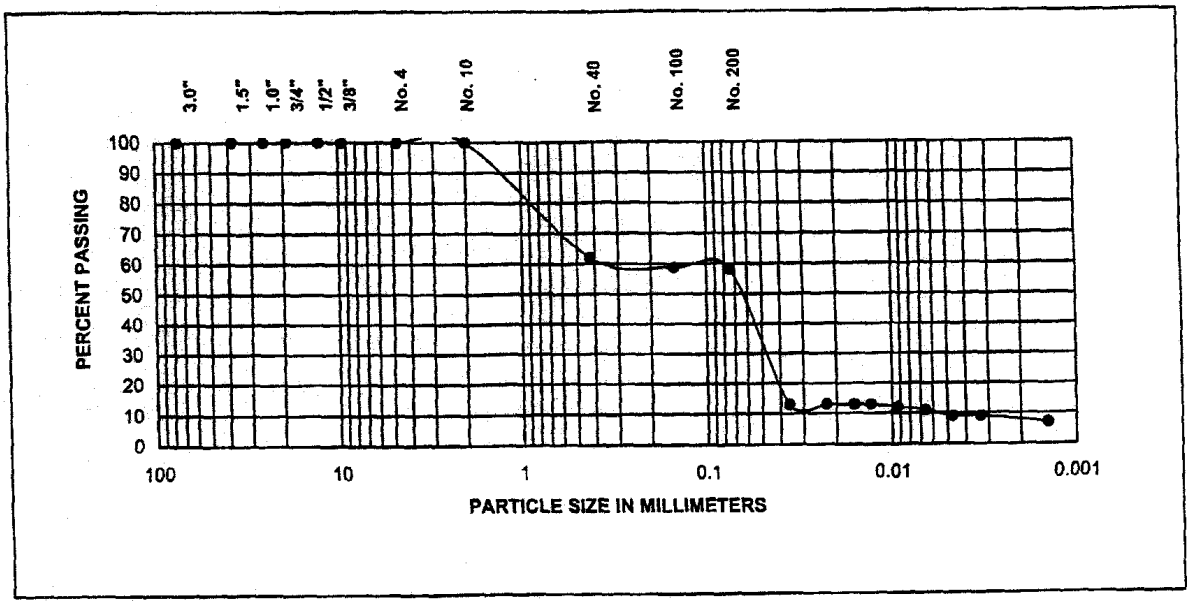
Soil Classification:	OH
Soil Description:	Sandy organic soil
System:	USCS

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	GRAIN SIZE ANALYSIS (ASTM D422)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	REF #5 CAHS-1001-HYD-2	**Date Tested**	2/28/2002	**Tested by**	MC
						Qc by	SB

Sample Location	CWRP- West
Sample Description	Black Aged High Solids



			Fines	
% + 3"	**% Gravel**	**% Sand**	**% Silt Size**	**% Clay Size**
0.0	0	42	48	10

For coarse-grained soils with <12% Fines	D60(mm)	D30(mm)	D10(mm)	Cu	Cc

Sieve Size	**Percent Passing**
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
No. 4	100.0
No. 10	100.0
No. 40	62.1
No. 100	58.7
No. 200	58.2

Liquid Limit, L_L	**Plastic Limit, PL**	**Plasticity Index, PI**
103	85	18

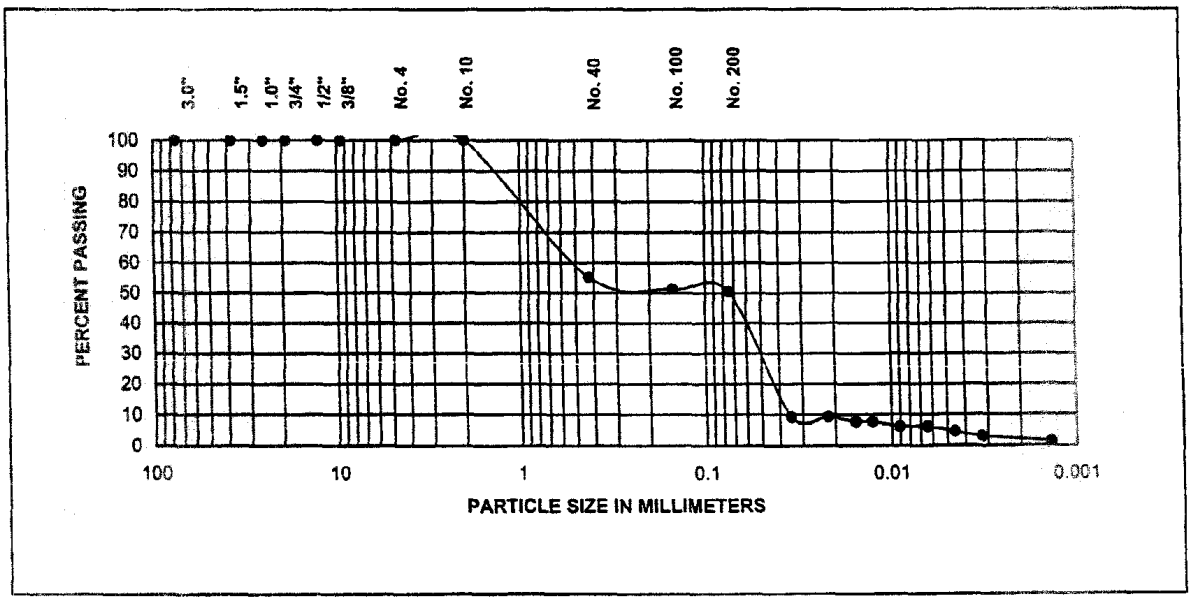
Soil Classification:	OH
Soil Description:	Sandy organic soil
System:	USCS

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	GRAIN SIZE ANALYSIS (ASTM D422)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#6-CALS-1000-HYD-1	**Date Tested**	3/1/2002	**Tested by**	MC
						Qc by	SB

Sample Location	CWRP-East
Sample Description	Black Aged Low Solids



			Fines	
% + 3"	**% Gravel**	**% Sand**	**% Silt Size**	**% Clay Size**
0.0	0	49	45	5

	D60(mm)	D30(mm)	D10(mm)	Cu	Cc
For coarse-grained soils with <12% Fines					

Sieve Size	Percent Passing
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
No. 4	100.0
No. 10	100.0
No. 40	55.3
No. 100	51.3
No. 200	50.6

Liquid Limit, L_L	Plastic Limit, PL	Plasticity Index, PI
91	70	21

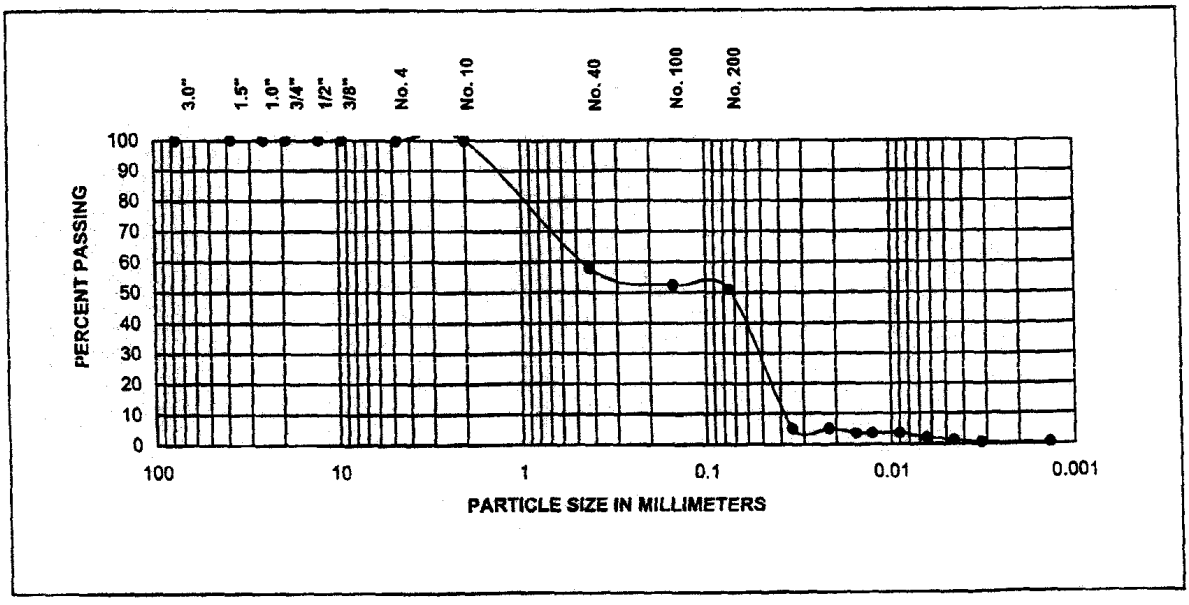
Soil Classification:	OH
Soil Description:	Sandy organic soil
System:	USCS

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	GRAIN SIZE ANALYSIS (ASTM D422)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	Sample #	Ref#6-CALS-1000-HYD-2	Date Tested	3/4/2002	Tested by	MC
						Qc by	SB

Sample Location	CWRP-East
Sample Description	Black Aged Low Solids



			Fines	
% + 3"	% Gravel	% Sand	% Silt Size	% Clay Size
0.0	0	49	49	2

For coarse-grained soils with <12% Fines	D60(mm)	D30(mm)	D10(mm)	Cu	Cc

Sieve Size	Percent Passing
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
No. 4	100.0
No. 10	100.0
No. 40	58.0
No. 100	52.3
No. 200	51.0

Liquid Limit, L_L	Plastic Limit, PL	Plasticity Index, PI
105	83	22

Soil Classification:	OH
Soil Description:	Sandy organic soil
System:	USCS

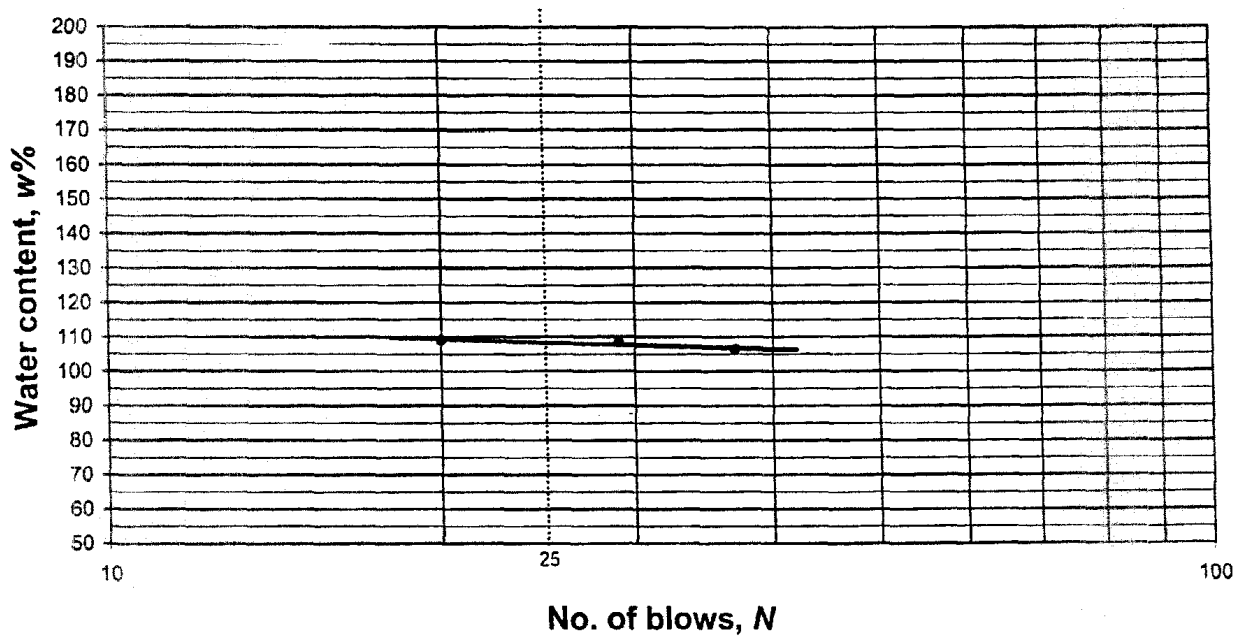
Remarks:

	Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	**Atterberg Limits** **(ASTM D4318)**

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	RFP10-Ref#1 SALS-1001-ABL	**Date Tested**	3/27/2002	**Tested By**	AK
						Qc By	SB

Sample Location	SWRP LAGOON-23 RASMA May/June Lift
Sample Description	Black Aged Low Solids

LIQUID LIMIT DETERMINATION



Results

Liquid Limit, LL	**108**	**Plastic Limit, PL**	**74**	**Plasticity Index, PI**	**34**

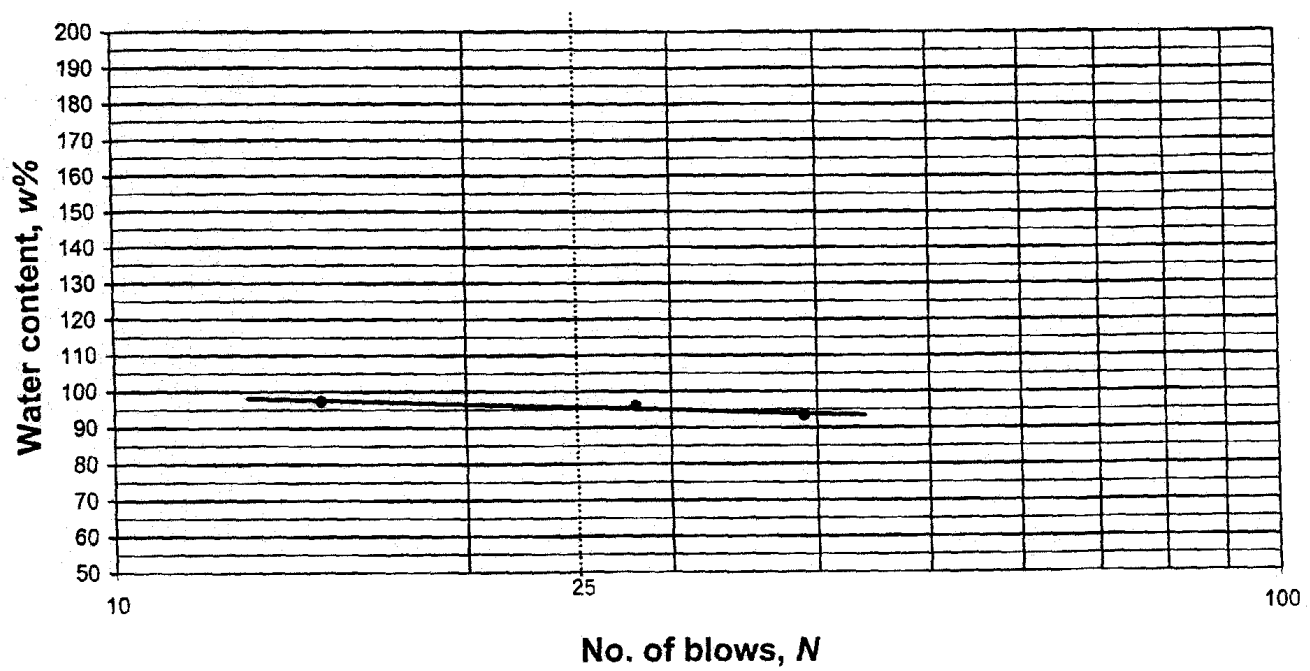
Remarks

	Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	**Atterberg Limits** **(ASTM D4318)**

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	REF#1 RFP10-SALS-1001	**Date Tested**	8/8/2002	**Tested By**	NP
						Qc By	SB

Sample Location	
Sample Description	Black aged low solids

LIQUID LIMIT DETERMINATION



Results

Liquid Limit, LL	**96**	**Plastic Limit, PL**	**71**	**Plasticity Index, PI**	**25**

Remarks

Great Lakes Soil & Environmental Consultants Inc.
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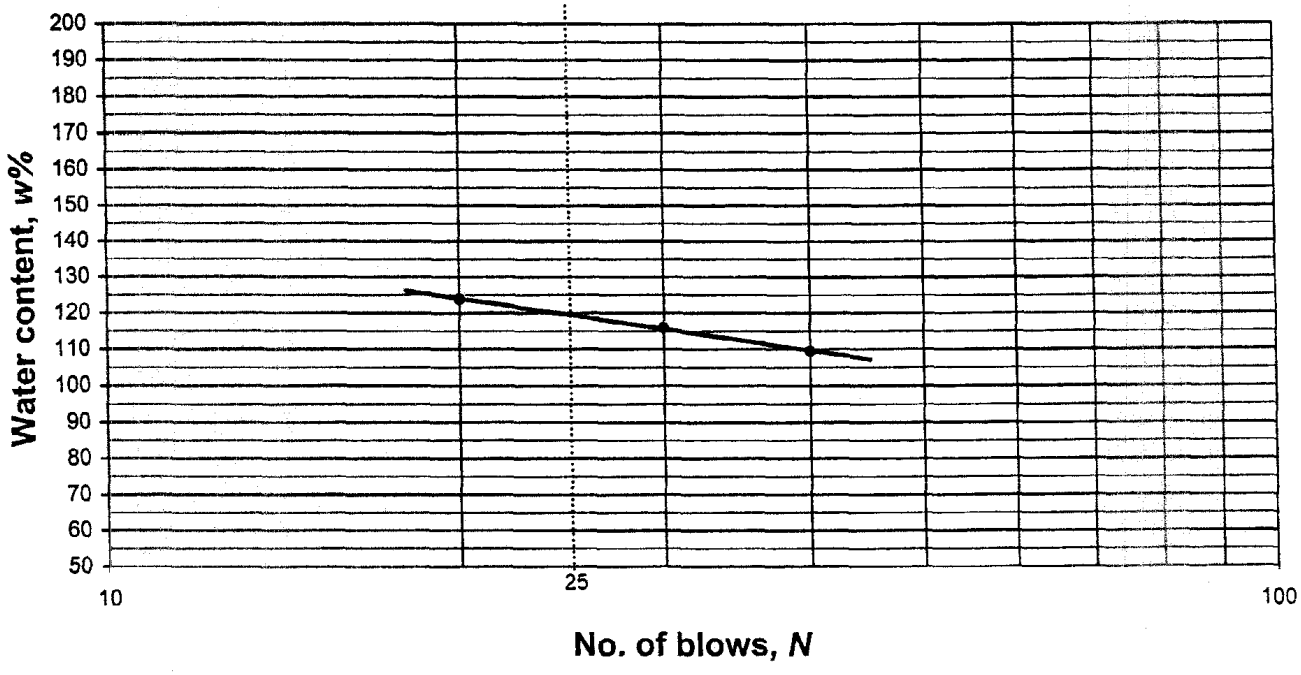
Atterberg Limits
(ASTM D4318)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	RFP10-Ref#2 SAHS-1001-ABL	**Date Tested**	3/27/2002	**Tested By**	AK
						Qc By	SB

Sample Location	SWRP Lagoon-24 HASMA
Sample Description	Black Aged High Solids

LIQUID LIMIT DETERMINATION



Results

Liquid Limit, LL	**119**	**Plastic Limit, PL**	**66**	**Plasticity Index, PI**	**53**

Remarks

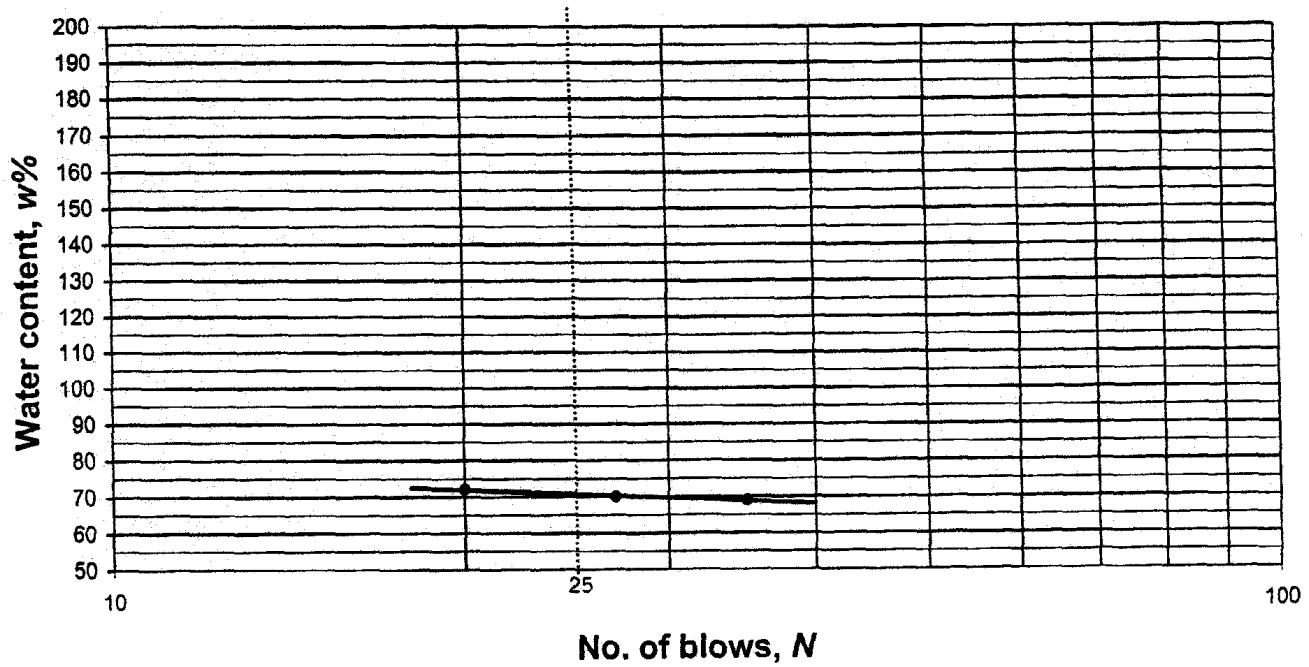
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

Atterberg Limits
(ASTM D4318)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	REF#2 RFP10-SAHS-1001	**Date Tested**	8/8/2002	**Tested By**	NP
						Qc By	SB

Sample Location	
Sample Description	Black Aged High Solids

LIQUID LIMIT DETERMINATION



Results

Liquid Limit, LL	71	**Plastic Limit, PL**	54	**Plasticity Index, PI**	17

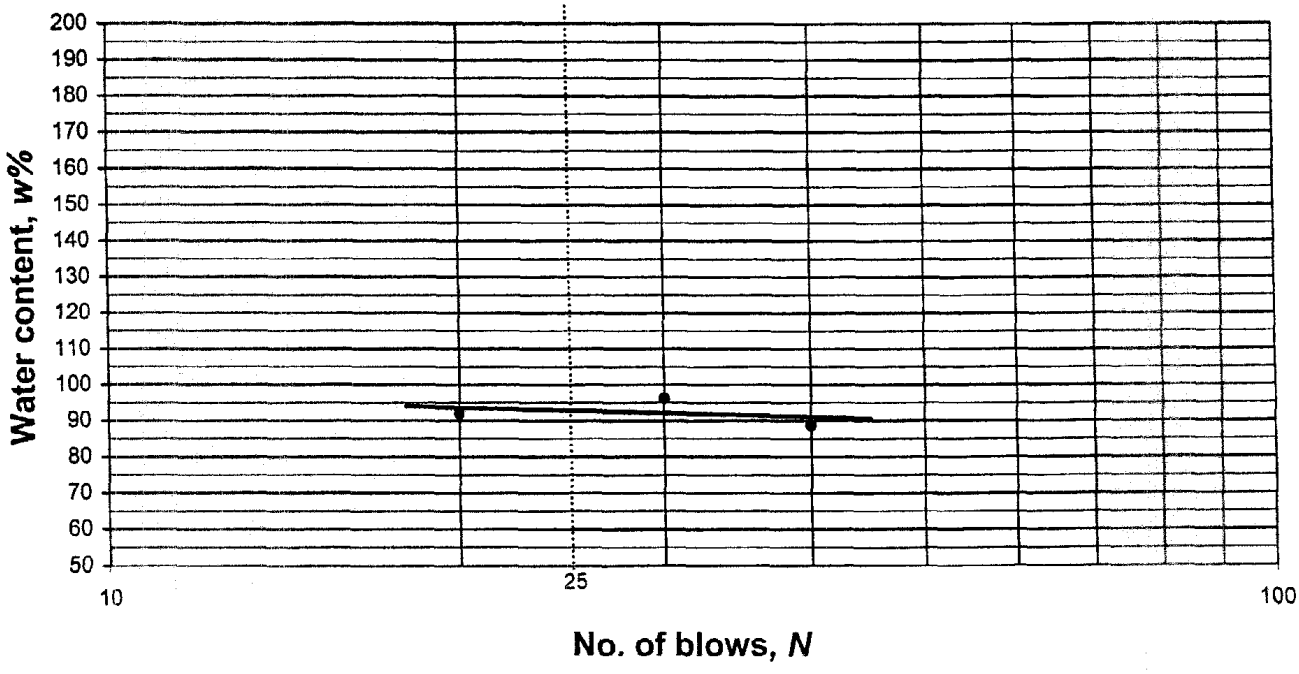
Remarks

	Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	**Atterberg Limits** **(ASTM D4318)**

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	RFP10-Ref#3 SULS-1001-ABL	**Date Tested**	3/27/2002	**Tested By**	AK
						Qc By	SB

Sample Location	SWRP Lagoon-16 Marathon
Sample Description	Black Under-aged Low Solids

LIQUID LIMIT DETERMINATION



Results

Liquid Limit, LL	**93**	**Plastic Limit, PL**	**66**	**Plasticity Index, PI**	**27**

Remarks

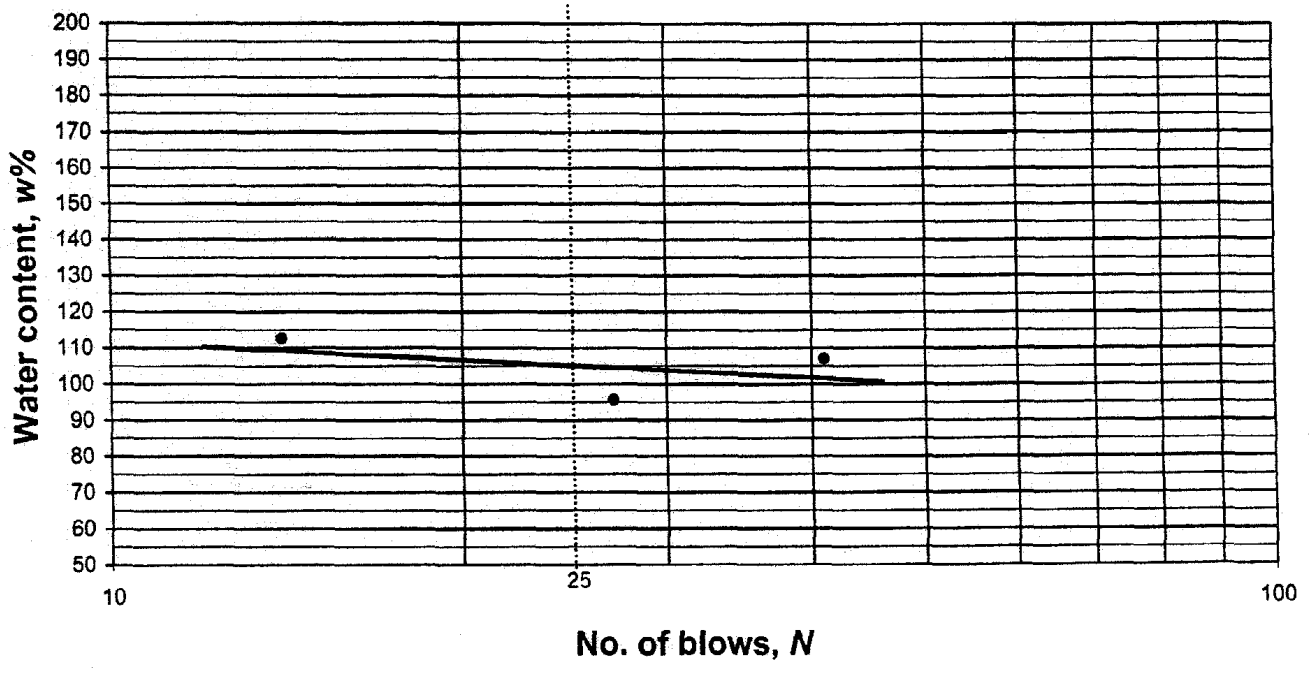
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

Atterberg Limits
(ASTM D4318)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	REF#3 RFP10-SULS-1001	**Date Tested**	8/8/2002	**Tested By**	NP
						Qc By	SB

Sample Location	
Sample Description	Black Under-aged Low Solids

LIQUID LIMIT DETERMINATION



Results

Liquid Limit, LL	**105**	**Plastic Limit, PL**	**82**	**Plasticity Index, PI**	**23**

Remarks

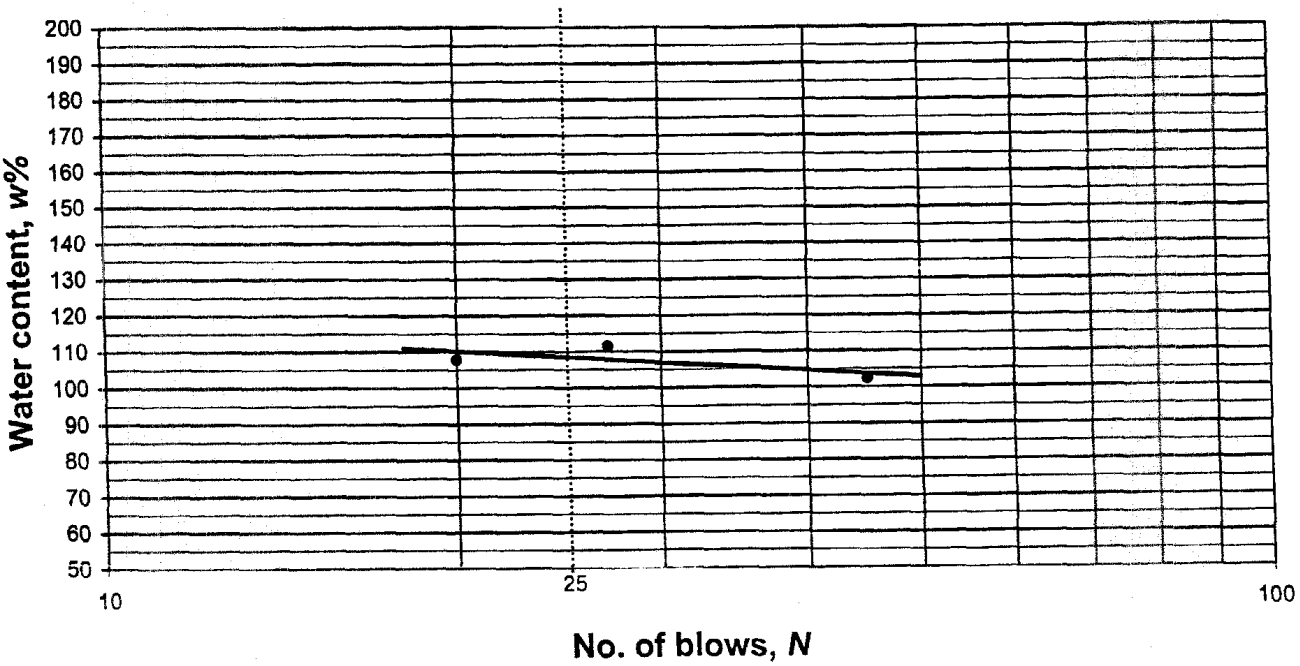
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

Atterberg Limits
(ASTM D4318)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	RFP10-Ref#4-SUHS-1001-ABL	**Date Tested**	3/16/2002	**Tested By**	SM
						Qc By	SB

Sample Location	SWRP 2001 Lift -Stoney Island
Sample Description	Black Under-aged High Solids

LIQUID LIMIT DETERMINATION



Results

Liquid Limit, LL	108	**Plastic Limit, PL**	60	**Plasticity Index, PI**	48

Remarks

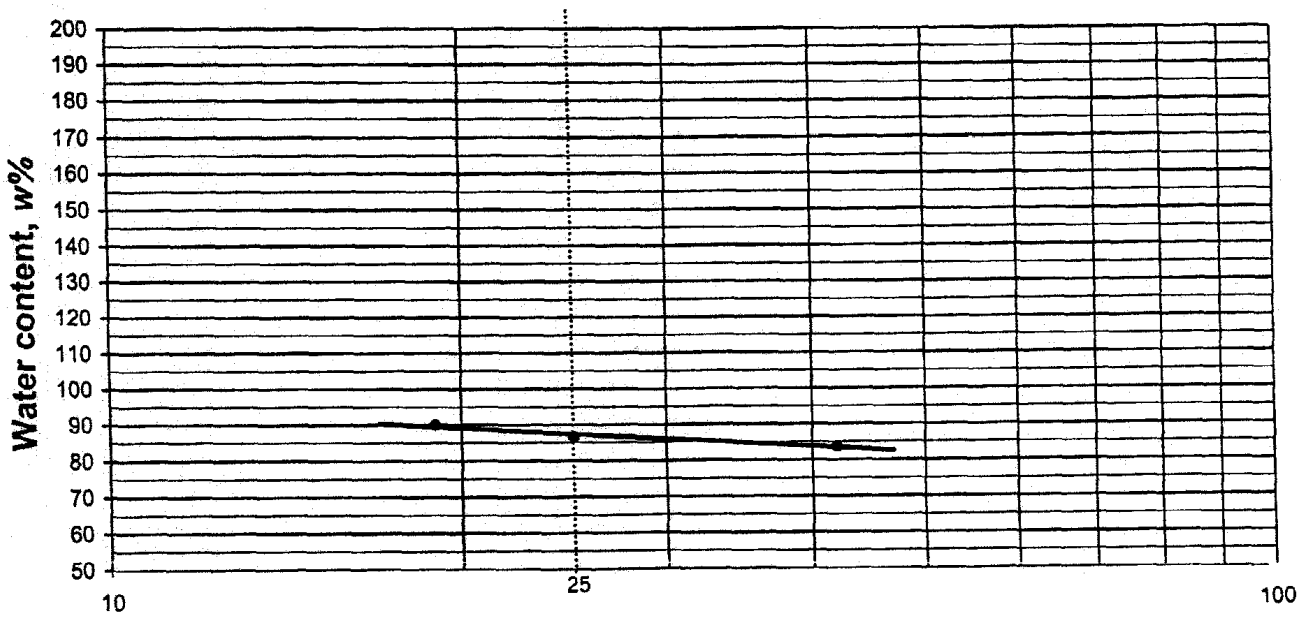
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

Atterberg Limits
(ASTM D4318)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	REF#4 RFP10-SUHS-1001	**Date Tested**	8/8/2002	**Tested By**	NP
						Qc By	SB

Sample Location	
Sample Description	Black Under-aged High Solids

LIQUID LIMIT DETERMINATION



Results

Liquid Limit, LL	87	**Plastic Limit, PL**	59	**Plasticity Index, PI**	28

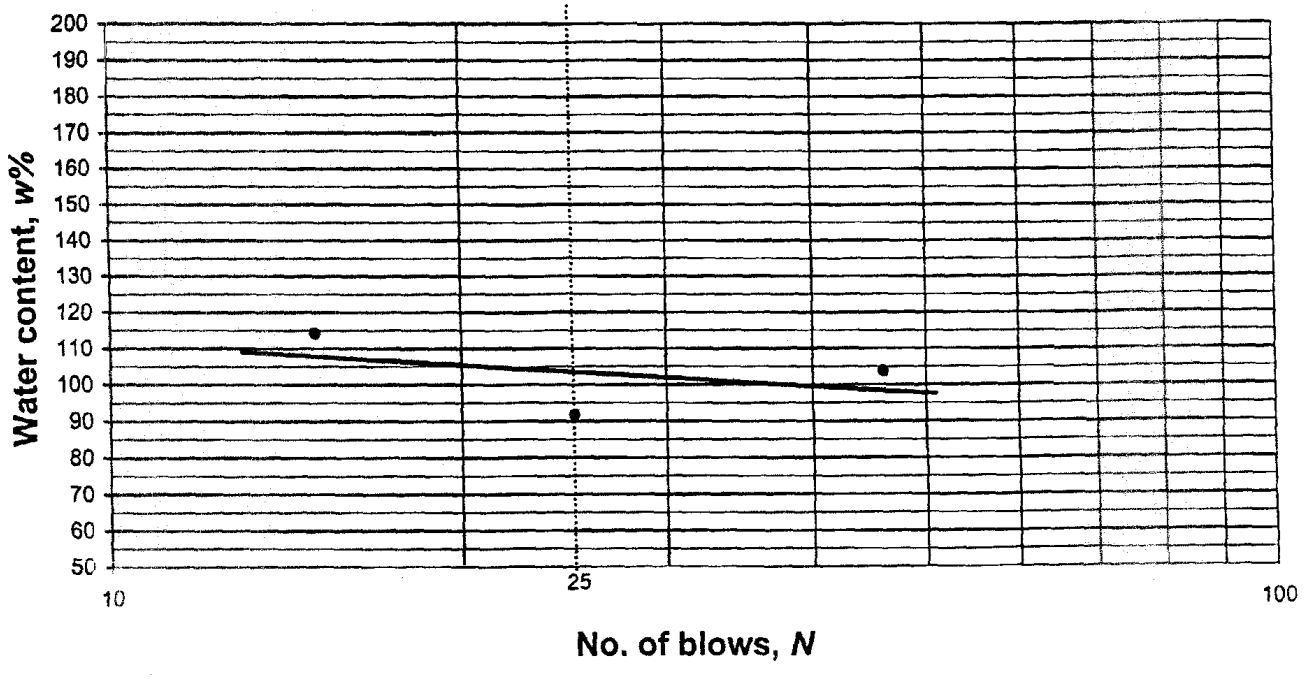
Remarks

Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	Atterberg Limits (ASTM D4318)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	RFP10-Ref#5 CAHS-1001-ABL	**Date Tested**	3/26/2002	**Tested By**	AK
						Qc By	SB

Sample Location	CWRP -West
Sample Description	Black Aged High Solids

LIQUID LIMIT DETERMINATION



Results

Liquid Limit, LL	103	**Plastic Limit, PL**	65	**Plasticity Index, PI**	38

Remarks

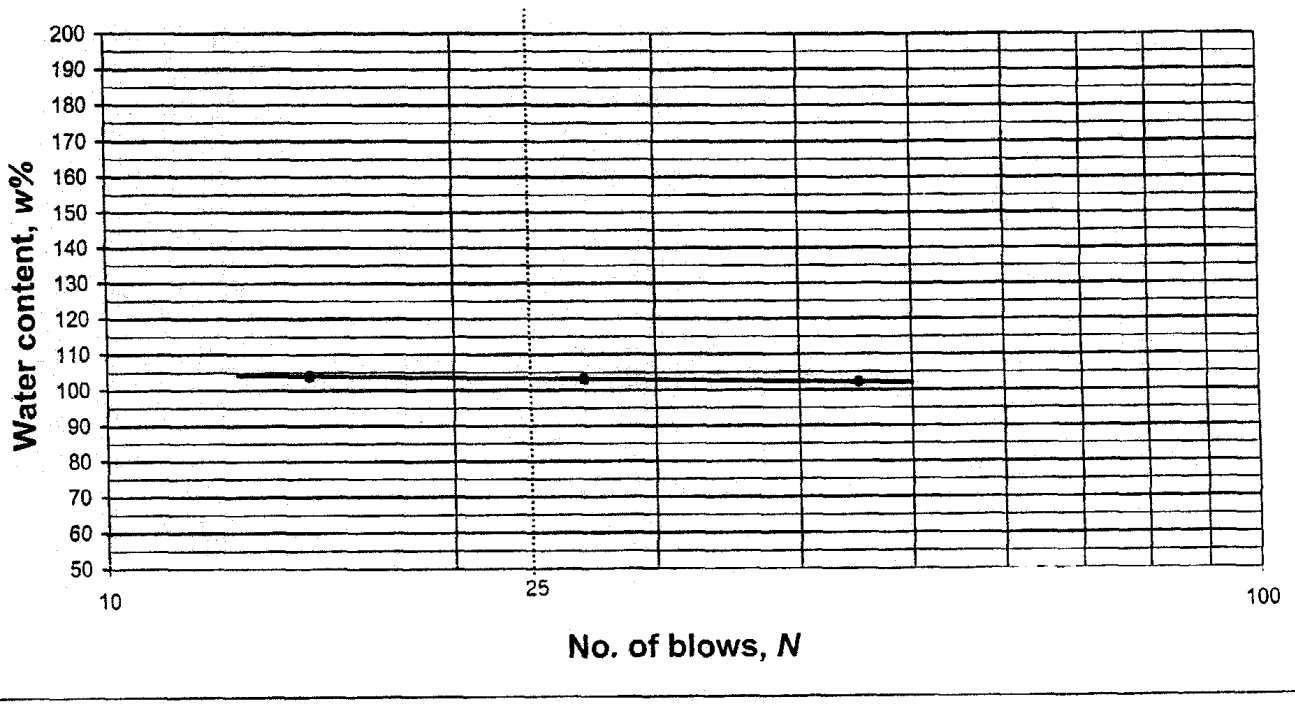
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60527 Ph: (630) 321-0944 Fax: (630) 321-0945

Atterberg Limits
(ASTM D4318)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie street, Chicago, IL 60611						
File No.	2355	**Sample #**	REF#5 RFP10-CAHS-1001	**Date Tested**	8/9/2002	**Tested By**	NP
						Qc By	SM

Sample Location	CWRP-West
Sample Description	Black Aged High Solids

LIQUID LIMIT DETERMINATION



Results

Liquid Limit, LL	103	**Plastic Limit, PL**	85	**Plasticity Index, PI**	18

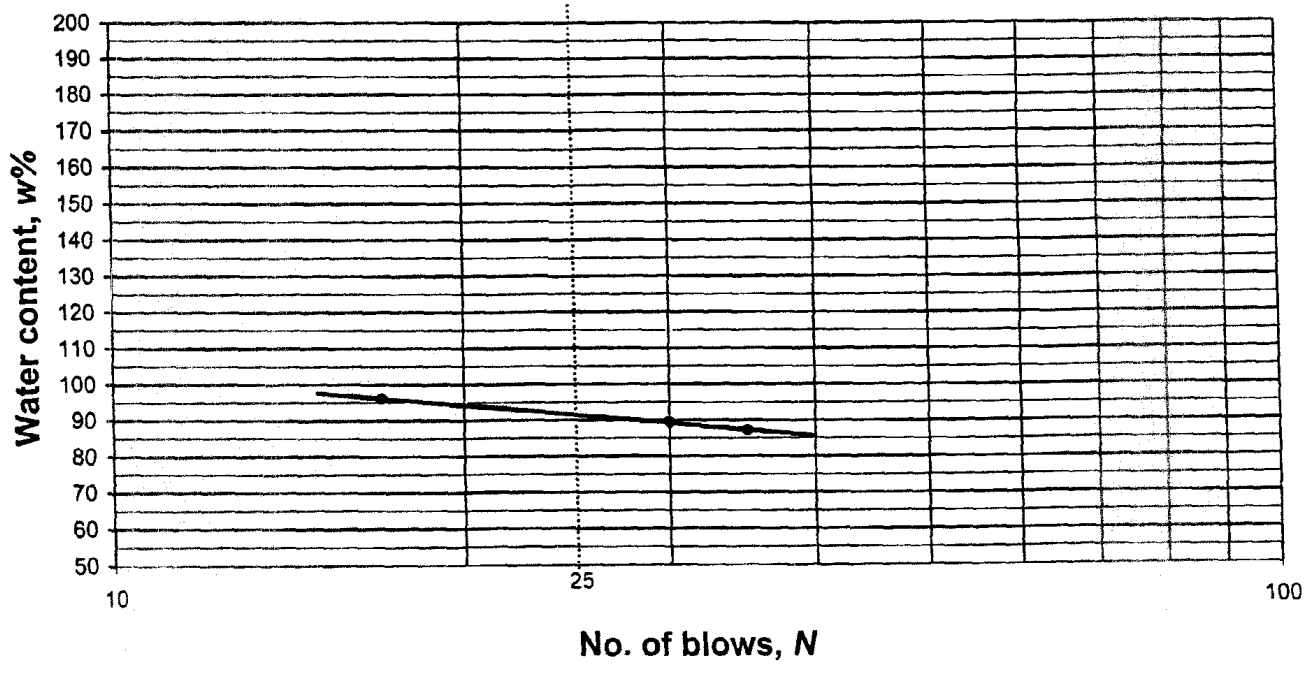
Remarks

Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	Atterberg Limits (ASTM D4318)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	RFP10-REF#6-CALS-1000-ABL	**Date Tested**	4/2/2002	**Tested By**	AK
						Qc By	SB

Sample Location	CWRP-East
Sample Description	Black Aged Low Solids

LIQUID LIMIT DETERMINATION



Results					
Liquid Limit, LL	91	**Plastic Limit, PL**	70	**Plasticity Index, PI**	21

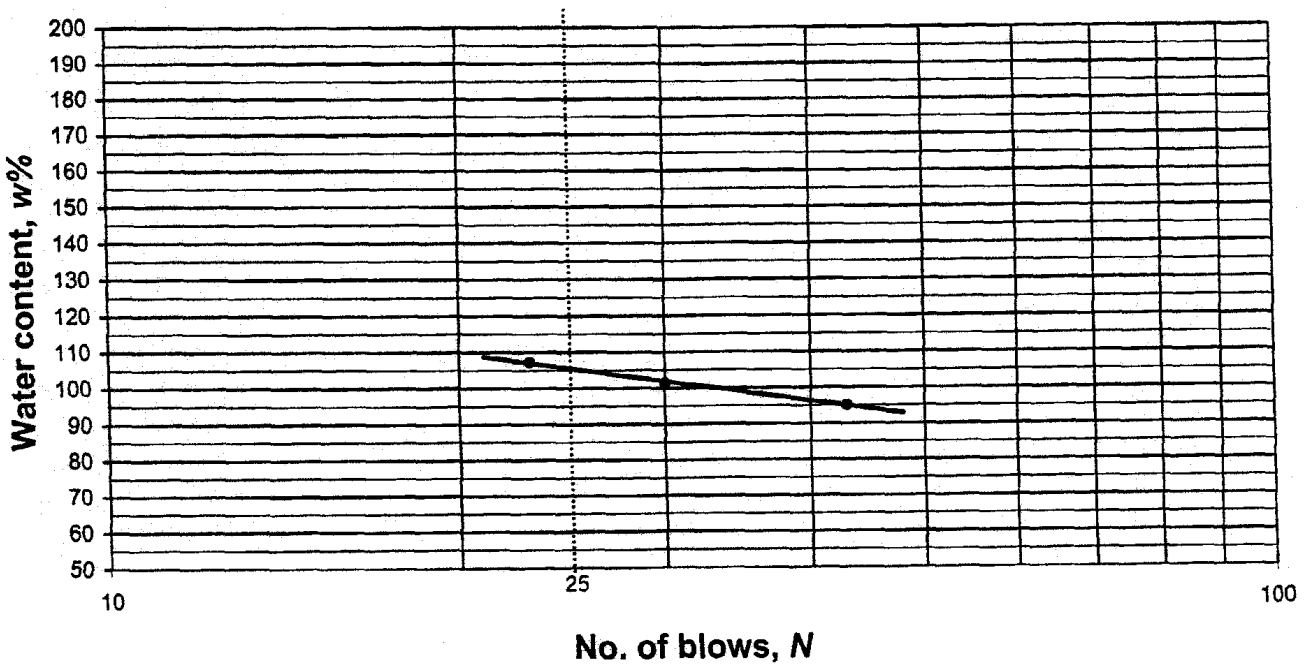
Remarks

Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	Atterberg Limits (ASTM D4318)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	REF#6 RFP10-CALS-1000	**Date Tested**	8/9/2002	**Tested By**	NP
						Qc By	SB

Sample Location	
Sample Description	Black Aged Low Solids

LIQUID LIMIT DETERMINATION



Results					
Liquid Limit, LL	105	**Plastic Limit, PL**	83	**Plasticity Index, PI**	22

Remarks

	Great Lakes Soil & Environmental Consultants, Inc. 3317 Washington St., Lansing, IL 60438. Ph: (708) 474-8860 Fax: (708) 474-7790	**SPECIFIC GRAVITY** **ASTM D 854**

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie street, Chicago, IL 60611								
File No.	2355	**Date**	3/1/02	**Report #**	1	**Tested by:**	AK	QC by:	SM

Sample Location	SWRP Lagoon 23 RASMA May/June Lift
Sample Description	Black Aged Low Solids
Sample ID	REF# 1-RFP 10-SALS-1001

	Replicate 1		Replicate 2	
Test No.	1	2	3	4
Vol. Of Flask @ 20°c	250.0	250.0	250.0	250.0
Method of air removal[1]	Vacuum	Vacuum	Vacuum	Vacuum
Mass fl.+ water+soil=M_{bws}	370.09	370.89	373.62	367.28
Temperature, °c	24.0	24.0	24.0	24.0
Mass fl.+water[2] = M_{bw}	357.32	359.35	361.0	354.6
Dish No.				
Mass dish + dry soil				
Mass of dish				
Mass of dry soil = M_s	25.00	25.00	25.00	25.00
$M_w = M_s+M_{bw}-M_{bws}$	12.23	13.46	12.38	12.32
$\alpha = \rho_t/\rho 20^0c$	0.99681	0.99681	0.99681	0.99681
$G_s = \alpha M_s/M_w$	2.038	1.851	2.013	2.023
Average Specific Gravity =	**1.94**		**2.02**	

Remarks:	M_{bw} is the mass of the flask filled with water at same temp. +/- 1°c as for M_{bws} or value from
calibration curve at T of M_{bws}	

Great Lakes Soil & Environmental Consultants, Inc.
3317 Washington St., Lansing, IL 60438. Ph: (708) 474-8860 Fax: (708) 474-7790

SPECIFIC GRAVITY
ASTM D 854

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie street, Chicago, IL 60611								
File No.	2355	**Date**	2/21/02	**Report #**	1	**Tested by:**	AK	**QC by:**	SM

Sample Location	SWRP Lagoon 24- HASMA
Sample Description	Black Aged High Solids
Sample ID	REF# 2-RFP 10-SAHS-1001

	Replicate 1		Replicate 2	
Test No.	1	2	3	4
Vol. Of Flask @ 20^0c	250.0	250.0	250.0	250.0
Method of air removal[1]	Vacuum	Vacuum	Vacuum	Vacuum
Mass fl.+ water+soil=M_{bws}	370.43	372.70	374.96	370.48
Temperature, ^{0}c	22.0	22.0	22.0	22.0
Mass fl.+water[2] = M_{bw}	357.47	359.31	361.3	357.12
Dish No.				
Mass dish + dry soil				
Mass of dish				
Mass of dry soil = M_s	25.00	25.00	25.00	25.00
$M_w = M_s+M_{bw}-M_{bws}$	12.04	11.61	11.34	11.64
$\alpha = \rho_t/\rho 20^0$c	0.99780	0.99780	0.99780	0.99780
$G_s = \alpha M_s/M_w$	2.072	2.149	2.200	2.143
Average Specific Gravity =	**2.11**		**2.17**	

Remarks:	M_{bw} is the mass of the flask filled with water at same temp. +/- 1^0c as for M_{bws} or value from
calibration curve at T of M_{bws}	

	Great Lakes Soil & Environmental Consultants, Inc. 3317 Washington St., Lansing, IL 60438. Ph: (708) 474-8860 Fax: (708) 474-7790	**SPECIFIC GRAVITY** **ASTM D 854**

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie street, Chicago, IL 60611								
File No.	2355	**Date**	2/21/02	**Report #**	1	**Tested by:**	AK	**QC by:**	SM

Sample Location	SWRP Lagoon 16- Marathon
Sample Description	Black Under-aged Low Solids
Sample ID	REF# 3-RFP 10-SULS-1001

	Replicate 1		Replicate 2	
Test No.	1	2	3	4
Vol. Of Flask @ 20^0c	250.0	250.0	250.0	250.0
Method of air removal[1]	Vacuum	Vacuum	Vacuum	Vacuum
Mass fl.+ water+soil=M_{bws}	369.47	370.13	372.70	373.06
Temperature, ^{0}c	22.0	22.0	22.0	22.0
Mass fl.+water[2] **= M_{bw}**	356.82	356.09	360.9	361.36
Dish No.				
Mass dish + dry soil				
Mass of dish				
Mass of dry soil = M_s	25.00	25.00	25.00	25.00
$M_w = M_s+M_{bw}-M_{bws}$	12.35	10.96	13.20	13.30
$\alpha = \rho_T/\rho 20^0$c	0.99780	0.99780	0.99780	0.99780
$G_s = \alpha\ M_s/M_w$	2.020	2.276	1.890	1.876
Average Specific Gravity =	**2.15**		**1.88**	

Remarks:	M_{bw} is the mass of the flask filled with water at same temp. +/- 1^0c as for M_{bws} or value from
calibration curve at T of M_{bws}	

	Great Lakes Soil & Environmental Consultants, Inc. 3317 Washington St., Lansing, IL 60438. Ph: (708) 474-8860 Fax: (708) 474-7790	**SPECIFIC GRAVITY** **ASTM D 854**

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie street, Chicago, IL 60611								
File No.	2355	**Date**	2/28/02	**Report #**	1	**Tested by:**	AK	**QC by:**	SM

Sample Location	SWRP 2001Lift-Stoney Island
Sample Description	Black Under-aged High Solids
Sample ID	REF# 4-RFP 10-SUHS-1001

	Replicate 1		Replicate 2	
Test No.	1	2	3	4
Vol. Of Flask @ 20^0c	250.0	250.0	250.0	250.0
Method of air removal[1]	Vacuum	Vacuum	Vacuum	Vacuum
Mass fl.+ water+soil=M_{bws}	369.26	373.19	366.20	372.84
Temperature, ^{0}c	22.0	22.0	22.0	22.0
Mass fl.+water[2] = M_{bw}	357.13	361.37	354.7	361.65
Dish No.				
Mass dish + dry soil				
Mass of dish				
Mass of dry soil = M_s	25.00	25.00	25.00	25.00
$M_w = M_s+M_{bw}-M_{bws}$	12.87	13.18	13.50	13.81
$\alpha = \rho_t/\rho 20^0$c	0.99780	0.99780	0.99780	0.99780
$G_s = \alpha M_s/M_w$	1.938	1.893	1.848	1.806
Average Specific Gravity =	**1.92**		**1.83**	

Remarks:	M_{bw} is the mass of the flask filled with water at same temp. +/- 1^0c as for M_{bws} or value from
calibration curve at T of M_{bws}	

	Great Lakes Soil & Environmental Consultants, Inc. 3317 Washington St., Lansing, IL 60438. Ph: (708) 474-8860 Fax: (708) 474-7790	**SPECIFIC GRAVITY** **ASTM D 854**

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie street, Chicago, IL 60611								
File No.	2355	**Date**	2/25/02	**Report #**	1	**Tested by:**	AK	**QC by:**	SM

Sample Location	CWRP- West
Sample Description	Black Aged High Solids
Sample ID	REF# 5-RFP 10-CAHS-1001

	Replicate 1		Replicate 2	
Test No.	1	2	3	4
Vol. Of Flask @ 20^0c	250.0	250.0	250.0	250.0
Method of air removal[1]	Vacuum	Vacuum	Vacuum	Vacuum
Mass fl.+ water+soil=M_{bws}	372.53	368.41	370.80	365.95
Temperature, ^{0}c	24.0	24.0	24.0	24.0
Mass fl.+water[2] **= M_{bw}**	361.36	357.18	359.3	354.8
Dish No.				
Mass dish + dry soil				
Mass of dish				
Mass of dry soil = M_s	25.00	25.00	25.00	25.00
$M_w = M_s+M_{bw}-M_{bws}$	13.83	13.77	13.50	13.85
$\alpha = \rho_t/\rho 20^0$c	0.99732	0.99732	0.99732	0.99732
$G_s = \alpha M_s/M_w$	1.803	1.811	1.847	1.800
Average Specific Gravity =	**1.81**		**1.82**	

Remarks:	M_{bw} is the mass of the flask filled with water at same temp. +/- 1^0c as for M_{bws} or value from
calibration curve at T of M_{bws}	

	Great Lakes Soil & Environmental Consultants, Inc. 3317 Washington St., Lansing, IL 60438. Ph: (708) 474-8860 Fax: (708) 474-7790	**SPECIFIC GRAVITY** **ASTM D 854**

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie street, Chicago, IL 60611								
File No.	2355	**Date**	2/28/02	**Report #**	1	**Tested by:**	AK	**QC by:**	SM

Sample Location	CWRP- East
Sample Description	Black Aged Low Solids
Sample ID	REF# 6-RFP 10-CALS-1000

	Replicate 1		Replicate 2	
Test No.	1	2	3	4
Vol. Of Flask @ 20^0c	250.0	250.0	250.0	250.0
Method of air removal[1]	Vacuum	Vacuum	Vacuum	Vacuum
Mass fl.+ water+soil=M_{bws}	369.75	366.46	373.35	371.79
Temperature, ^{0}c	24.0	24.0	24.0	24.0
Mass fl.+water[2] = M_{bw}	357.26	354.66	361.4	359.56
Dish No.				
Mass dish + dry soil				
Mass of dish				
Mass of dry soil = M_s	25.00	25.00	25.00	25.00
$M_w = M_s+M_{bw}-M_{bws}$	12.51	13.20	13.05	12.77
$\alpha = \rho_t/\rho 20^0$c	0.99732	0.99732	0.99732	0.99732
$G_s = \alpha M_s/M_w$	1.993	1.889	1.911	1.952
Average Specific Gravity =	**1.94**		**1.93**	

Remarks:	M_{bw} is the mass of the flask filled with water at same temp. +/- 1^0c as for M_{bws} or value from
calibration curve at T of M_{bws}	

Appendix B

Moisture-Density Relationship Test Results

- Standard Proctor Test
- Modified Proctor Test

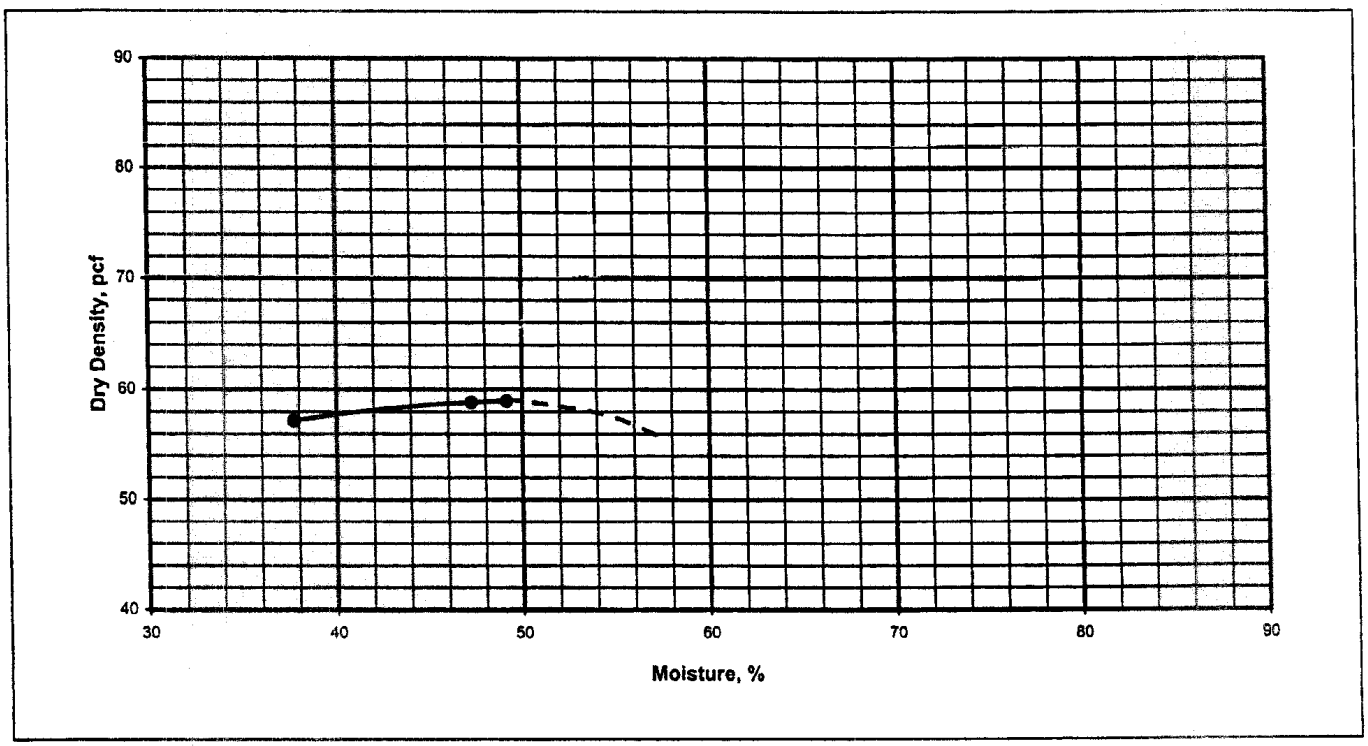
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D698-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#1-SALS-1001-STD-1	**Date Tested**	2/18/2002	**Tested By**	HS
						Qc By	SM

Sample Location	SWRP Lagoon-23 RASMA May/June Lift								
Sample Description	Black Aged Low Solids								
Type of Proctor	Standard	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	5.5	**Drop, in.**	12
No. of Layers	3	**No. of Blows per Layer**		25					



Results

Maximum Dry Density, pcf	59.0	**Optimum Moisture Content, %**	49.0	**Natural Moisture Content, %**	46.0

Remarks

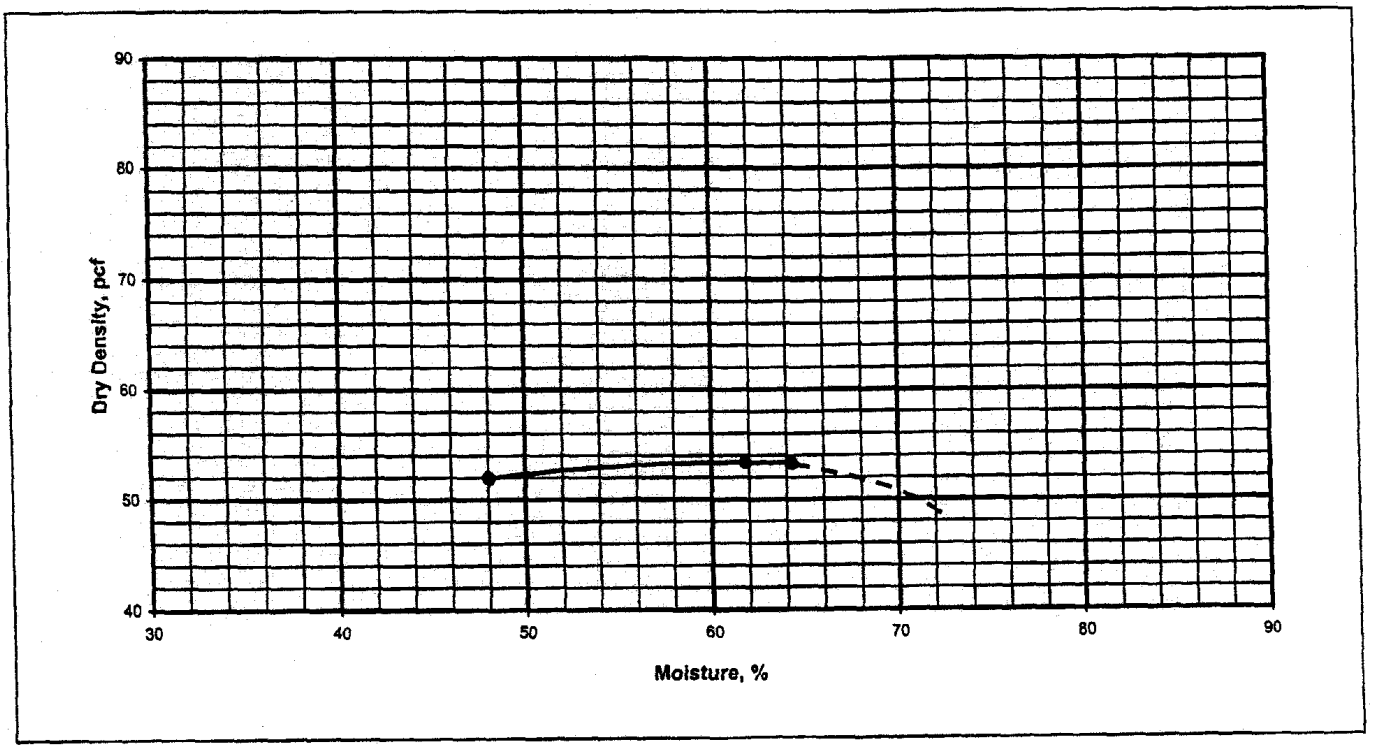
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D698-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#1-SALS-1001-STD-2	**Date Tested**	2/23/2002	**Tested By**	AK
						Qc By	SM

Sample Location	SWRP Lagoon-23 RASMA May/June Lift								
Sample Description	Black Aged Low Solids								
Type of Proctor	Standard	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	5.5	**Drop, in.**	12
No. of Layers	3	**No. of Blows per Layer**		25					



Results

Maximum Dry Density, pcf	54.0	**Optimum Moisture Content, %**	62.0	**Natural Moisture Content, %**	46.0

Remarks

Great Lakes Soil & Environmental Consultants Inc.

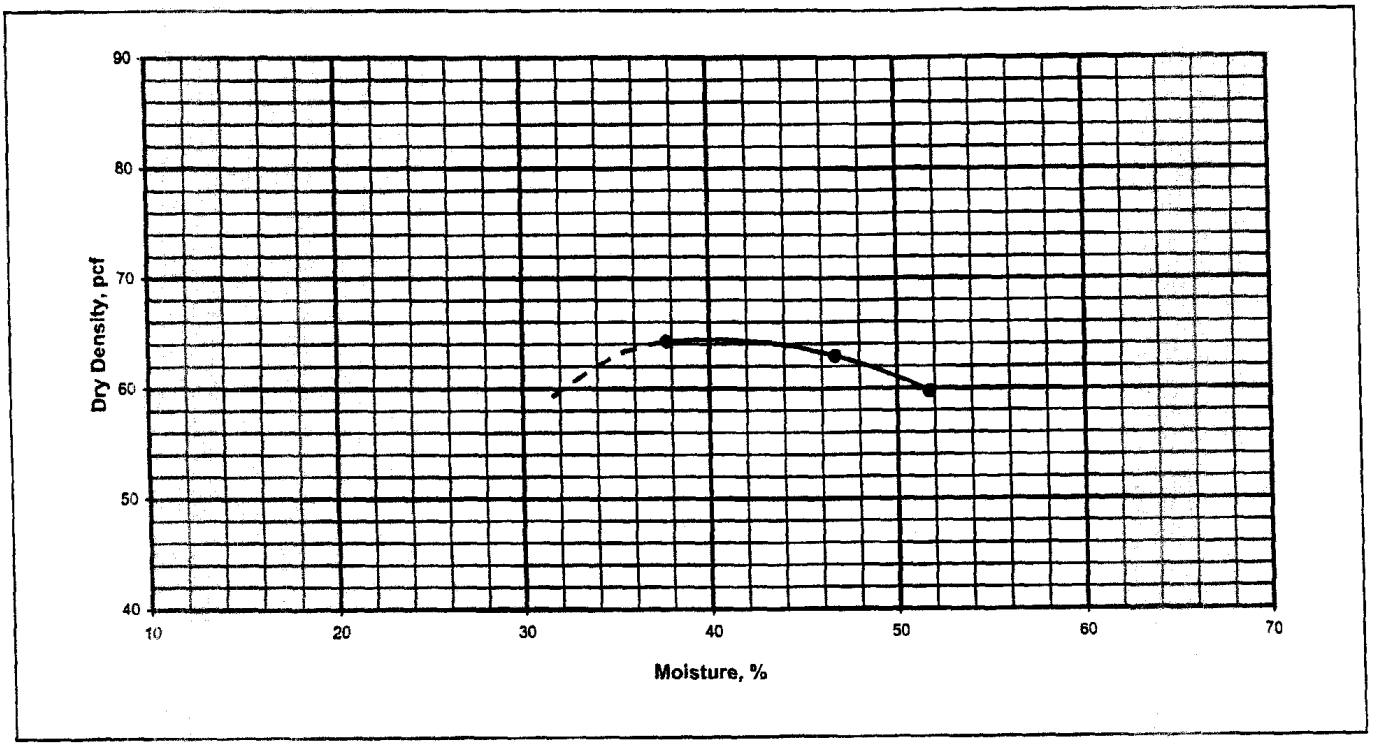
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D1557-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#1-SALS-1001-MOD-1	**Date Tested**	2/18/2002	**Tested By**	HS
						Qc By	SM

Sample Location	SWRP Lagoon-23 RASMA May/June Lift								
Sample Description	Black Aged Low Solids								
Type of Proctor	Modified	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	10	**Drop, in.**	18
No. of Layers	5	**No. of Blows per Layer**			25				



Results

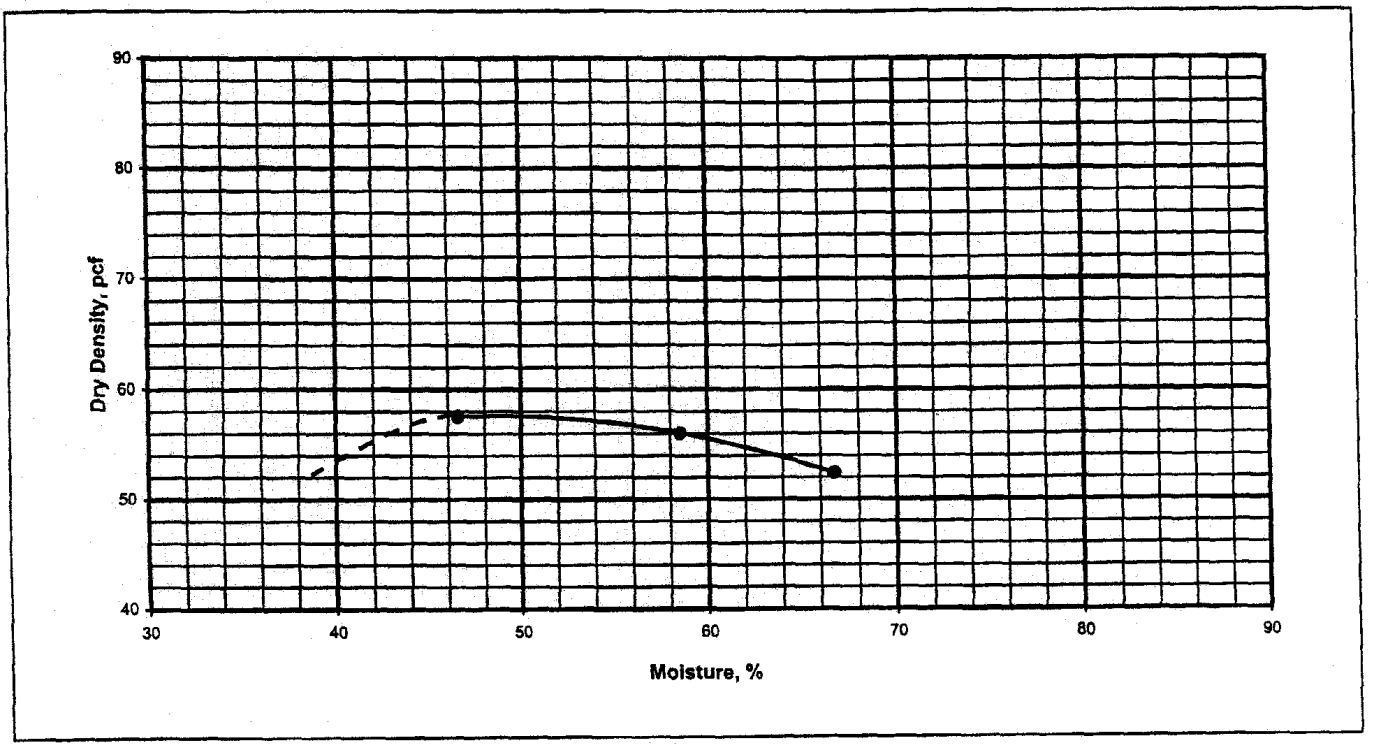
Maximum Dry Density, pcf	64.0	**Optimum Moisture Content, %**	40.0	**Natural Moisture Content, %**	46.0

Remarks

Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	MOISTURE - DENSITY RELATIONSHIP CURVE ASTM D1557-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	Sample #	Ref#1-SALS-1001-MOD-2	Date Tested	2/23/2002	Tested By	AK
						Qc By	SM

Sample Location	SWRP Lagoon-23 RASMA May/June Lift								
Sample Description	Black Aged Low Solids								
Type of Proctor	Modified	Method:	A	Mold Size, in.	4	Hammer Weight, lb.	10	Drop, in.	18
No. of Layers	5	No. of Blows per Layer		25					



Results

Maximum Dry Density, pcf	58.0	Optimum Moisture Content, %	48.0	Natural Moisture Content, %	46.0

Remarks

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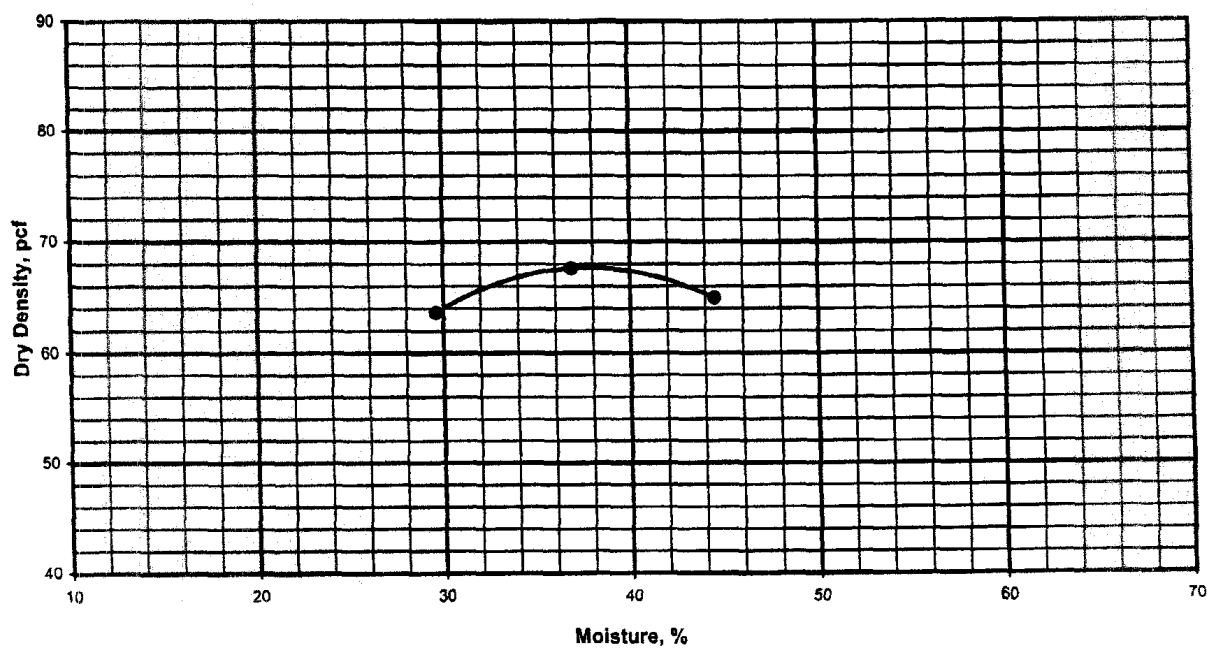
MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D698-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#2-SAHS-1001-STD-1	**Date Tested**	2/11/2002	**Tested By**	AK
						Qc By	SM

Sample Location	SWRP Lagoon-24 HASMA								
Sample Description	Black Aged High Solids								
Type of Proctor	Standard	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	5.5	**Drop, in.**	12
No. of Layers	3	**No. of Blows per Layer**			25				



Results

Maximum Dry Density, pcf	68.0	**Optimum Moisture Content, %**	37.0	**Natural Moisture Content, %**	42.0

Remarks

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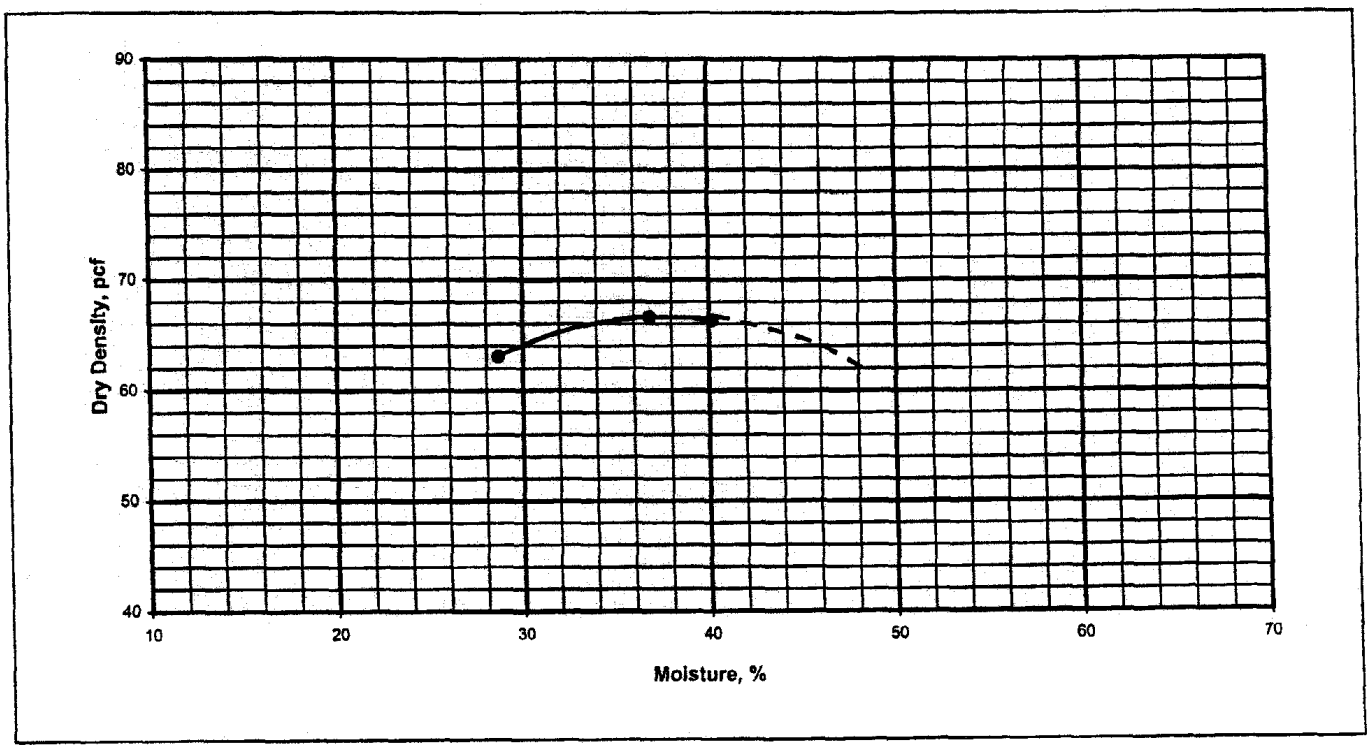
MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D698-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#2 SAHS-1001-STD-2	**Date Tested**	2/25/2002	**Tested By**	AK
						Qc By	SM

Sample Location	SWRP-Lagoon 24 HASMA								
Sample Description	Black Aged High Solids								
Type of Proctor	Standard	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	5.5	**Drop, in.**	12
No. of Layers	3	**No. of Blows per Layer**			25				



Results

Maximum Dry Density, pcf	67.0	**Optimum Moisture Content, %**	38.0	**Natural Moisture Content, %**	42.0

Remarks

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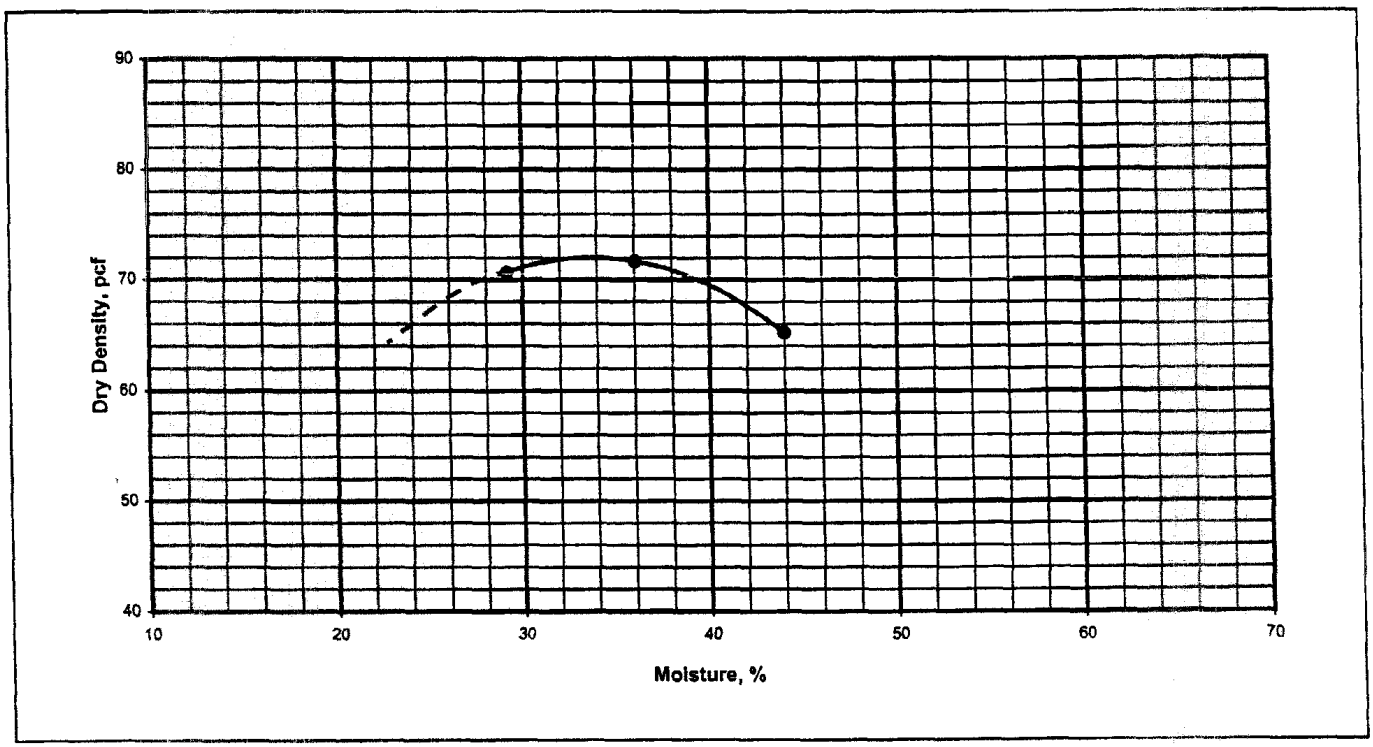
MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D1557-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#2-SAHS-1001-MOD-1	**Date Tested**	2/11/2002	**Tested By**	AK
						Qc By	SM

Sample Location	SWRP Lagoon-24 HASMA								
Sample Description	Black Aged High Solids								
Type of Proctor	Modified	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	10	**Drop, in.**	18
No. of Layers	5	**No. of Blows per Layer**		25					



Results

Maximum Dry Density, pcf	72.0	**Optimum Moisture Content, %**	34.0	**Natural Moisture Content, %**	42.0

Remarks

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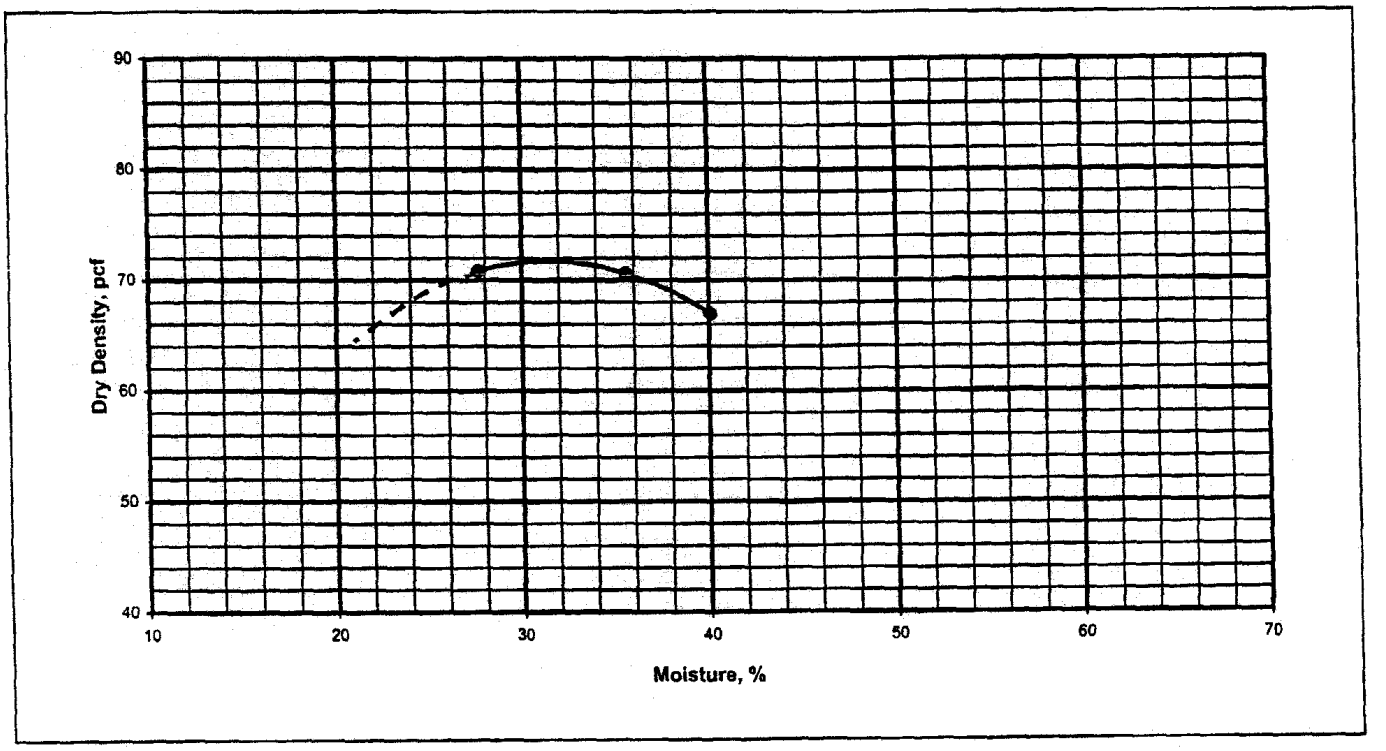
MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D1557-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#2 SAHS-1001-MOD-2	**Date Tested**	2/25/2002	**Tested By**	AK
						Qc By	SM

Sample Location	SWRP- Laggon 24 HASMA								
Sample Description	Black Aged High Solids								
Type of Proctor	Modified	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	10	**Drop, in.**	18
No. of Layers	5	**No. of Blows per Layer**			25				



Results

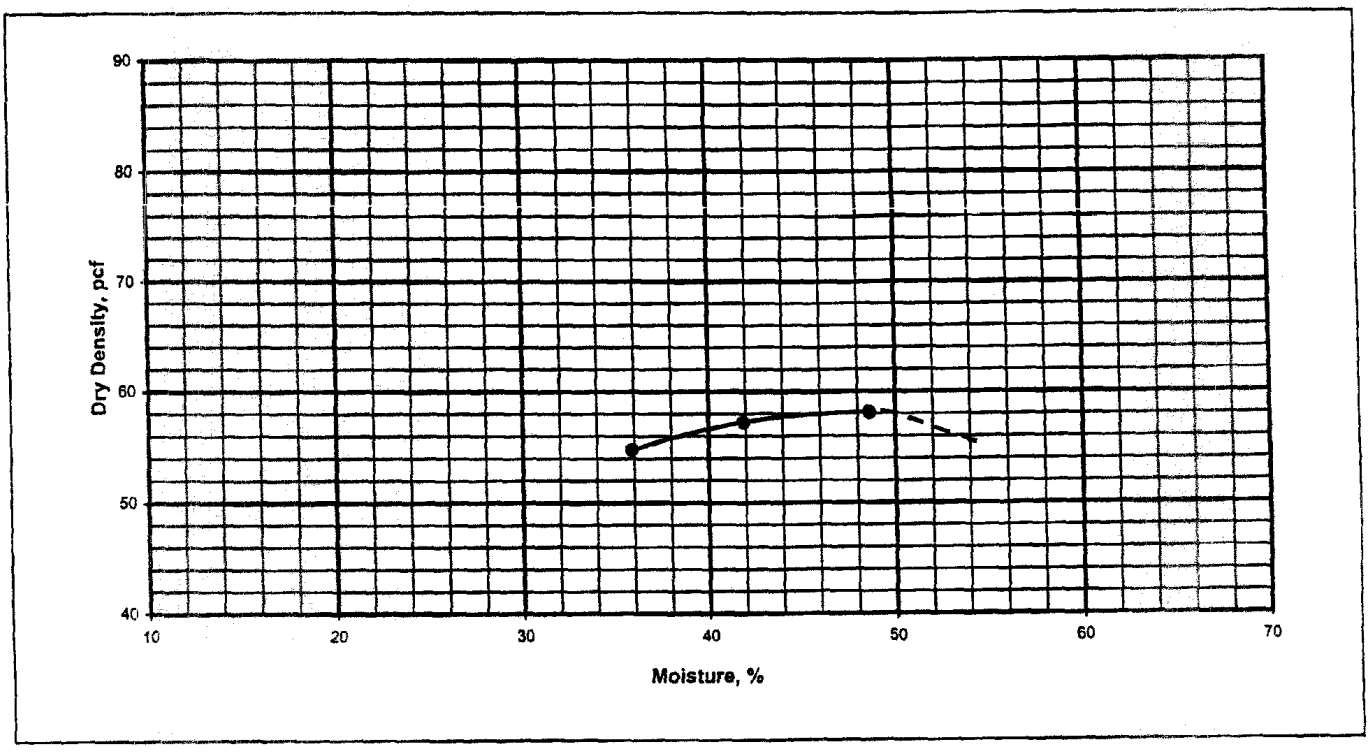
Maximum Dry Density, pcf	72.0	**Optimum Moisture Content, %**	31.0	**Natural Moisture Content, %**	42.0

Remarks

	Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	**MOISTURE - DENSITY RELATIONSHIP CURVE** **ASTM D698-91**

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#3-SULS-1001-STD-1	**Date Tested**	2/21/2002	**Tested By**	AK
						Qc By	SM

Sample Location	SWRP Lagoon-16 Marathon								
Sample Description	Black Under-aged Low Solids								
Type of Proctor	Standard	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	5.5	**Drop, in.**	12
No. of Layers	3	**No. of Blows per Layer**		25					



Results

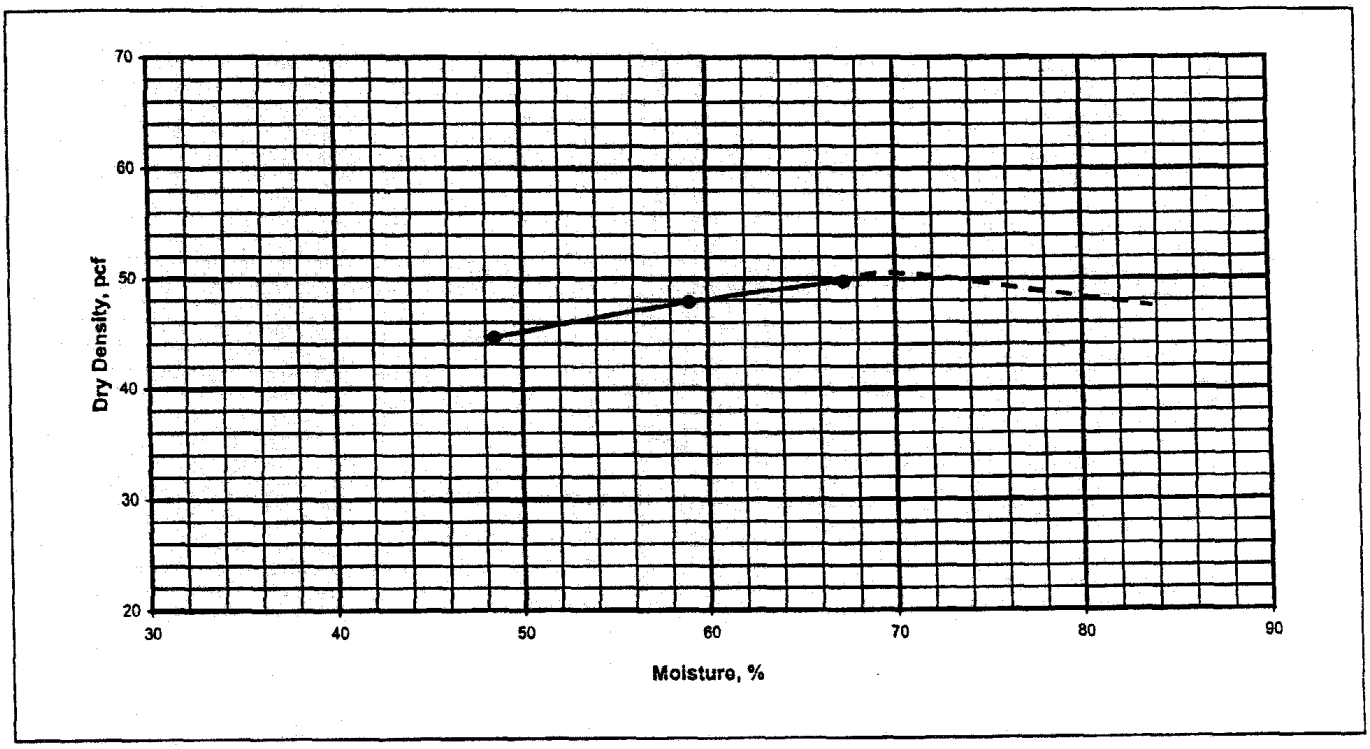
Maximum Dry Density, pcf	58.0	**Optimum Moisture Content, %**	48.0	**Natural Moisture Content, %**	65.0

Remarks

	Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	**MOISTURE - DENSITY RELATIONSHIP CURVE** **ASTM D698-91**

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#3-SULS-1001-STD-2	**Date Tested**	2/23/2002	**Tested By**	AK
						Qc By	SM

Sample Location	SWRP Lagoon-16 Marathon								
Sample Description	Black Under-aged Low Solids								
Type of Proctor	Standard	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	5.5	**Drop, in.**	12
No. of Layers	3	**No. of Blows per Layer**		25					



Results

Maximum Dry Density, pcf	50.0	**Optimum Moisture Content, %**	70.0	**Natural Moisture Content, %**	65.0

Remarks

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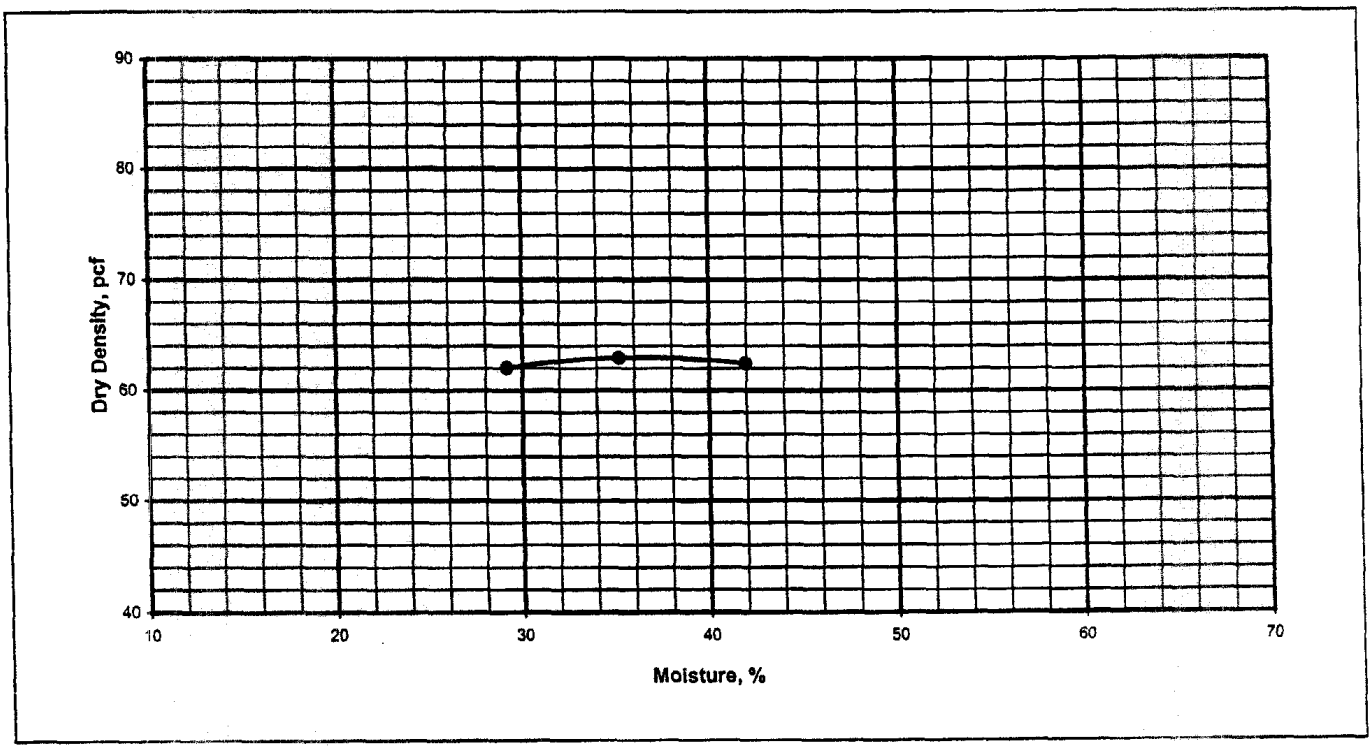
MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D1557-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#3-SULS-1001-MOD-1	**Date Tested**	2/21/2002	**Tested By**	AK
						Qc By	SM

Sample Location	SWRP Lagoon-16 Marathon								
Sample Description	Black Under-aged Low Solids								
Type of Proctor	Modified	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	10	**Drop, in.**	18
No. of Layers	5	**No. of Blows per Layer**		25					



Results

Maximum Dry Density, pcf	63.0	**Optimum Moisture Content, %**	35.0	**Natural Moisture Content, %**	65.0

Remarks

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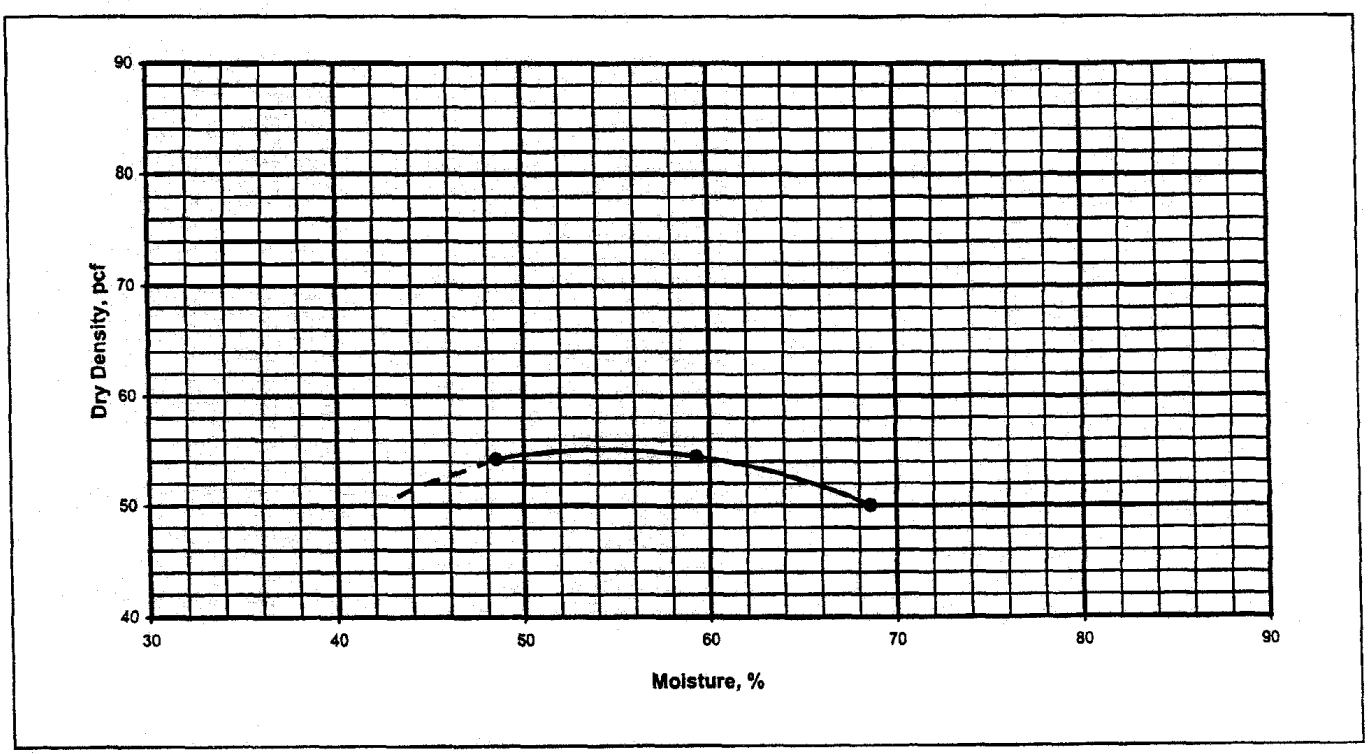
MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D1557-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#3-SULS-1001-MOD-2	**Date Tested**	2/23/2002	**Tested By**	AK
						Qc By	SM

Sample Location	SWRP Lagoon-16 Marathon								
Sample Description	Black Under-aged Low Solids								
Type of Proctor	Modified	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	10	**Drop, in.**	18
No. of Layers	5	**No. of Blows per Layer**		25					



Results

Maximum Dry Density, pcf	55.5	**Optimum Moisture Content, %**	54.0	**Natural Moisture Content, %**	65.0

Remarks

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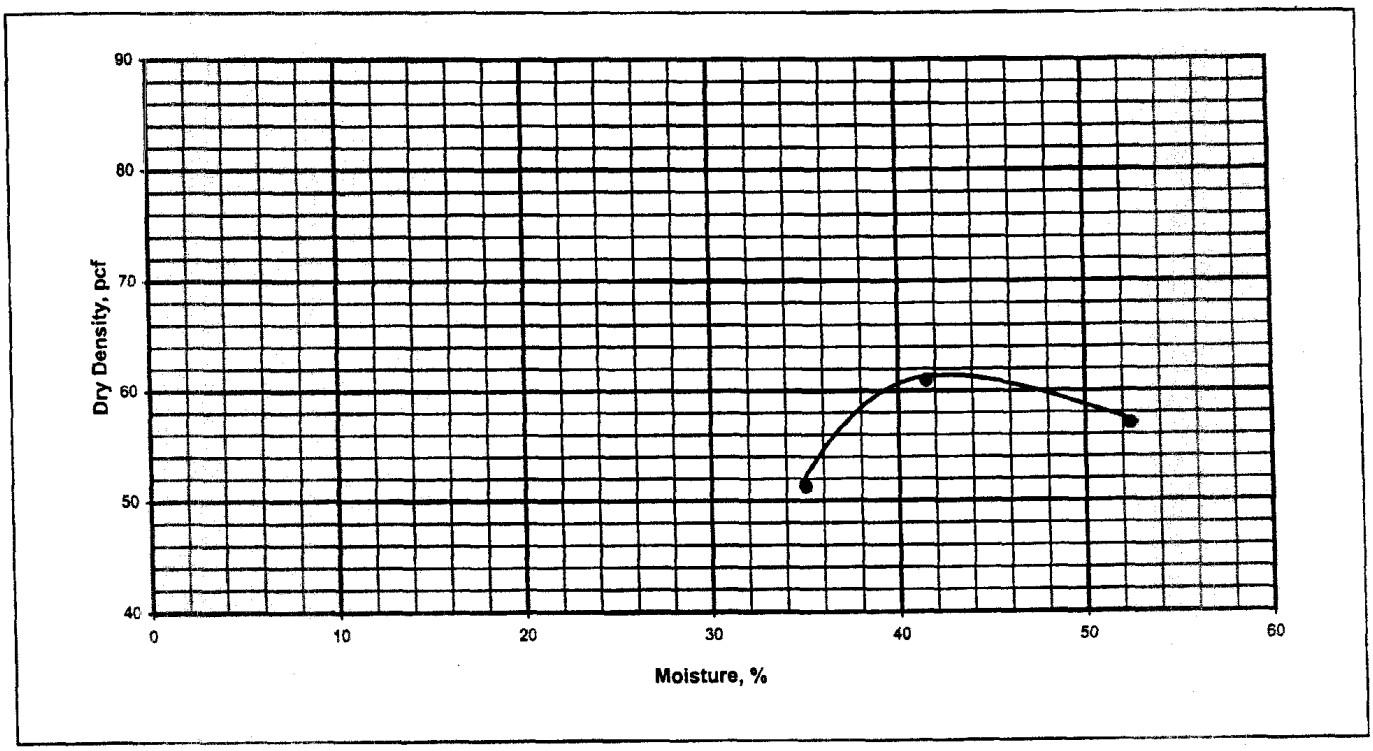
MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D698-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#4-SUHS-1001-STD-1	**Date Tested**	2/21/2002	**Tested By**	AK
						Qc By	SM

Sample Location	SWRP 2001 Lift-Stoney Island								
Sample Description	Black Under-aged High Solids								
Type of Proctor	Standard	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	5.5	**Drop, in.**	12
No. of Layers	3	**No. of Blows per Layer**		25					



Results

Maximum Dry Density, pcf	61.0	**Optimum Moisture Content, %**	42.0	**Natural Moisture Content, %**	75.0

Remarks

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive, Burr Ridge, IL 60527 Ph.: (630) 321-0944 Fax: (630) 321-0945

PERCENT FINES
ASTM D1140

Project							
Client							
File No.		Date		Sample #		Tested By	

Source of Material	
Description of Soil	

Control Sieve No.	=
Weight of empty pan, gm.	=
Weight of pan + dry sample	=
Weight of pan + dry sample after washing	=
Percent fines, %	=

Remarks	

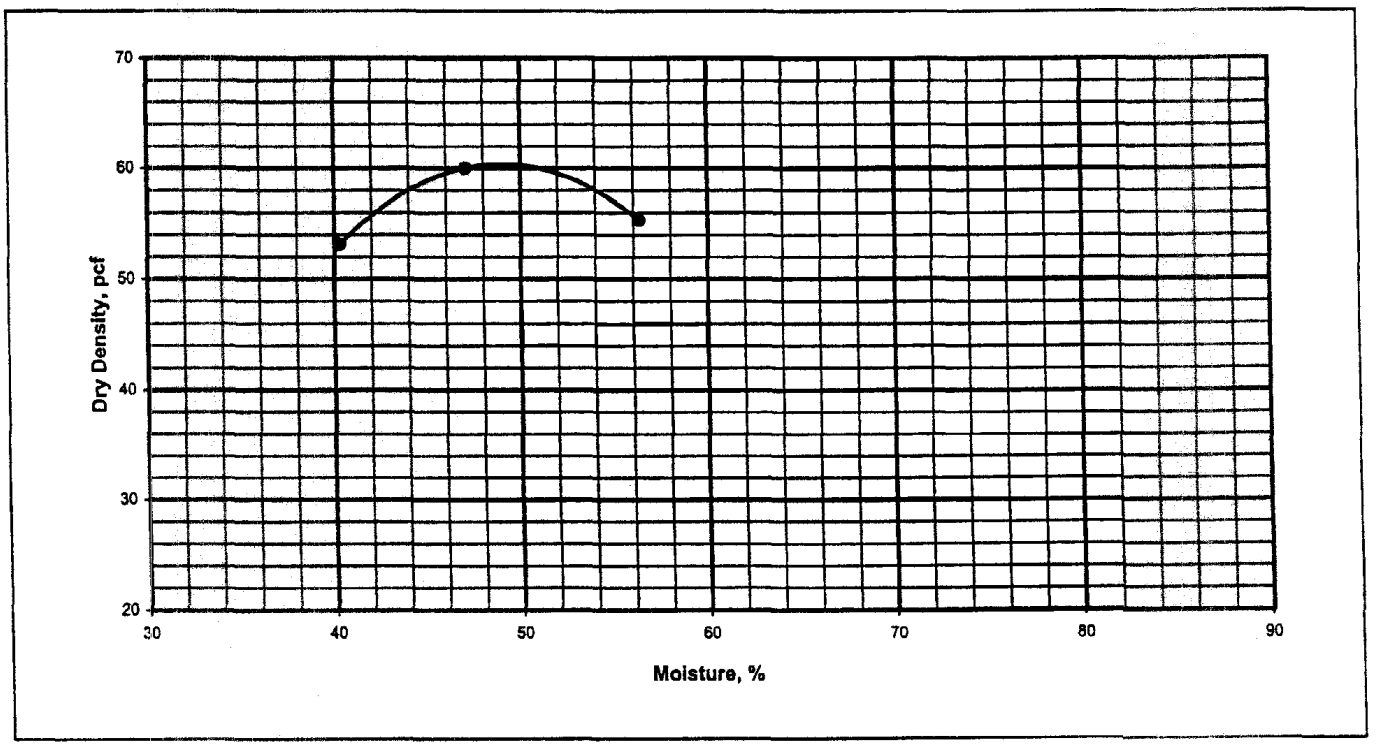
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D698-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#4 SUHS-1001-STD-2	**Date Tested**	2/26/2002	**Tested By**	AK
						Qc By	SM

Sample Location	SWRP 2001 Lift - Stony Island								
Sample Description	Black Under-aged High Solids								
Type of Proctor	Standard	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	5.5	**Drop, in.**	12
No. of Layers	3	**No. of Blows per Layer**		25					



Results

Maximum Dry Density, pcf	60.0	**Optimum Moisture Content, %**	49.0	**Natural Moisture Content, %**	75.0

Remarks

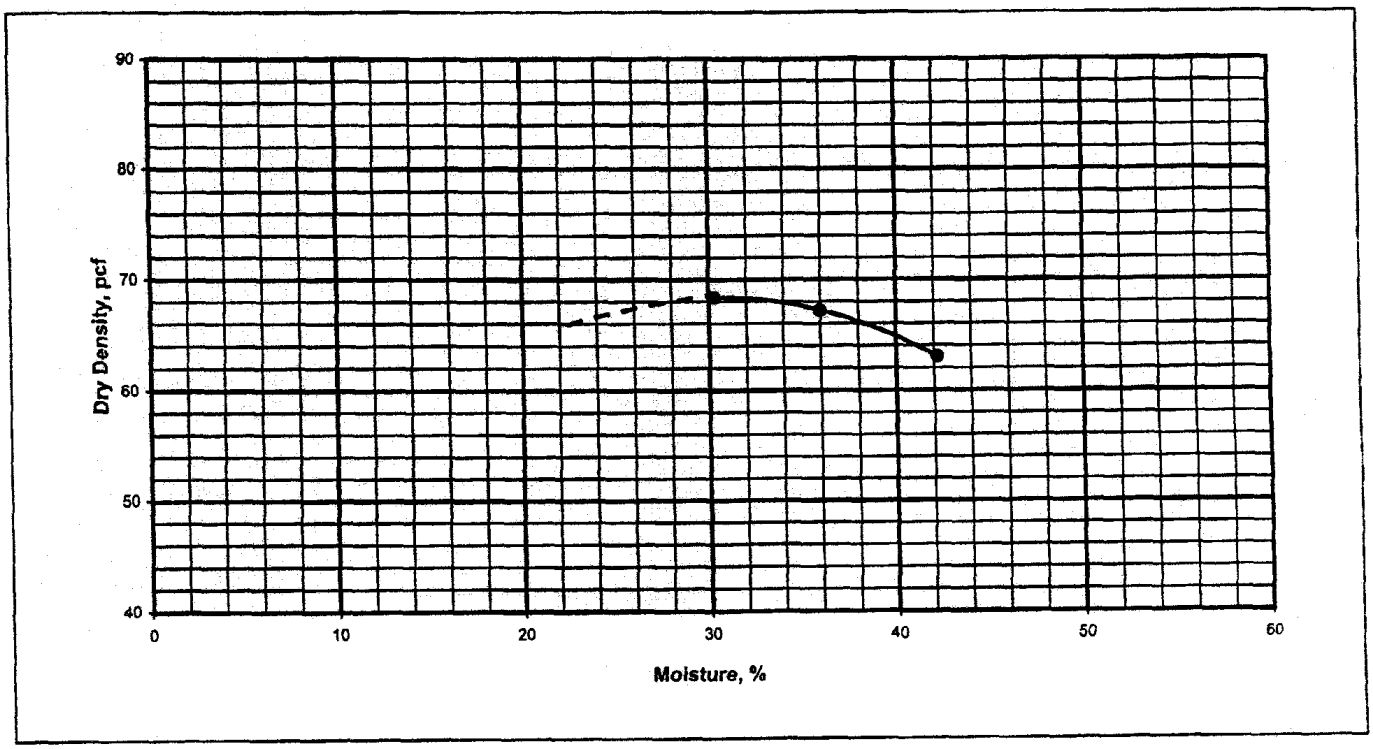
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D1557-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#4-SUHS-1001-MOD-1	**Date Tested**	2/21/2002	**Tested By**	AK
						Qc By	SM

Sample Location	SWRP 2001 Lift-Stoney Island								
Sample Description	Black Under-aged High Solids								
Type of Proctor	Modified	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	10	**Drop, in.**	18
No. of Layers	5	**No. of Blows per Layer**			25				



Results

Maximum Dry Density, pcf	68.0	**Optimum Moisture Content, %**	30.0	**Natural Moisture Content, %**	75.0

Remarks

Great Lakes Soil & Environmental Consultants Inc.
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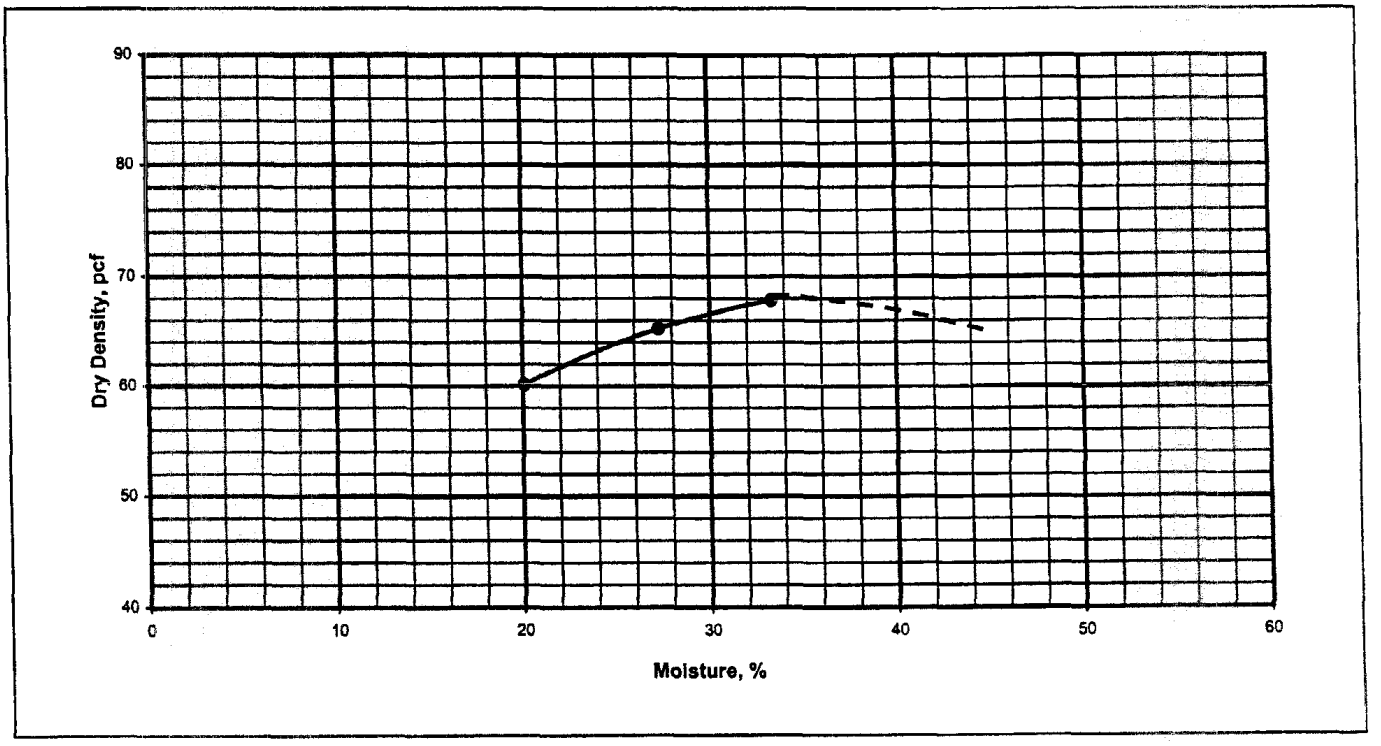
MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D1557-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#4-SUHS-1001-MOD-2	**Date Tested**	2/26/2002	**Tested By**	JM
						Qc By	SM

Sample Location	SWRP 2001 Lift - Stony Island								
Sample Description	Black Under-aged High Solids								
Type of Proctor	Modified	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	10	**Drop, in.**	18
No. of Layers	5	**No. of Blows per Layer**			25				



Results

Maximum Dry Density, pcf	68.0	**Optimum Moisture Content, %**	34.0	**Natural Moisture Content, %**	75.0

Remarks

Great Lakes Soil & Environmental Consultants Inc.
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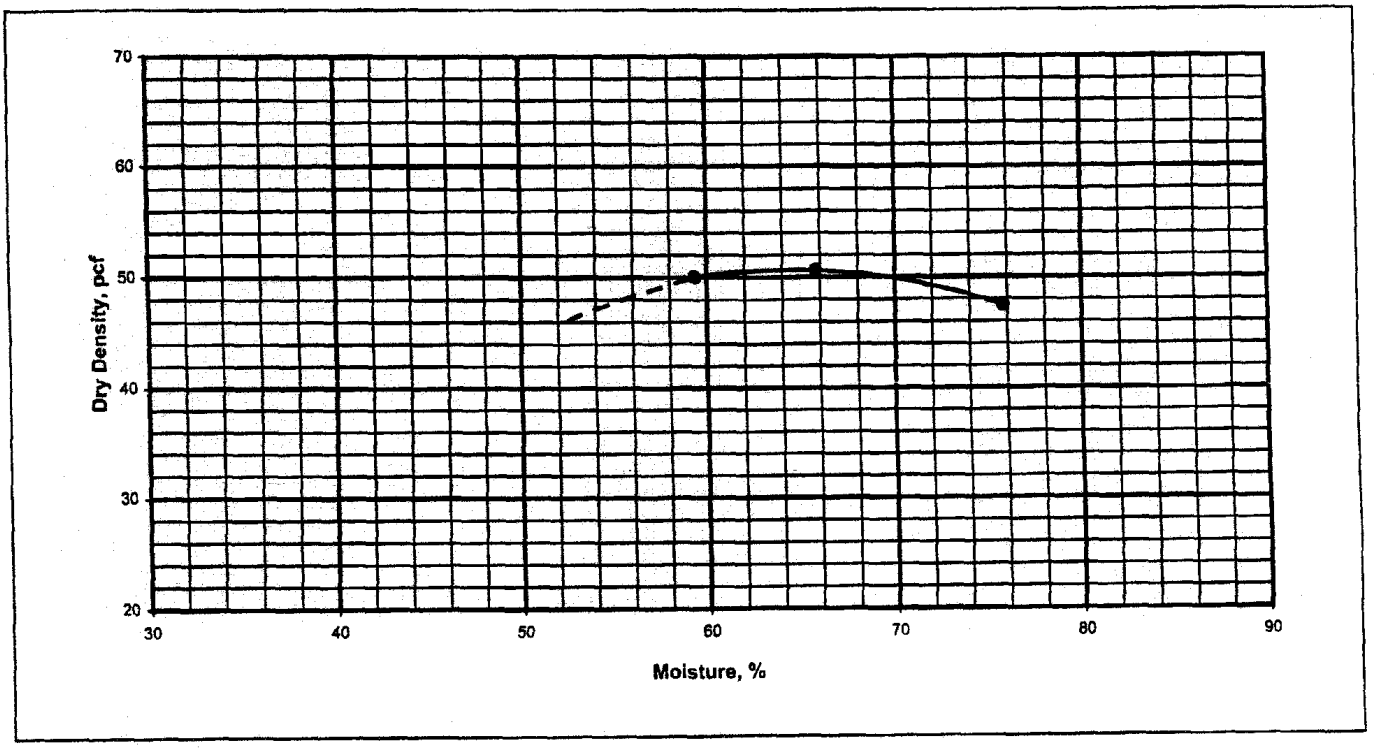
MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D698-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#5-CAHS-1001-STD-1	**Date Tested**	2/12/2002	**Tested By**	JM
						Qc By	SM

Sample Location	CWRP-West								
Sample Description	Black Aged High Solids								
Type of Proctor	Standard	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	5.5	**Drop, in.**	12
No. of Layers	3	**No. of Blows per Layer**		25					



Results

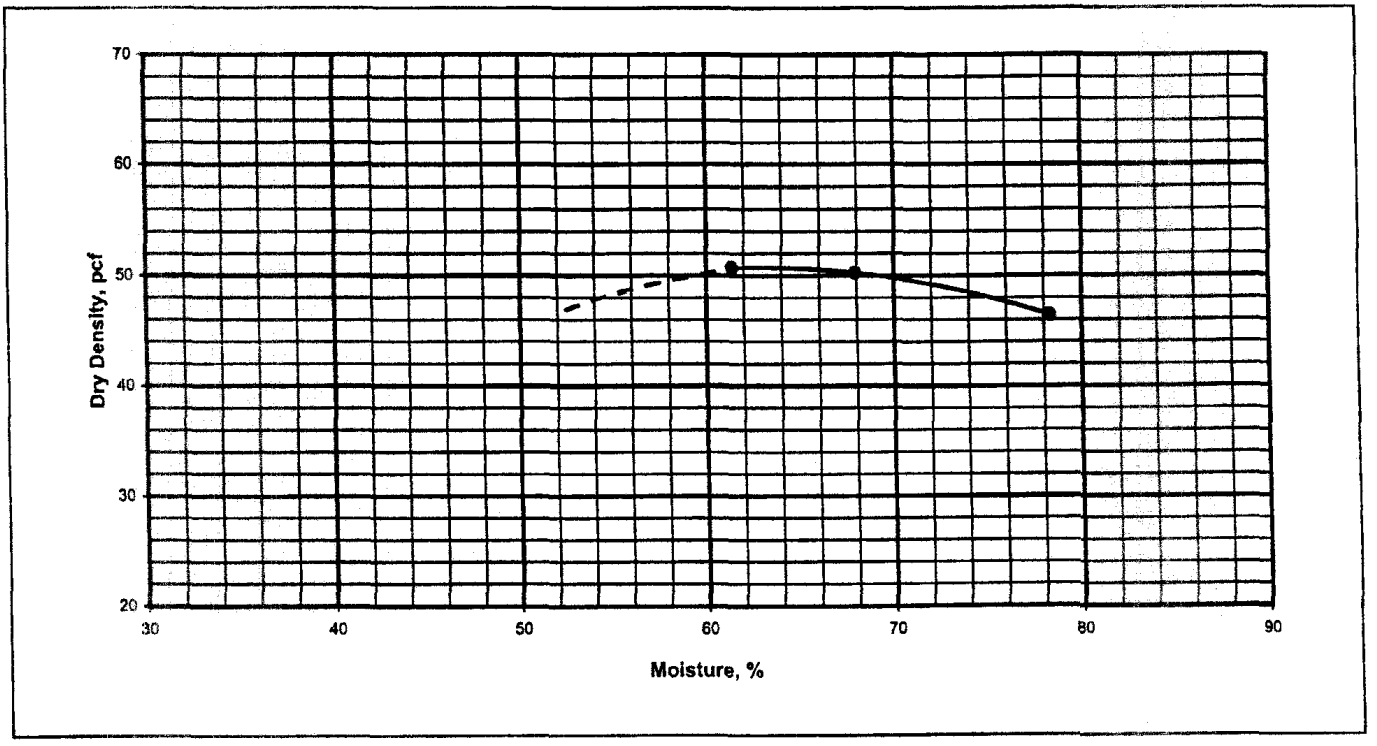
Maximum Dry Density, pcf	51.0	**Optimum Moisture Content, %**	64.0	**Natural Moisture Content, %**	50.0

Remarks

	Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	**MOISTURE - DENSITY RELATIONSHIP CURVE** **ASTM D698-91**

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#5-CAHS-1001 STD-2	**Date Tested**	2/21/2002	**Tested By**	JM
						Qc By	SM

Sample Location	CWRP-West								
Sample Description	Black Aged High Solids								
Type of Proctor	Standard	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	5.5	**Drop, in.**	12
No. of Layers	3	**No. of Blows per Layer**		25					



Results

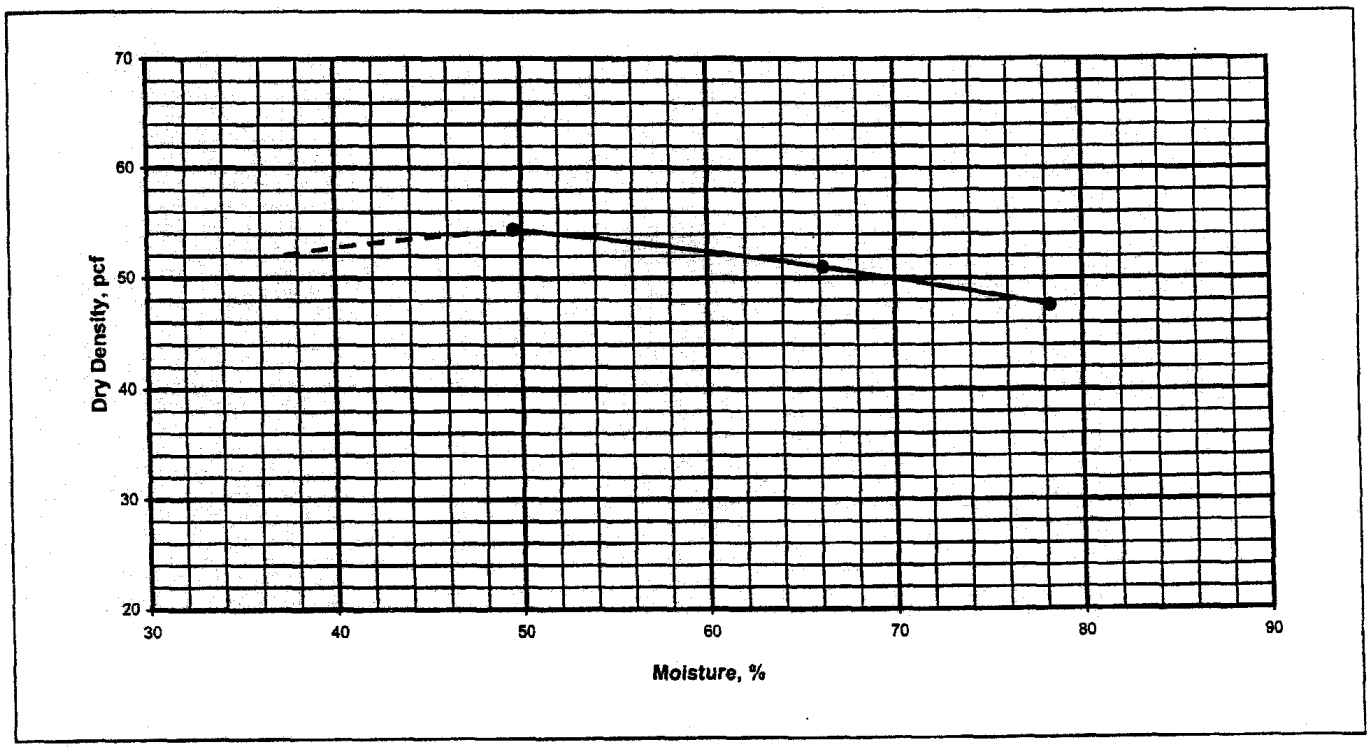
Maximum Dry Density, pcf	**50.5**	**Optimum Moisture Content, %**	**64.0**	**Natural Moisture Content, %**	**50.0**

Remarks

	Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945	**MOISTURE - DENSITY RELATIONSHIP CURVE** **ASTM D1557-91**

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#5-CAHS-1001-MOD-1	**Date Tested**	2/12/2002	**Tested By**	AK
						Qc By	SM

Sample Location	CWRP-WEST								
Sample Description	Black Aged High Solids								
Type of Proctor	Modified	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	10	**Drop, in.**	18
No. of Layers	5	**No. of Blows per Layer**		25					



Results

Maximum Dry Density, pcf	54.0	**Optimum Moisture Content, %**	50.0	**Natural Moisture Content, %**	50.0

Remarks

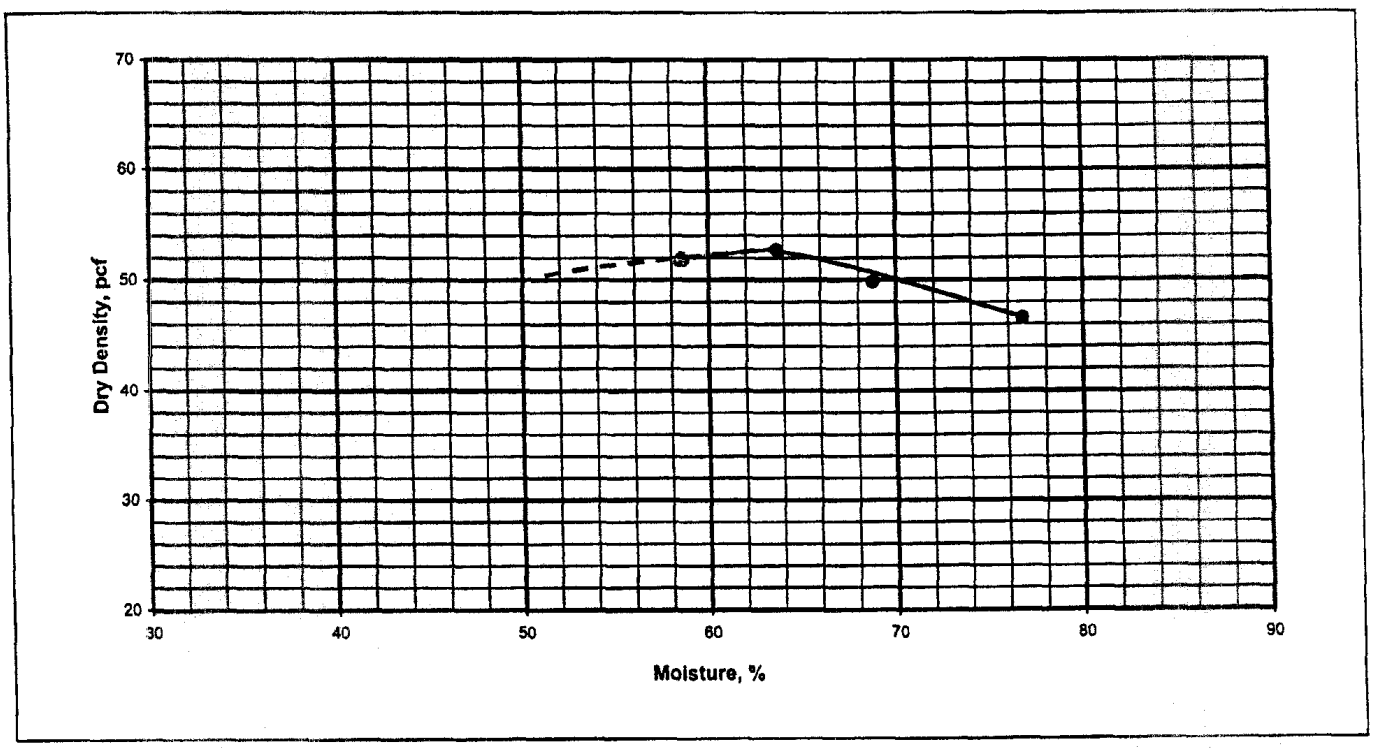
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D1557-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#5-CAHS-1001-MOD-2	**Date Tested**	2/21/2002	**Tested By**	JM
						Qc By	SM

Sample Location	CWRP WEST								
Sample Description	Black Aged High Solids								
Type of Proctor	Modified	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	10	**Drop, in.**	18
No. of Layers	5	**No. of Blows per Layer**		25					



Results

Maximum Dry Density, pcf	52.0	**Optimum Moisture Content, %**	64.0	**Natural Moisture Content, %**	50.0

Remarks

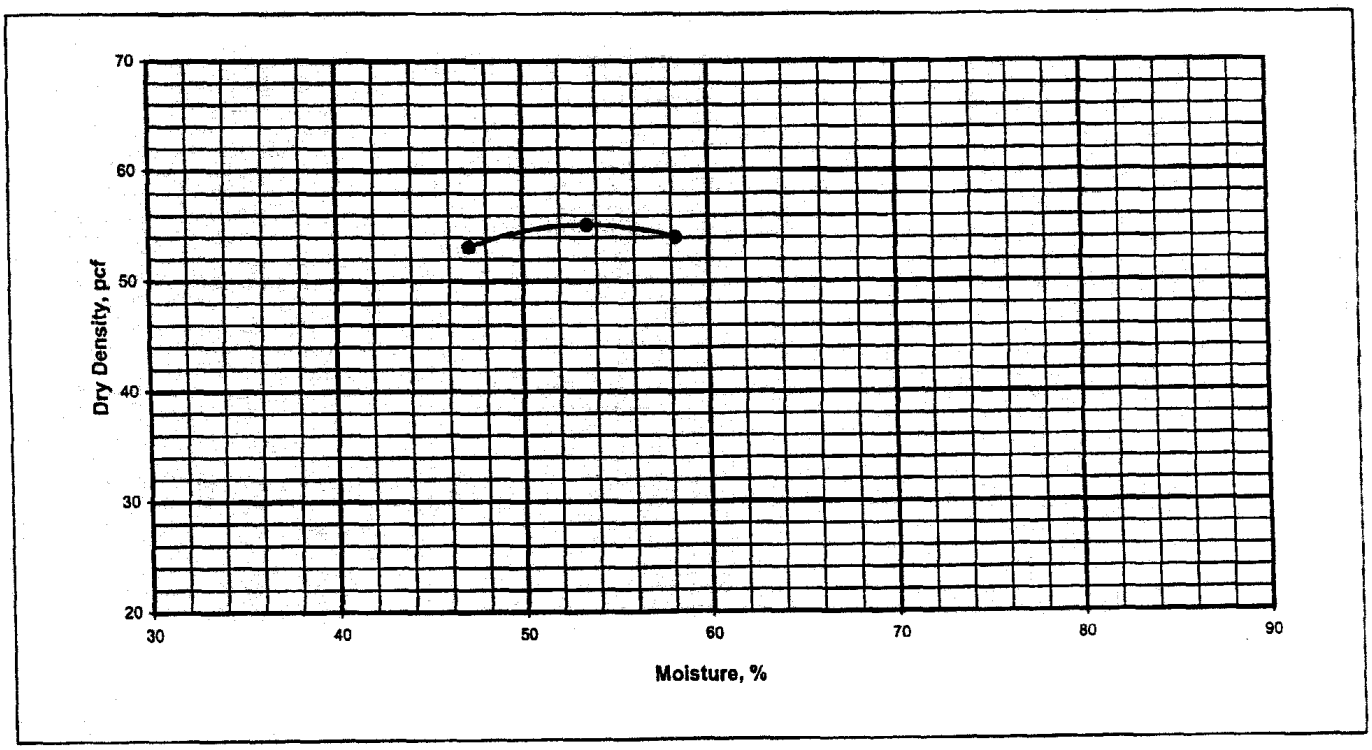
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D698-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#6-CALS-1000-STD-1	**Date Tested**	2/13/2002	**Tested By**	AK
						Qc By	SM

Sample Location	CWRP-EAST								
Sample Description	Black Aged Low Solids								
Type of Proctor	Standard	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	5.5	**Drop, in.**	12
No. of Layers	3	**No. of Blows per Layer**			25				



Results

Maximum Dry Density, pcf	55.0	**Optimum Moisture Content, %**	53.0	**Natural Moisture Content, %**	55.0

Remarks

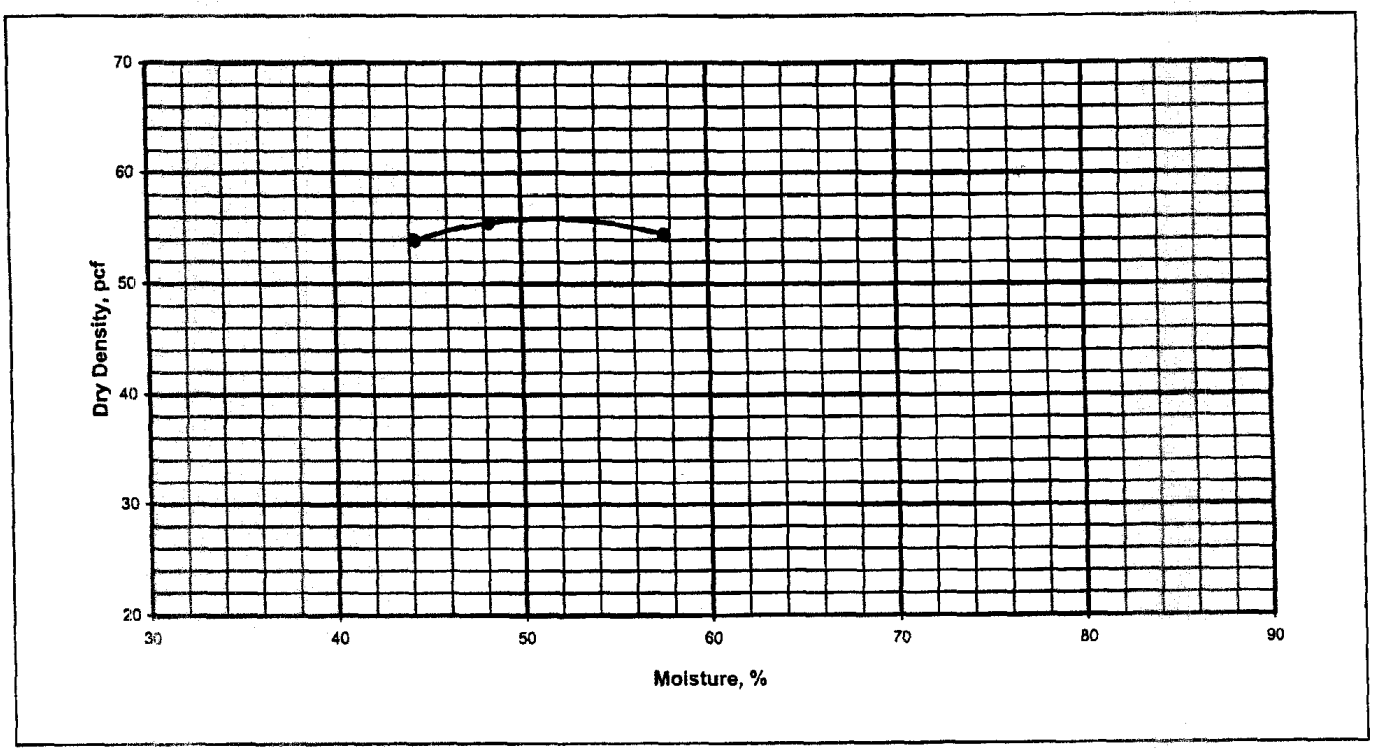
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D698-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#6-CALS-1000-STD-2	**Date Tested**	2/25/2002	**Tested By**	AK
						Qc By	SM

Sample Location	CWRP- East								
Sample Description	Black Aged Low Solids								
Type of Proctor	Standard	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	5.5	**Drop, in.**	12
No. of Layers	3	**No. of Blows per Layer**			25				



Results

Maximum Dry Density, pcf	56.0	**Optimum Moisture Content, %**	51.0	**Natural Moisture Content, %**	55.0

Remarks

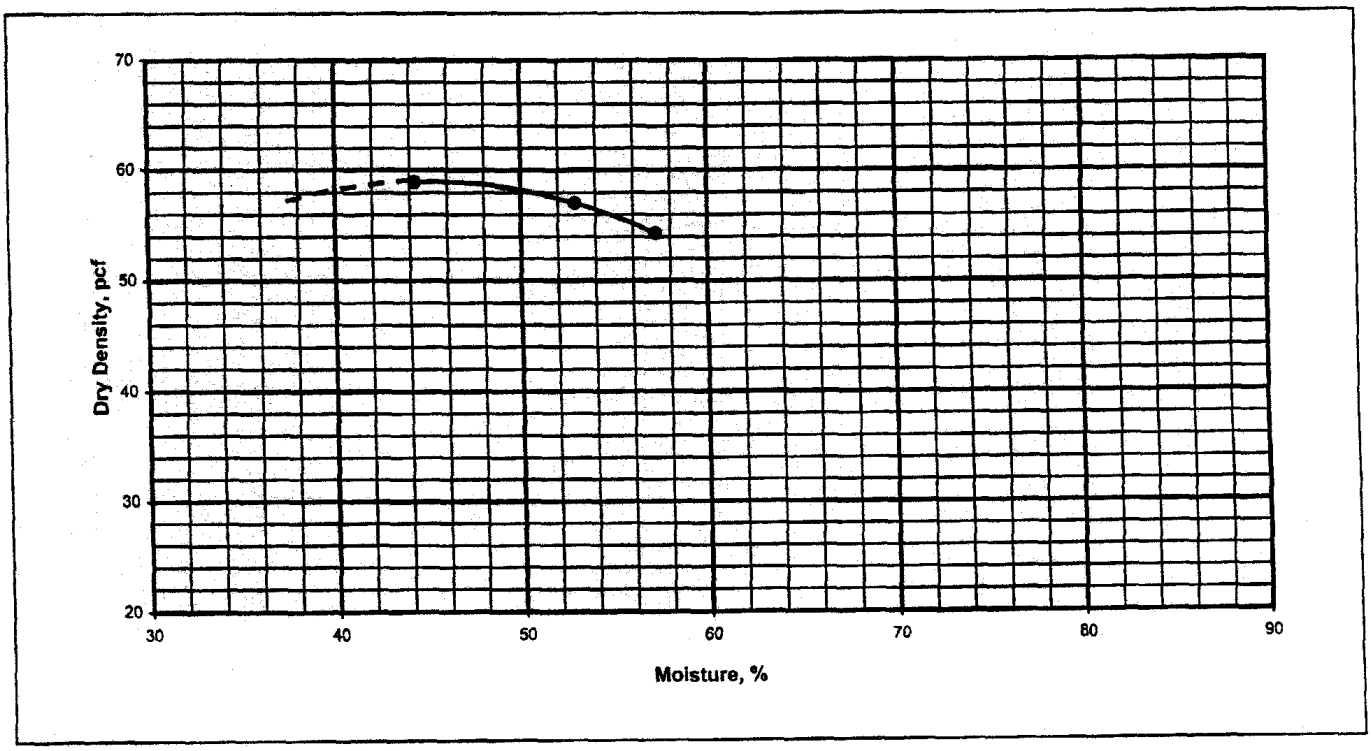
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D1557-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	Ref#6CALS-1000-MOD-1	**Date Tested**	2/13/2002	**Tested By**	AK
						Qc By	SM

Sample Location	CWRP-East								
Sample Description	Black Aged Low Solids								
Type of Proctor	Modified	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	10	**Drop, in.**	18
No. of Layers	5	**No. of Blows per Layer**		25					



Results

Maximum Dry Density, pcf	59.0	**Optimum Moisture Content, %**	45.0	**Natural Moisture Content, %**	55.0

Remarks

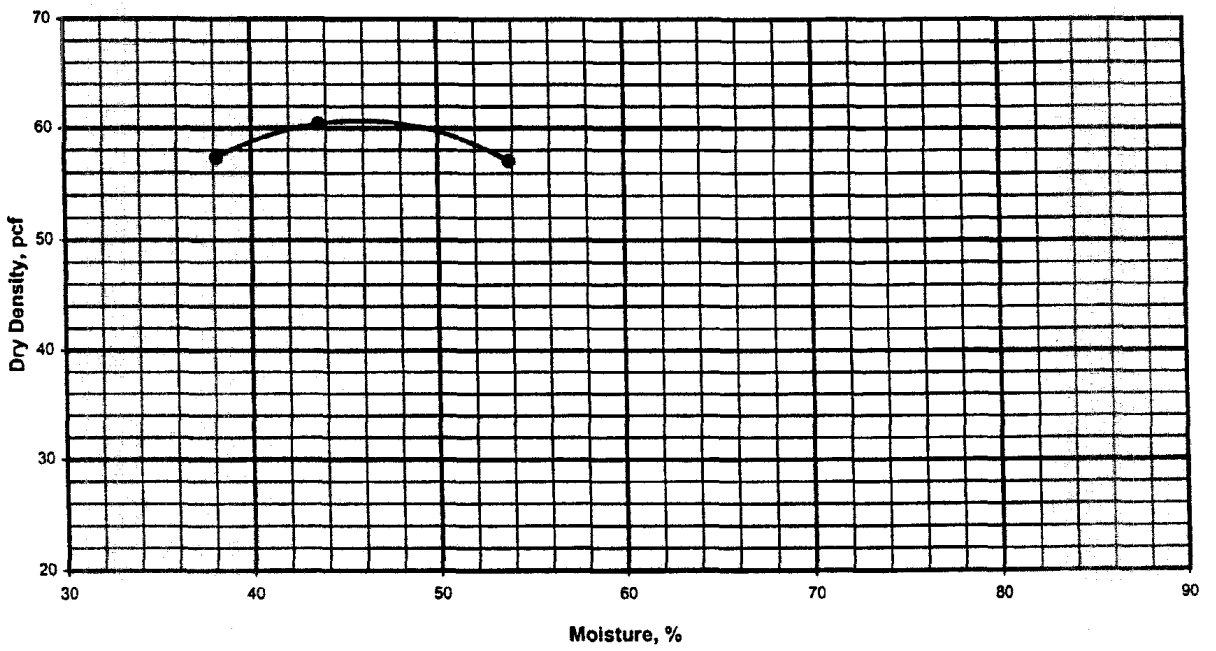
Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521 Ph: (630) 321-0944 Fax: (630) 321-0945

MOISTURE - DENSITY RELATIONSHIP CURVE

ASTM D1557-91

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	**Sample #**	REF# 6 CALS-MOD2	**Date Tested**	2/26/2002	**Tested By**	JM
						Qc By	SM

Sample Location	CWRP-EAST								
Sample Description	Black Aged Low Solids								
Type of Proctor	Modified	**Method:**	A	**Mold Size, in.**	4	**Hammer Weight, lb.**	10	**Drop, in.**	18
No. of Layers	5	**No. of Blows per Layer**		25					



Results

Maximum Dry Density, pcf	61.0	**Optimum Moisture Content, %**	45.0	**Natural Moisture Content, %**	55.0

Remarks

Appendix C

Consolidation Test Results

Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521; Ph: (630)321-0944; Fax: (630)321-0945

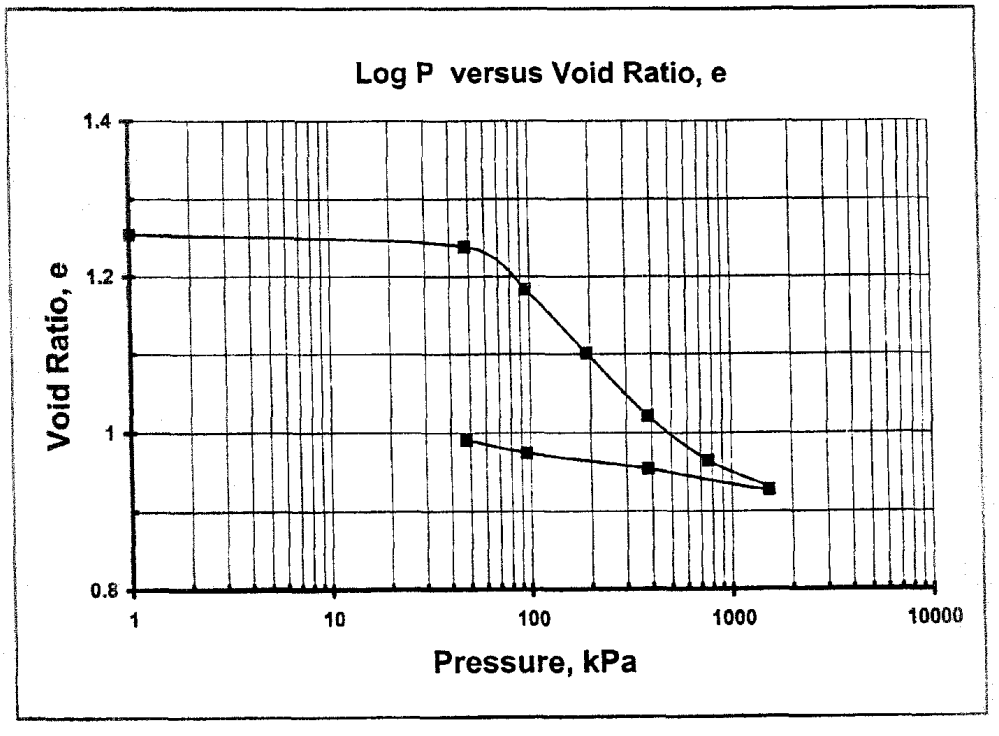
CONSOLIDATION TEST ASTM D2435

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie Street, Chicago, IL 60611								
File No.	2355	Date	5/6/2002	Sample #	SALS	Tested By	PA	Checked By	SB

Source of Material	Stickney WRP	Atterberg Limits	LL%	PL%	PI
Description of Soil	Black Aged Low Solids		102	73	29

Specimen Data and Test Results

Initial Moisture Content, %	55.00	Final Moisture Content, %	53.29
Initial Dry Unit Weight, pcf	54.79	Final Dry Unit Weight, pcf	57.68
Initial Void Ratio, e	1.25	Final Void Ratio, e	0.99
Initial Degree of Saturation, %	86.79	Final Degree of Saturation, %	94.89



Remarks	

Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521; Ph: (630)321-0944; Fax: (630)321-0945

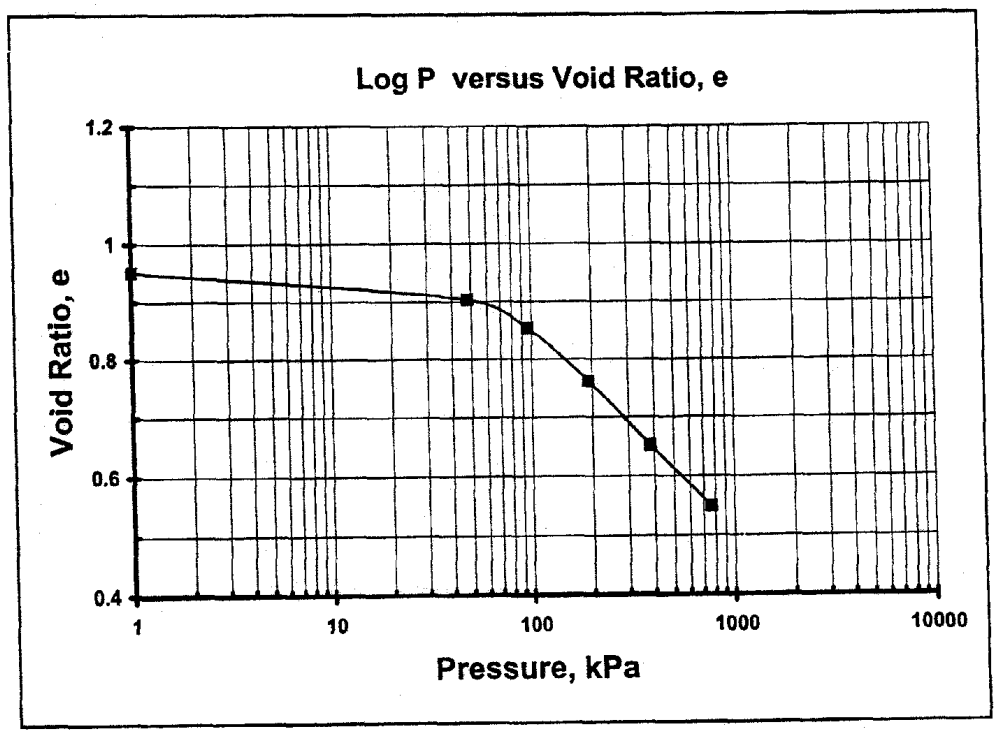
CONSOLIDATION TEST ASTM D2435

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie Street, Chicago, IL 60611								
File No.	2355	**Date**	4/12/2002	Sample #	SAHS	Tested By	PA	Checked By	SB

Source of Material	Stickney WRP	Atterberg Limits	LL%	PL%	PI
Description of Soil	Black Aged High Solids		95	60	35

Specimen Data and Test Results

Initial Moisture Content, %	33.00	Final Moisture Content, %	37.96
Initial Dry Unit Weight, pcf	68.43	Final Dry Unit Weight, pcf	77.79
Initial Void Ratio, e	0.95	Final Void Ratio, e	0.55
Initial Degree of Saturation, %	74.22	Final Degree of Saturation, %	133.42



Remarks	

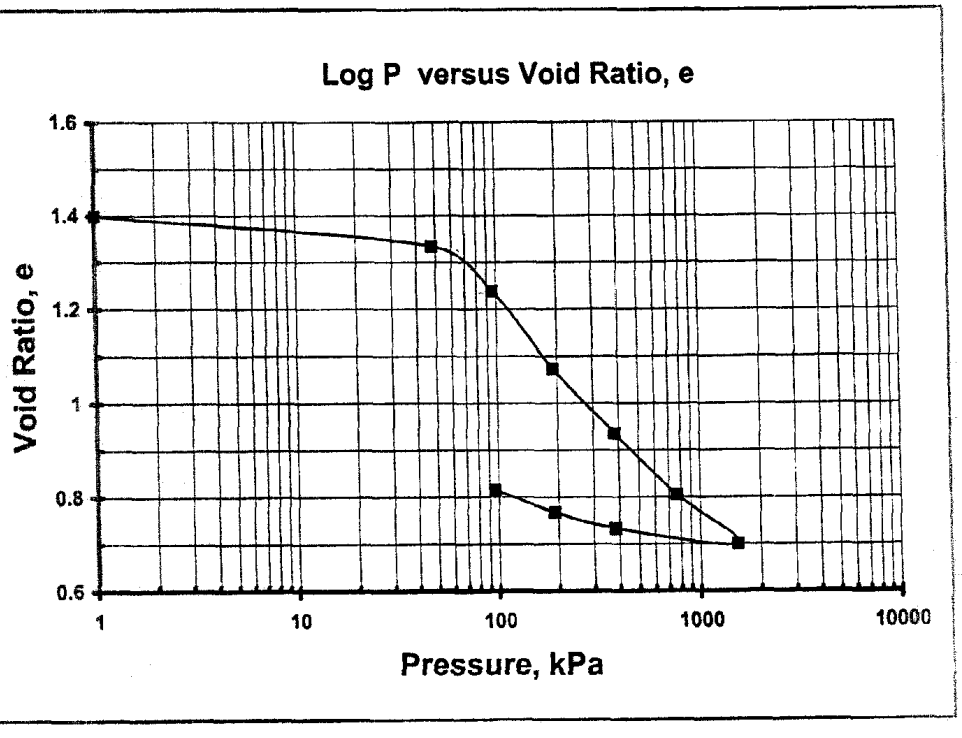
	Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521; Ph: (630)321-0944; Fax: (630)321-0945	**CONSOLIDATION TEST ASTM D2435**

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie Street, Chicago, IL 60611								
File No.	2355	Date	5/6/2002	Sample #	SULS	Tested By	PA	Checked By	SB

Source of Material	Stickney WRP	Atterberg Limits	LL%	PL%	PI
Description of Soil	Black Under-Aged Low Solids		99	74	25

Specimen Data and Test Results

Initial Moisture Content, %	60.00	Final Moisture Content, %	50.55
Initial Dry Unit Weight, pcf	52.28	Final Dry Unit Weight, pcf	68.76
Initial Void Ratio, e	1.40	Final Void Ratio, e	0.82
Initial Degree of Saturation, %	86.19	Final Degree of Saturation, %	123.98



Remarks	

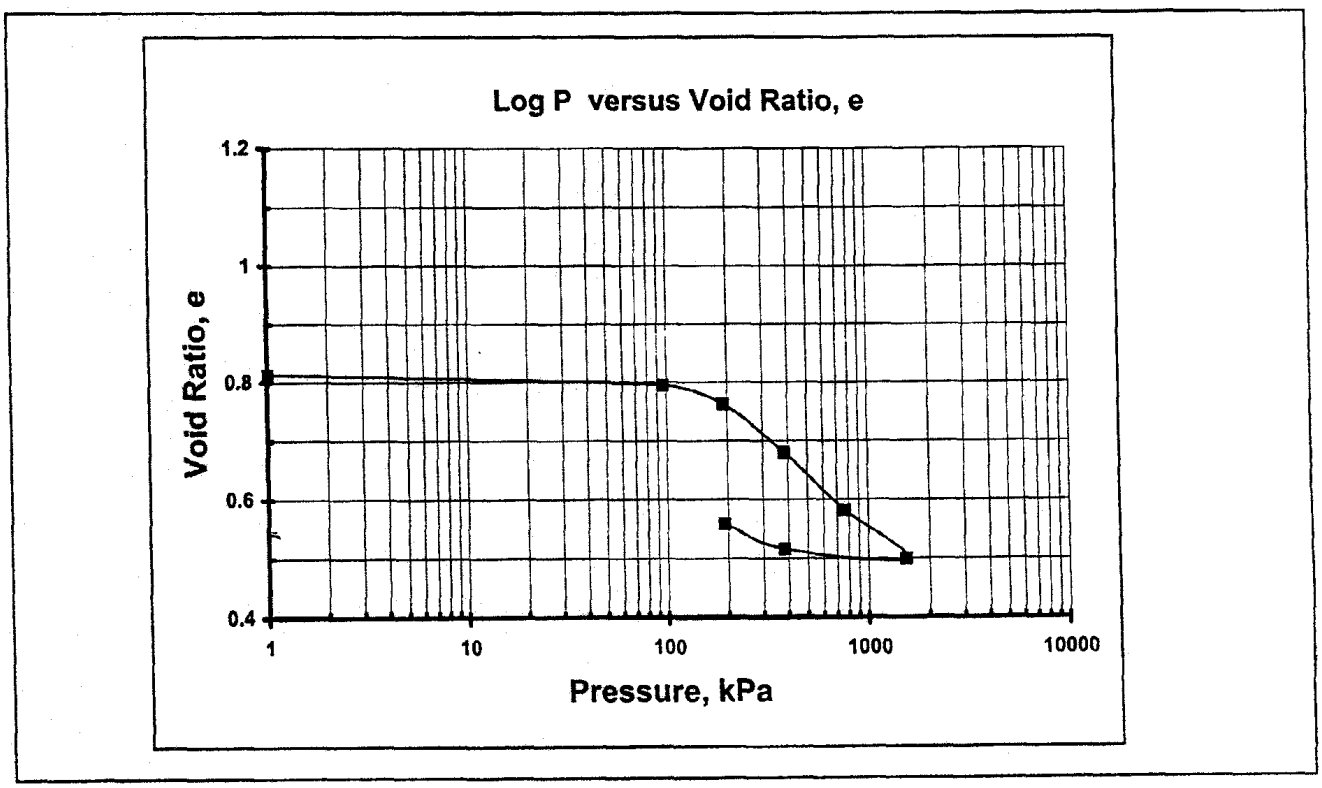
	Great Lakes Soil & Environmental Consultants Inc. 333 Shore Drive, Burr Ridge, IL 60521; Ph: (630)321-0944; Fax: (630)321-0945	**CONSOLIDATION TEST ASTM D2435**

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie Street, Chicago, IL 60611								
File No.	2355	Date	4/20/2002	Sample #	SULS	Tested By	PA	Checked By	SB

Source of Material	Stickney WRP	Atterberg Limits	LL%	PL%	PI
Description of Soil	Black Under-Aged Low Solids		98	60	38

Specimen Data and Test Results

Initial Moisture Content, %	32.00	Final Moisture Content, %	28.61
Initial Dry Unit Weight, pcf	64.69	Final Dry Unit Weight, pcf	69.86
Initial Void Ratio, e	0.81	Final Void Ratio, e	0.00
Initial Degree of Saturation, %	73.97	Final Degree of Saturation, %	89.30



Remarks	

Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521; Ph: (630)321-0944; Fax: (630)321-0945

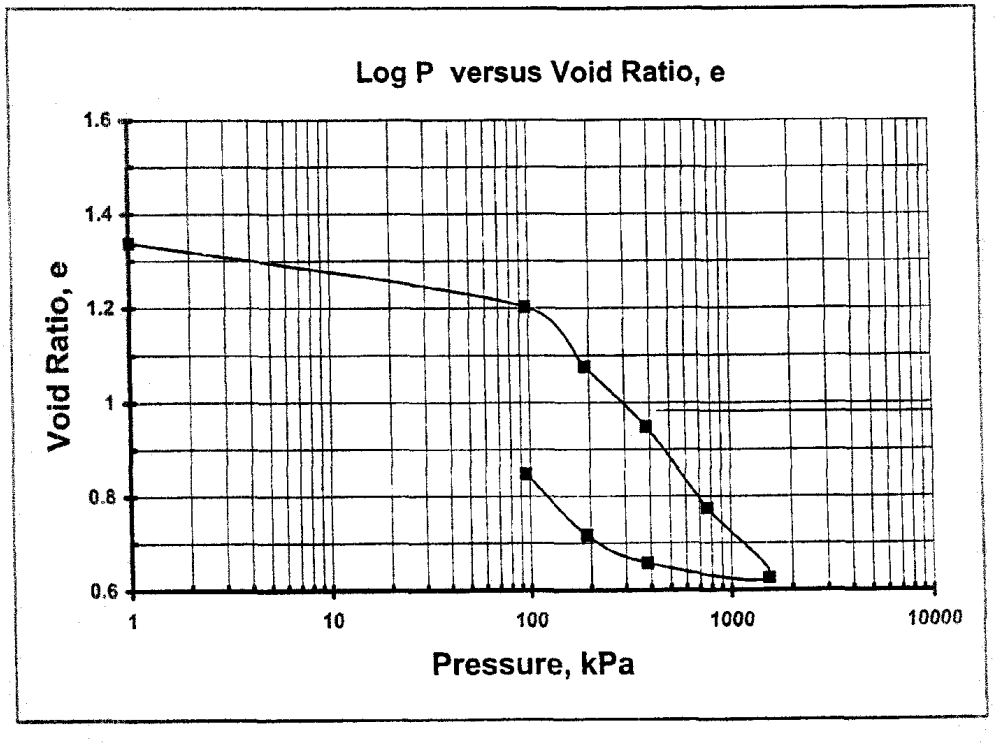
CONSOLIDATION TEST ASTM D2435

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie Street, Chicago, IL 60611								
File No.	2355	Date	4/20/2002	Sample #	CAHS	Tested By	PA	Checked By	SB

Source of Material	Calumet WRP	Atterberg Limits	LL%	PL%	PI
Description of Soil	Black Aged High Solids		103	75	28

Specimen Data and Test Results

Initial Moisture Content, %	65.00	Final Moisture Content, %	53.39
Initial Dry Unit Weight, pcf	48.30	Final Dry Unit Weight, pcf	65.39
Initial Void Ratio, e	1.34	Final Void Ratio, e	0.85
Initial Degree of Saturation, %	87.90	Final Degree of Saturation, %	121.89



Remarks	

Great Lakes Soil & Environmental Consultants Inc.
333 Shore Drive, Burr Ridge, IL 60521; Ph: (630)321-0944; Fax: (630)321-0945

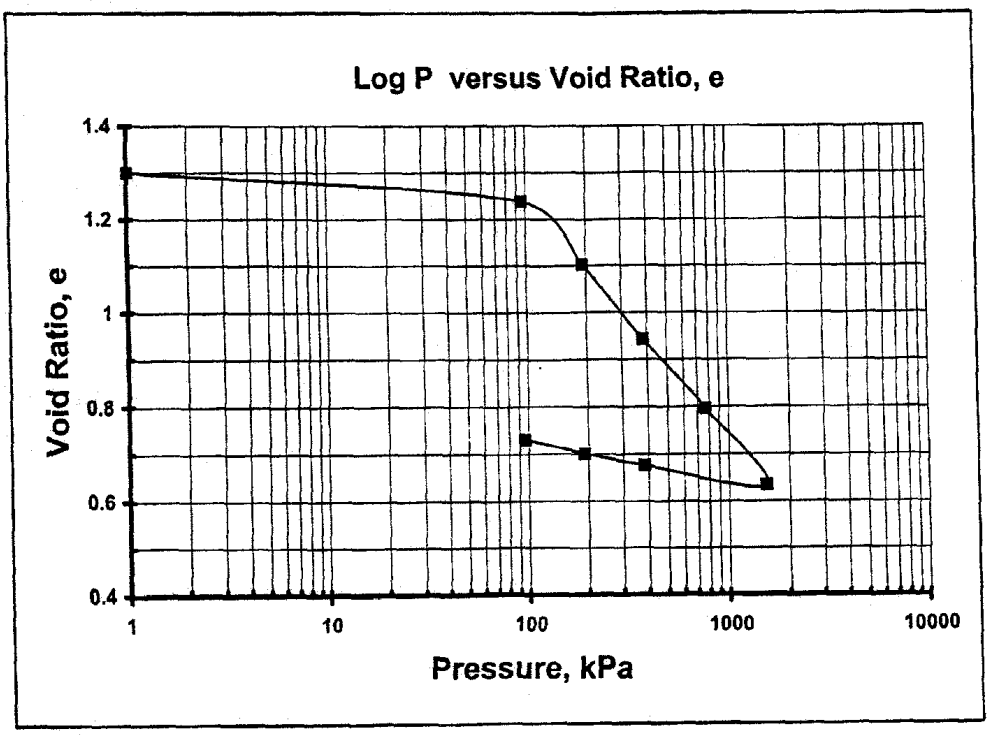
CONSOLIDATION TEST ASTM D2435

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie Street, Chicago, IL 60611								
File No.	2355	Date	5/6/2002	Sample #	CALS	Tested By	PA	Checked By	SB

Source of Material	Calumet WRP	Atterberg Limits	LL%	PL%	PI
Description of Soil	Black Aged Low Solids		98	77	21

Specimen Data and Test Results

Initial Moisture Content, %	55.00	Final Moisture Content, %	38.25
Initial Dry Unit Weight, pcf	56.96	Final Dry Unit Weight, pcf	76.23
Initial Void Ratio, e	1.30	Final Void Ratio, e	0.73
Initial Degree of Saturation, %	88.81	Final Degree of Saturation, %	115.06



Remarks	

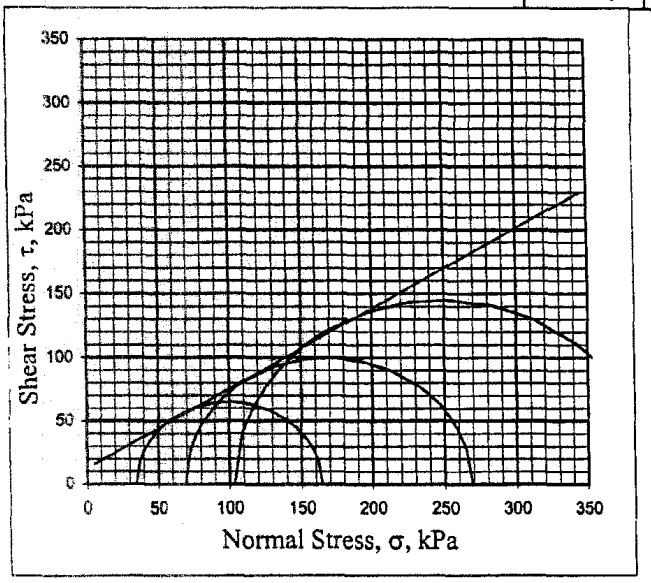
Appendix D

Triaxial Compression Test Results

- Unconsolidated-Undrained (UU) Triaxial Tests
- Consolidated-Undrained (CU) Triaxial Tests

	Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945	**Unconsolidate Undrained (UU) Triaxial Test ASTM D2850**

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie St., Chicago, IL 60611						
File No.	2355	**Date**	5/16/2002		**Sample No.**	Ref#1-SALS-1001	
Description of Soil		Black Aged Low Solids			**Location**	SWRP Lagoon 23, RASMA May/June Lift	
				Tested By	NP	**Checked By**	SB



Failure Sketches

Spec. 1

Spec. 2

Spec. 3

Specimen		1	2	3
Initial	Water content(%)	12.78	12.78	12.78
	Dry Density (g/cm^3)	1.16	1.16	1.18
	Void Ratio	0.72	0.72	0.70
	Saturation (%)	-	-	-
Before Shear	Water content(%)			
	Dry Density (g/cm^3)			
	Void Ratio			
	Saturation (%)			
	Back pressure (kPa)	0.00	0.00	0.00
Specific Gravity, Gs		2.00	2.00	2.00
Minor Principal Stress (kPa)		34.47	68.95	103.42
Max. Deviator Stress (kPa)		130	200	290
Rate of Strain Inc. (%/min)		1	1	1
Initial Diameter (cm)		7.2	7.2	7.2
Initial Height (cm)		15	15	14.7
B-Value		-	-	-

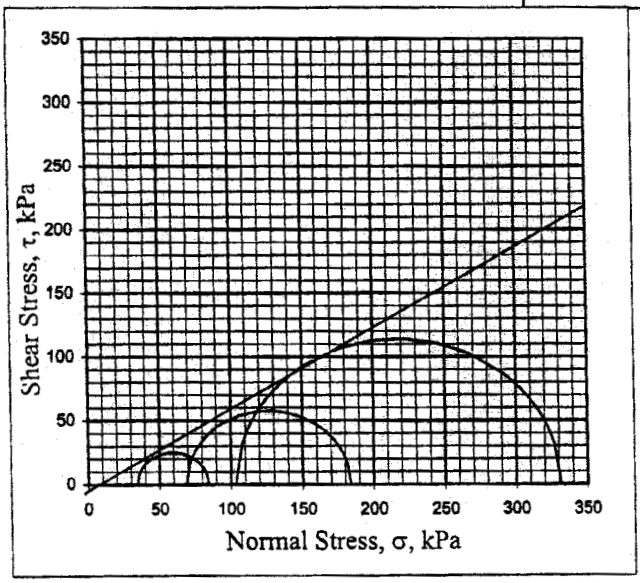
Results

Total Strength Parameters	**Cohesion**	15.0	kPa	**Friction Angle**	32.2	Deg.

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945	Unconsolidate Undrained (UU) Triaxial Test ASTM D2850

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie St., Chicago, IL 60611						
File No.	2355	**Date**	5/22/2002		Sample No.	Ref#2-SAHS-1001	
Description of Soil		Black Aged High Solids			Location	SWRP Lagoon-24-HASMA	
				Tested By	NP	Checked By	SB



Failure Sketeches

Spec. 1

Spec. 2

Spec. 3

Specimen		1	2	3
Initial	Water content(%)	12.78	12.78	12.78
	Dry Density (g/cm^3)	1.21	1.16	1.27
	Void Ratio	0.65	0.72	0.58
	Saturation (%)	-	-	-
Before Shear	Water content(%)			
	Dry Density (g/cm^3)			
	Void Ratio			
	Saturation (%)			
	Back pressure (kPa)	0.00	0.00	0.00
Specific Gravity, Gs		2.00	2.00	2.00
Minor Principal Stress (kPa)		34.47	68.95	103.42
Max. Deviator Stress (kPa)		50	115	228
Rate of Strain Inc. (%/min)		1	1	1
Initial Diameter (cm)		7.2	7.2	7.2
Initial Height (cm)		15	15	14.3
B-Value		-	-	-

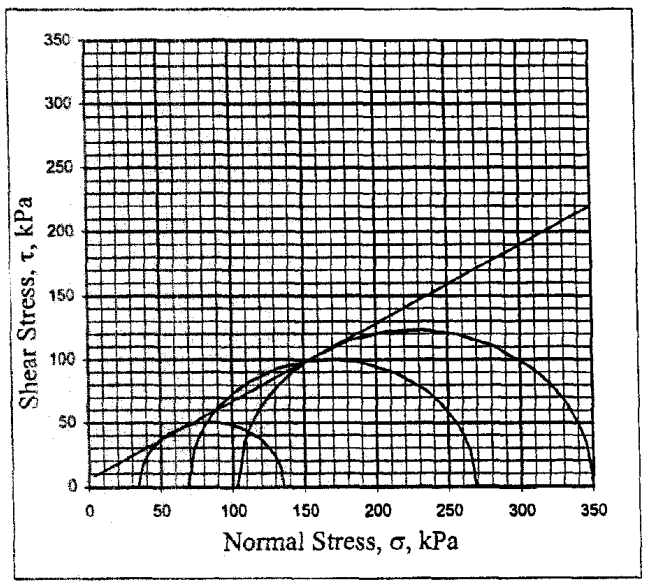
Results

Total Strength Parameters	Cohesion	0.0	kPa	Friction Angle	32.2	Deg.

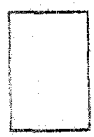
Remarks:	

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945	Unconsolidate Undrained (UU) Triaxial Test ASTM D2850

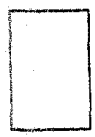
Project	Geotechnical Characterization of Biosolids					
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie St., Chicago, IL 60611					
File No.	2355	Date	5/10/2002		Sample No.	Ref#3-SULS-1001
Description of Soil		Black Unaged Low Solids			Location	SWRP Lagoon-16 Marathon
				Tested By	NP	Checked By	SB



Failure Sketeches


Spec. 1


Spec. 2


Spec. 3

Specimen		1	2	3
Initial	Water content(%)	12.78	12.78	12.78
	Dry Density (g/cm^3)	1.21	1.16	1.18
	Void Ratio	0.65	0.72	0.70
	Saturation (%)	-	-	-
Before Shear	Water content(%)			
	Dry Density (g/cm^3)			
	Void Ratio			
	Saturation (%)			
	Back pressure (kPa)	0.00	0.00	0.00
Specific Gravity, Gs		2.00	2.00	2.00
Minor Principal Stress (kPa)		34.47	68.95	103.42
Max. Deviator Stress (kPa)		101	200	290
Rate of Strain inc. (%/min)		1	1	1
Initial Diameter (cm)		7.2	7.2	7.2
Initial Height (cm)		14	15	14.7
B-Value		-	-	-

Results

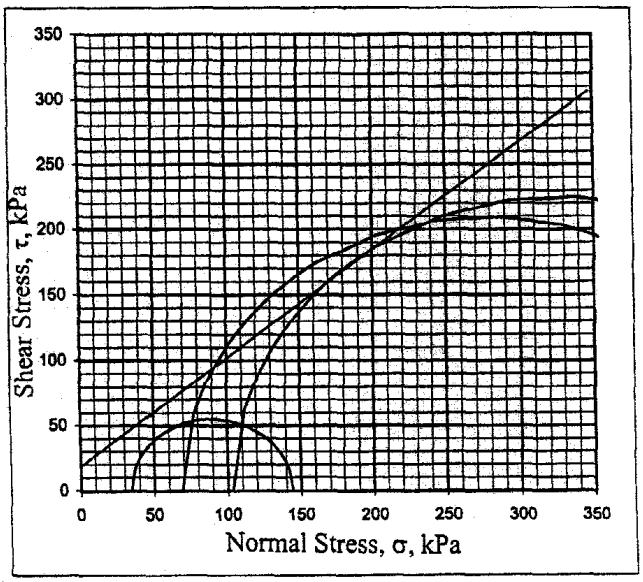
Total Strength Parameters	Cohesion	10.0	kPa	Friction Angle	31.0	Deg.

Remarks:	

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

Unconsolidate Undrained (UU) Triaxial Test ASTM D2850

Project	Geotechnical Characterization of Biosolids					
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie St., Chicago, IL 60611					
File No.	2355	Date	5/7/2002		Sample No.	Ref#4-SUHS-1001
Description of Soil	Black Unaged High Solids				Location	SWRP 2001 Lift-Stoney Island
				Tested By	NP	Checked By	SB



Failure Sketeches

Spec. 1

Spec. 2

Spec. 3

Specimen		1	2	3
Initial	Water content(%)	12.78	12.78	12.78
	Dry Density (g/cm^3)	1.18	1.16	1.17
	Void Ratio	0.69	0.72	0.70
	Saturation (%)	-	-	-
Before Shear	Water content(%)			
	Dry Density (g/cm^3)			
	Void Ratio			
	Saturation (%)			
	Back pressure (kPa)	0.00	0.00	0.00
Specific Gravity, Gs		2.00	2.00	2.00
Minor Principal Stress (kPa)		34.47	68.95	103.42
Max. Deviator Stress (kPa)		110	419	450
Rate of Strain Inc. (%/min)		1	1	1
Initial Diameter (cm)		7.2	7.2	7.2
Initial Height (cm)		14.8	15	14.8
B-Value		-	-	-

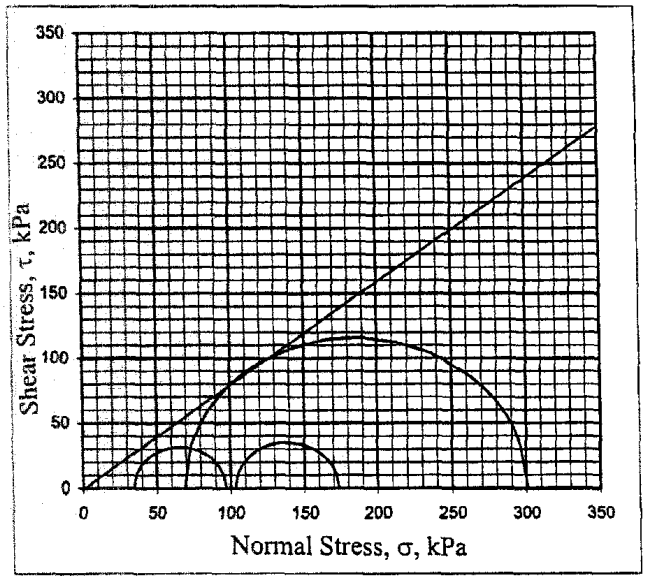
Results

Total Strength Parameters	**Cohesion**	**20.0**	**kPa**	**Friction Angle**	**39.6**	**Deg.**

Remarks:

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945	Unconsolidate Undrained (UU) Triaxial Test ASTM D2850

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie St., Chicago, IL 60611						
File No.	2355	Date	5/1/2002		Sample No.	Ref#5-CAHS-1001	
Description of Soil		Black Aged High Solids			Location	CWRP West	
				Tested By	NP	Checked By	SB



Failure Sketches

Spec. 1

Spec. 2

Spec. 3

Specimen		1	2	3
Initial	Water content(%)	12.78	12.78	12.78
	Dry Density (g/cm^3)	1.14	1.23	1.11
	Void Ratio	0.76	0.63	0.79
	Saturation (%)	-	-	-
Before Shear	Water content(%)			
	Dry Density (g/cm^3)			
	Void Ratio			
	Saturation (%)			
	Back pressure (kPa)	0.00	0.00	0.00
Specific Gravity, Gs		2.00	2.00	2.00
Minor Principal Stress (kPa)		34.47	68.95	103.42
Max. Deviator Stress (kPa)		62.6	232	70
Rate of Strain Inc. (%/min)		1	1	1
Initial Diameter (cm)		7.2	7	7.2
Initial Height (cm)		14.3	14	14.5
B-Value		-	-	-

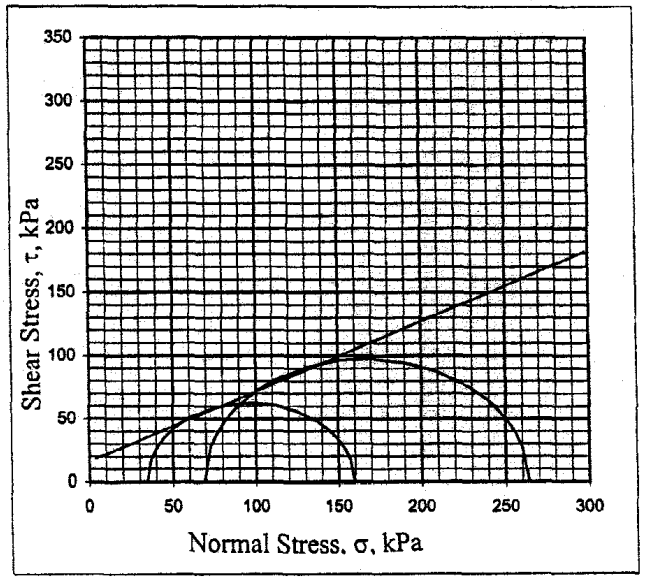
Results

Total Strength Parameters	Cohesion	0.0	kPa	Friction Angle	37.6	Deg.

Remarks:	

	Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945	**Unconsolidate Undrained (UU) Triaxial Test ASTM D2850**

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie St., Chicago, IL 60611						
File No.	2355	Date	4/23/2002		Sample No.	Ref#6-CALS-1000	
Description of Soil		Black Aged Low Solids			Location	CWRP-East	
				Tested By	NP	Checked By	SB



Failure Sketeches

Spec. 1

Spec. 2

Spec. 3

Specimen		1	2	3
Initial	Water content(%)	12.78	12.78	
	Dry Density (g/cm^3)	1.28	1.30	
	Void Ratio	0.57	0.54	
	Saturation (%)	-	-	-
Before Shear	Water content(%)			
	Dry Density (g/cm^3)			
	Void Ratio			
	Saturation (%)			
	Back pressure (kPa)	0.00	0.00	
Specific Gravity, Gs		2.00	2.00	2.00
Minor Principal Stress (kPa)		34.47	68.95	
Max. Deviator Stress (kPa)		125	195	
Rate of Strain Inc. (%/min)		1	1	1
Initial Diameter (cm)		7	7	
Initial Height (cm)		14.5	14	
B-Value		-	-	-

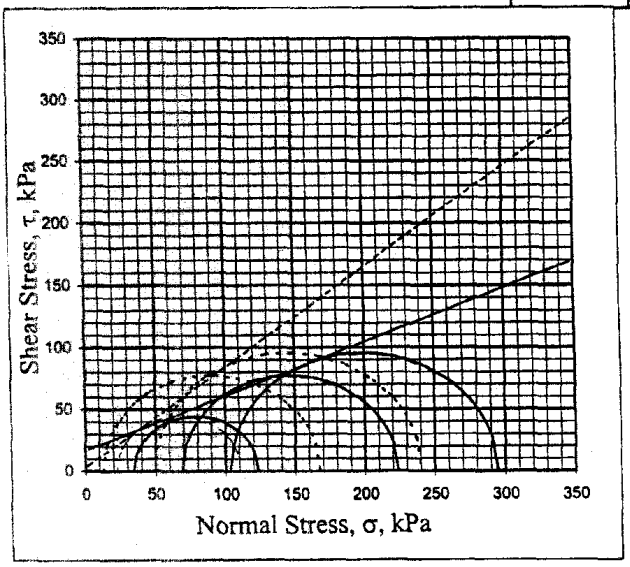
Results

Total Strength Parameters	**Cohesion**	20.0	kPa	**Friction Angle**	24.6 Deg.

Remarks:	

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945	Triaxial (CU) Test ASTM D4767

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie St., Chicago, IL 60611						
File No.	2355	Date	5/16/2002		Sample No.	Reff#1-SALS-1001	
Description of Soil		Black Aged Low Solids			Location	SWRP Lagoon 23, RASMA May/June Lift	
				Tested By	NP	Checked By	SB



Failure Sketeches

Spec. 1

Spec. 2

Spec. 3

Specimen		1	2	3
Initial	Water content(%)	79.9	77.4	73.4
	Dry Density (g/cm^3)	0.74	0.75	0.77
	Void Ratio	1.72	1.65	1.59
	Saturation (%)	93.2	93.7	92.1
Before Shear	Water content(%)			
	Dry Density (g/cm^3)			
	Void Ratio			
	Saturation (%)			
	Back pressure (kPa)	517	517	517
Specific Gravity, Gs		2.00	2.00	2.00
Minor Principal Stress (kPa)		34.5	68.9	103.4
Max. Deviator Stress (kPa)		89	155	191
Rate of Strain Inc. (%/min)		0.1	0.1	0.1
Initial Diameter (cm)		7.2	7.2	7.2
Initial Height (cm)		14.8	14.5	14.8
B-Value		0.95	0.95	0.95

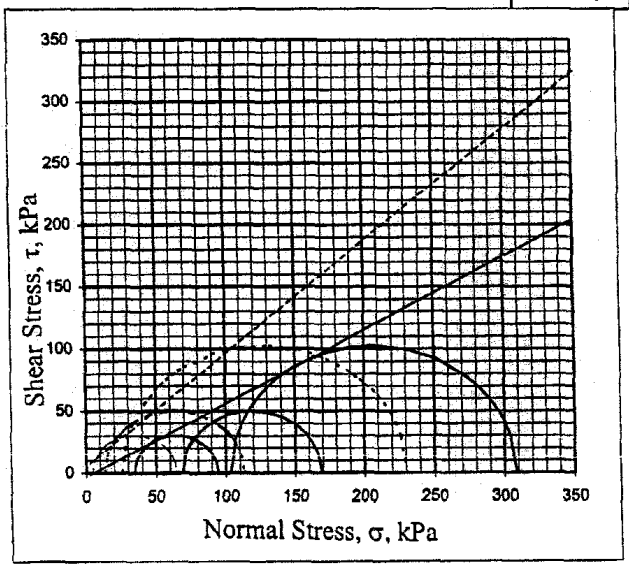
Results

Total Strength Parameters	**Cohesion**	**20**	**kPa**	**Friction Angle**	**23.2 Deg.**
Effective Strength Parameters	**Cohesion**	**10**	**kPa**	**Friction Angle**	**37.6 Deg.**

Remarks:	

	Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945	**Triaxial (CU) Test** **ASTM D4767**

Project	Geotechnical Characterization of Biosolids					
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie St., Chicago, IL 60611					
File No.	2355	Date	5/22/2002	Sample No.	Ref#2-SAHS-1001	
Description of Soil	Black Aged High Solids			Location	SWRP Lagoon-24-HASMA	
			Tested By	NP	Checked By	SB



Failure Sketeches

Spec. 1

Spec. 2

Spec. 3

Specimen		1	2	3
Initial	Water content(%)	59.7	54.8	46.5
	Dry Density (g/cm^3)	0.89	0.93	1.01
	Void Ratio	1.24	1.15	0.97
	Saturation (%)	96.2	95.6	95.7
Before Shear	Water content(%)			
	Dry Density (g/cm^3)			
	Void Ratio			
	Saturation (%)			
	Back pressure (kPa)	517	517	517
Specific Gravity, Gs		2.00	2.00	2.00
Minor Principal Stress (kPa)		34.5	68.9	103.4
Max. Deviator Stress (kPa)		60	100	205
Rate of Strain Inc. (%/min)		0.1	0.1	0.1
Initial Diameter (cm)		7.2	7.2	7.2
Initial Height (cm)		14.8	14.2	14.2
B-Value		0.95	0.95	0.95

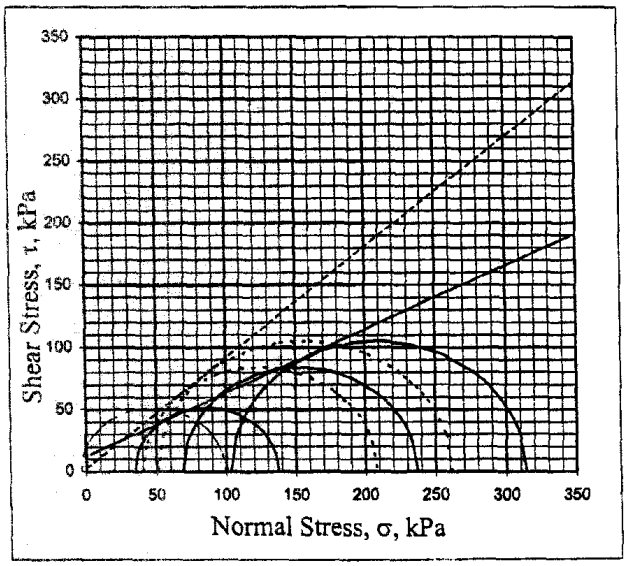
Results

Total Strength Parameters	**Cohesion**	0	kPa	**Friction Angle**	29.7	Deg.
Effective Strength Parameters	**Cohesion**	0	kPa	**Friction Angle**	40.6	Deg.

Remarks:	

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945	Triaxial (CU) Test ASTM D4767

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie St., Chicago, IL 60611						
File No.	2355	**Date**	5/10/2002		**Sample No.**	Ref#3-SULS-1001	
Description of Soil		Black Unaged Low Solids			**Location**	SWRP Lagoon-16 Marathon	
				Tested By	NP	**Checked By**	SB



Failure Sketches


Spec. 1


Spec. 2


Spec. 3

Specimen		1	2	3
Initial	Water content(%)	68.2	67.4	62.3
	Dry Density (g/cm^3)	0.80	0.82	0.83
	Void Ratio	1.51	1.45	1.41
	Saturation (%)	90.6	93.0	88.7
Before Shear	Water content(%)			
	Dry Density (g/cm^3)			
	Void Ratio			
	Saturation (%)			
	Back pressure (kPa)	517	517	517
Specific Gravity, Gs		2.00	2.00	2.00
Minor Principal Stress (kPa)		34.5	68.9	103.4
Max. Deviator Stress (kPa)		103	168	211
Rate of Strain Inc. (%/min)		0.1	0.1	0.1
Initial Diameter (cm)		7.2	7.2	7.2
Initial Height (cm)		14.2	13.8	13.8
B-Value		0.95	0.95	0.95

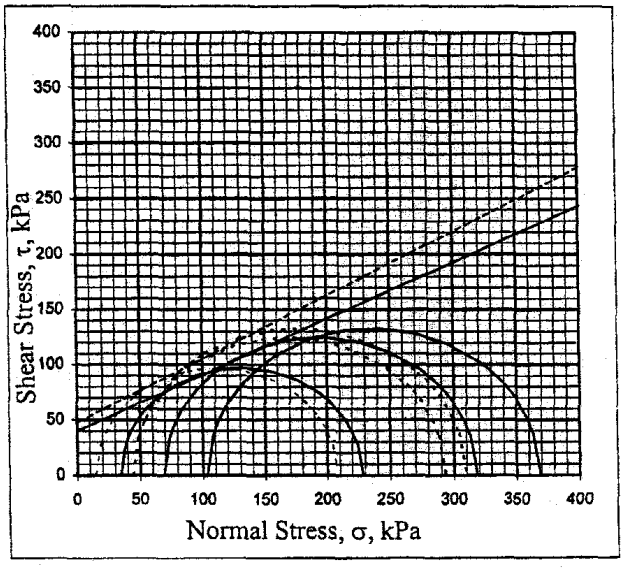
Results

Total Strength Parameters	**Cohesion**	15	kPa	**Friction Angle**	26.6	Deg.
Effective Strength Parameters	**Cohesion**	0	kPa	**Friction Angle**	42.0	Deg.

Remarks:	

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945	Triaxial (CU) Test ASTM D4767

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie St., Chicago, IL 60611						
File No.	2355	Date	5/7/2002		Sample No.	Ref#4-SUHS-1001	
Description of Soil		Black Unaged High Solids			Location	SWRP 2001 Lift-Stoney Island	
				Tested By	NP	Checked By	SB



Failure Sketeches

Spec. 1

Spec. 2

Spec. 3

Specimen		1	2	3
Initial	Water content(%)	57.4	50.7	49.5
	Dry Density (g/cm^3)	0.88	0.88	0.89
	Void Ratio	1.28	1.26	1.24
	Saturation (%)	89.7	80.2	79.7
Before Shear	Water content(%)			
	Dry Density (g/cm^3)			
	Void Ratio			
	Saturation (%)			
	Back pressure (kPa)	517	517	517
Specific Gravity, Gs		2.00	2.00	2.00
Minor Principal Stress (kPa)		34.5	68.9	103.4
Max. Deviator Stress (kPa)		194	249	266
Rate of Strain Inc. (%/min)		0.1	0.1	0.1
Initial Diameter (cm)		7.2	7.2	7.2
Initial Height (cm)		14.2	14.8	14.8
B-Value		0.95	0.95	0.95

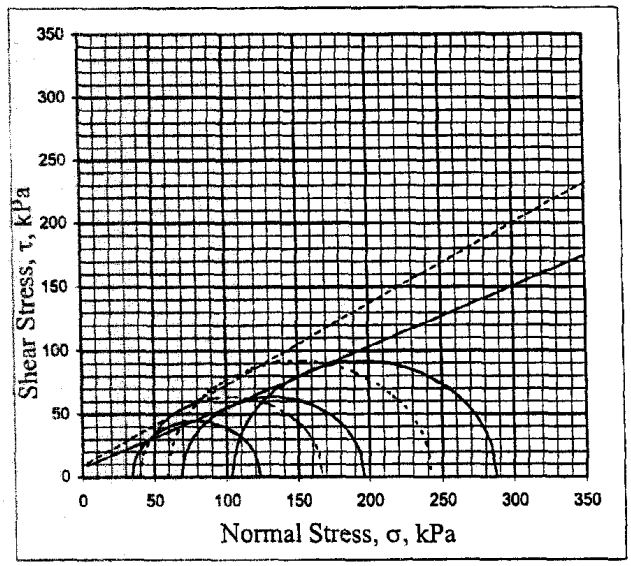
Results

Total Strength Parameters	**Cohesion**	40	kPa	**Friction Angle**	29.7	Deg.
Effective Strength Parameters	**Cohesion**	50	kPa	**Friction Angle**	33.3	Deg.

Remarks:	

Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945	Triaxial (CU) Test ASTM D4767

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie St., Chicago, IL 60611						
File No.	2355	Date	5/1/2002		Sample No.	Ref#5-CAHS-1001	
Description of Soil		Black Aged High Solids			Location	CWRP West	
				Tested By	NP	Checked By	SB



Failure Sketches

Spec. 1

Spec. 2

Spec. 3

Specimen		1	2	3
Initial	Water content(%)	79.5	80.1	54.0
	Dry Density (g/cm^3)	0.69	0.69	0.83
	Void Ratio	1.89	1.91	1.42
	Saturation (%)	84.1	83.8	76.3
Before Shear	Water content(%)			
	Dry Density (g/cm^3)			
	Void Ratio			
	Saturation (%)			
	Back pressure (kPa)	517	517	517
Specific Gravity, Gs		2.00	2.00	2.00
Minor Principal Stress (kPa)		34.5	68.9	103.4
Max. Deviator Stress (kPa)		89	128	184
Rate of Strain Inc. (%/min)		0.1	0.1	0.1
Initial Diameter (cm)		7.2	7.2	7.2
Initial Height (cm)		14.8	14.8	14
B-Value		0.95	0.95	0.95

Results

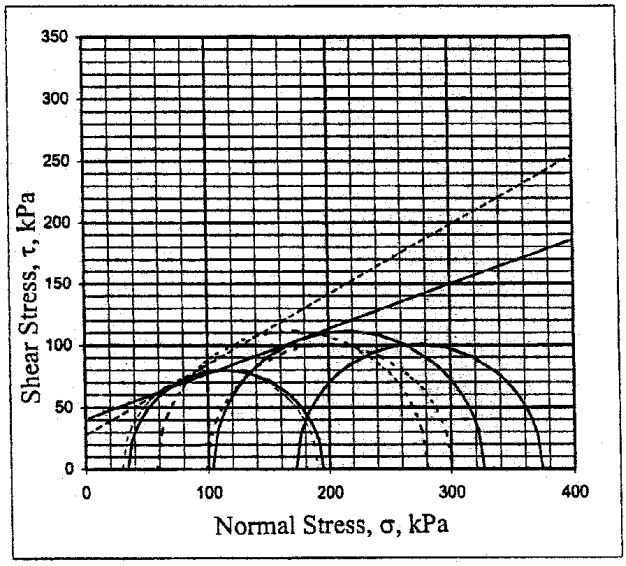
Total Strength Parameters	Cohesion	10	kPa	Friction Angle	25.2	Deg.
Effective Strength Parameters	Cohesion	10	kPa	Friction Angle	32.2	Deg.

Remarks:	

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

Triaxial (CU) Test
ASTM D4767

Project	Geotechnical Characterization of Biosolids					
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie St., Chicago, IL 60611					
File No.	2355	**Date**	4/23/2002	**Sample No.**	Ref#6-CALS-1000	
Description of Soil	Black Aged Low Solids			**Location**	CWRP-East	
			Tested By	NP	**Checked By**	SB



Failure Sketeches

Spec. 1

Spec. 2

Spec. 3

Specimen		1	2	3
Initial	Water content(%)	62.9	61.8	68.6
	Dry Density (g/cm^3)	0.92	0.91	0.87
	Void Ratio	1.17	1.20	1.30
	Saturation (%)	107.4	103.4	105.9
Before Shear	Water content(%)			
	Dry Density (g/cm^3)			
	Void Ratio			
	Saturation (%)			
	Back pressure (kPa)	517	517	517
Specific Gravity, Gs		2.00	2.00	2.00
Minor Principal Stress (kPa)		34.5	103.4	172.4
Max. Deviator Stress (kPa)		160	223	202
Rate of Strain Inc. (%/min)		0.1	0.1	0.1
Initial Diameter (cm)		7	7	7
Initial Height (cm)		13.5	14	14.5
B-Value		0.95	0.95	0.95

Results

Total Strength Parameters	**Cohesion**	40	kPa	**Friction Angle**	21.1	Deg.
Effective Strength Parameters	**Cohesion**	30	kPa	**Friction Angle**	32.2	Deg.

Remarks:

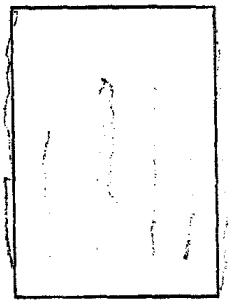
Appendix E

Unconfined Compression Test Results

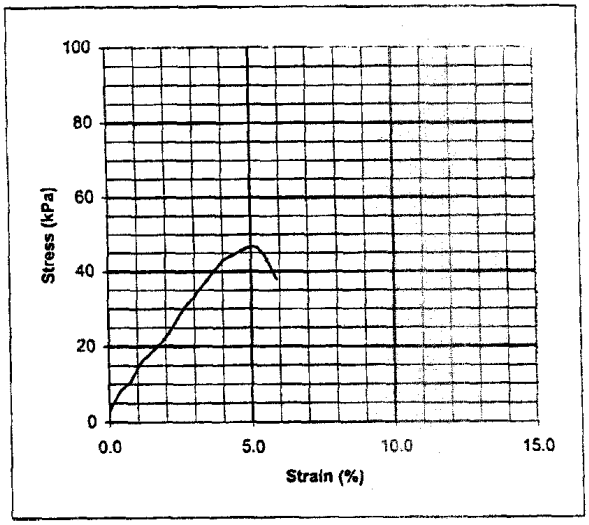
Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive Burr Ridge, IL 60527; Ph:(630)321-0944, Fax: (630)321-0945	UNCONFINED COMPRESSIVE STRENGTH (ASTM D 2166)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	Date	8/13/2002	Report No.	Sample No.	REF#1-RFP 10-SALS-1001	
Description of Soil		Black Aged Low Solids			Source	Stickney WRP	
			Tested By		NP	Checked By	SB

Type of Sample	Remolded	
Average Height =	13.80	cm
Average Diameter =	7.20	cm
Height/Diameter Ratio =	1.92	
Wet Sample Weight=	779.40	g
Wet Density =	1.39	g/cc
Moisture Content =	49.5	%
Dry Density =	0.93	g/cc
Strain Rate =	0.30	%/min



Failure Sketch



Unconfined Compressive Strength =	45.9 **958**	kPa **psf**
Shear Strength =	23 479	kPa psf
Strain at Failure =	5.2	%

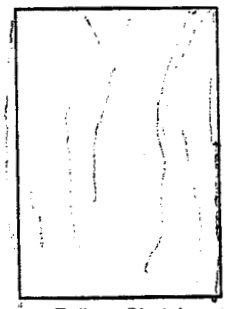
Remarks:	

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive Burr Ridge, IL 60527: Ph:(630)321-0944, Fax: (630)321-0945

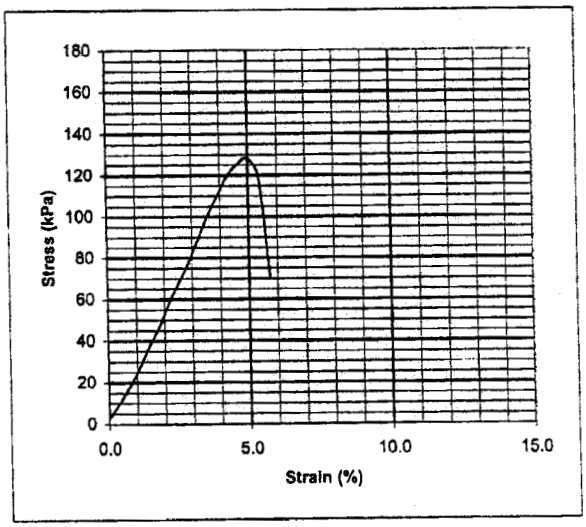
UNCONFINED COMPRESSIVE STRENGTH (ASTM D 2166)

Project	Geotechnical Characterization of Biosolids					
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie Street, Chicago, IL 60611					
File No.	2355	**Date**	8/12/2002	Report No.	Sample No.	REF#2-RFP 10-SAHS-1001
Description of Soil		Black Aged High Solids			Source	Stickney WRP
			Tested By		NP	Checked By SB

Type of Sample	Remolded	
Average Height =	14.20	cm
Average Diameter =	7.20	cm
Height/Diameter Ratio =	1.97	
Wet Sample Weight=	827.50	g
Wet Density =	1.43	g/cc
Moisture Content =	35.1	%
Dry Density =	1.06	g/cc
Strain Rate =	0.30	%/min



Failure Sketch



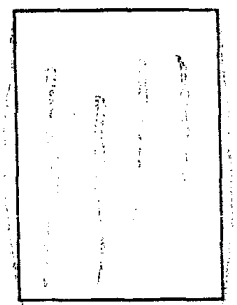
Unconfined Compressive Strength =	126.4	kPa
	2640	psf
Shear Strength =	63	kPa
	1320	psf
Strain at Failure =	5.0	%

Remarks:

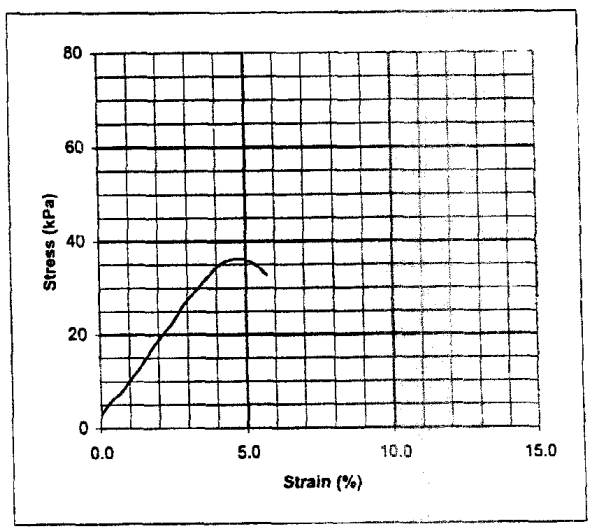
Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive Burr Ridge, IL 60527; Ph:(630)321-0944, Fax: (630)321-0945	UNCONFINED COMPRESSIVE STRENGTH (ASTM D 2166)

Project	Geotechnical Characterization of Biosolids					
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie Street, Chicago, IL 60611					
File No.	2355	Date	8/13/2002	Report No.	Sample No.	REF#3-RFP 10-SULS-1001
Description of Soil		Black Under-aged Low Solids			Source	Stickney WRP
			Tested By		NP	Checked By SB

Type of Sample	Remolded	
Average Height =	14.20	cm
Average Diameter =	7.20	cm
Height/Diameter Ratio =	1.97	
Wet Sample Weight=	773.30	g
Wet Density =	1.34	g/cc
Moisture Content =	43.2	%
Dry Density =	0.93	g/cc
Strain Rate =	0.30	%/min



Failure Sketch



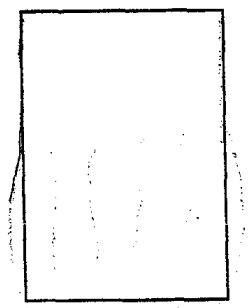
Unconfined Compressive Strength =	36.0 **752**	kPa **psf**
Shear Strength =	18 376	kPa psf
Strain at Failure =	4.7	%

Remarks:	

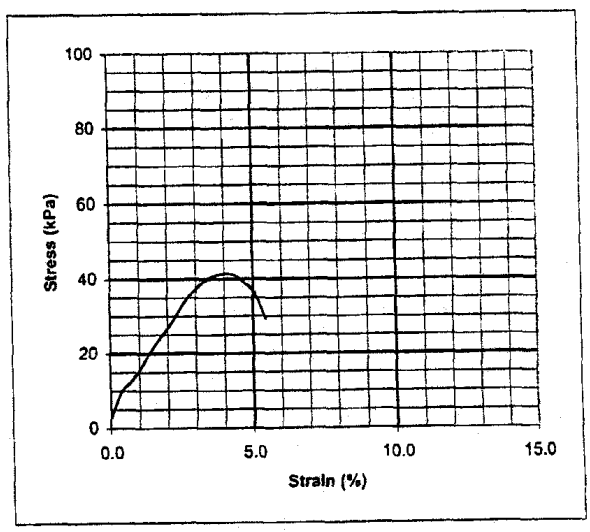
Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive Burr Ridge, IL 60527; Ph:(630)321-0944, Fax: (630)321-0945	UNCONFINED COMPRESSIVE STRENGTH (ASTM D 2166)

Project	Geotechnical Characterization of Biosolids						
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie Street, Chicago, IL 60611						
File No.	2355	Date	8/14/2002	Report No.	Sample No.	REF#4-RFP 10-SUHS-1001	
Description of Soil		Black Under-aged High Solids			Source	Stickney WRP	
			Tested By		NP	Checked By	SB

Type of Sample	Remolded	
Average Height =	14.00	cm
Average Diameter =	7.20	cm
Height/Diameter Ratio =	1.94	
Wet Sample Weight=	794.20	g
Wet Density =	1.39	g/cc
Moisture Content =	42.8	%
Dry Density =	0.98	g/cc
Strain Rate =	0.30	%/min



Failure Sketch



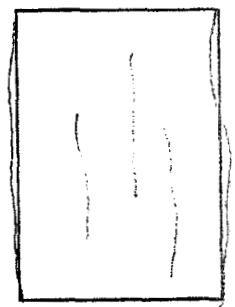
Unconfined Compressive Strength =	41.7 **870**	kPa **psf**
Shear Strength =	21 435	kPa psf
Strain at Failure =	4.0	%

Remarks:	

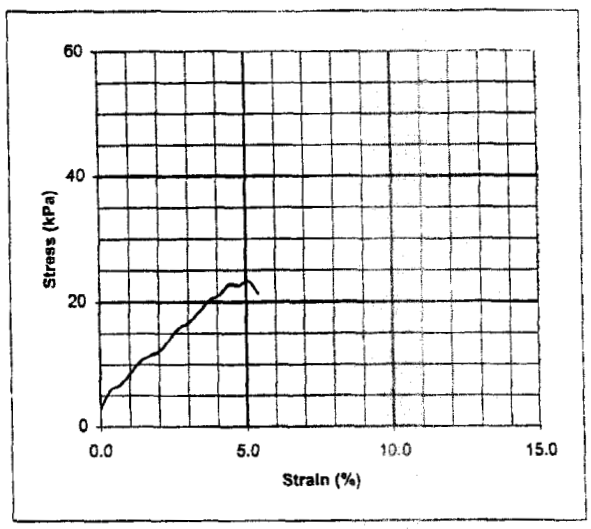
Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive Burr Ridge, IL 60527; Ph:(630)321-0944, Fax: (630)321-0945	UNCONFINED COMPRESSIVE STRENGTH (ASTM D 2166)

Project	Geotechnical Characterization of Biosolids					
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie Street, Chicago, IL 60611					
File No.	2355	Date	8/14/2002	Report No.	Sample No.	REF#5-RFP 10-CAHS-1001
Description of Soil		Black Aged High Solids			Source	Calumet WRP
			Tested By		NP	Checked By SB

Type of Sample	Remolded	
Average Height =	15.00	cm
Average Diameter =	7.20	cm
Height/Diameter Ratio =	2.08	
Wet Sample Weight=	786.00	g
Wet Density =	1.29	g/cc
Moisture Content =	57.2	%
Dry Density =	0.82	g/cc
Strain Rate =	0.30	%/min



Failure Sketch



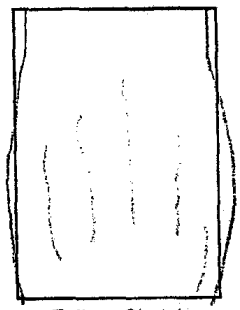
Unconfined Compressive Strength =	22.9 479	kPa psf
Shear Strength =	11 240	kPa psf
Strain at Failure =	5.1	%

Remarks:	

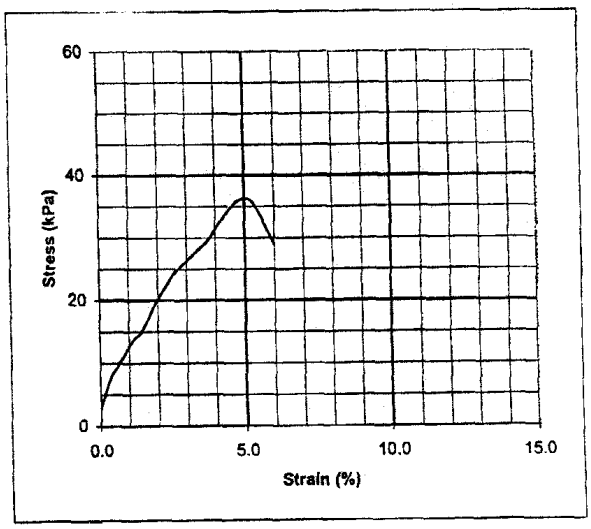
Great Lakes Soil & Environmental Consultants, Inc. 333 Shore Drive Burr Ridge, IL 60527; Ph:(630)321-0944, Fax: (630)321-0945	UNCONFINED COMPRESSIVE STRENGTH (ASTM D 2166)

Project	Geotechnical Characterization of Biosolids					
Client	Metropolitan Water Reclamation District of Greater Chicago, 100 East Erie Street, Chicago, IL 60611					
File No.	2355	*Date*	8/13/2002	Report No.	Sample No.	REF#6-RFP 10-CALS-1000
Description of Soil		Black Aged Low Solids			Source	Calumet WRP
			Tested By		NP	Checked By	SB

Type of Sample	Remolded	
Average Height =	13.60	cm
Average Diameter =	7.20	cm
Height/Diameter Ratio =	1.89	
Wet Sample Weight=	745.90	g
Wet Density =	1.35	g/cc
Moisture Content =	47.9	%
Dry Density =	0.91	g/cc
Strain Rate =	0.30	%/min



Failure Sketch



Unconfined Compressive Strength =	35.7 **746**	kPa **psf**
Shear Strength =	18 373	kPa psf
Strain at Failure =	4.9	%

Remarks:	

Appendix F

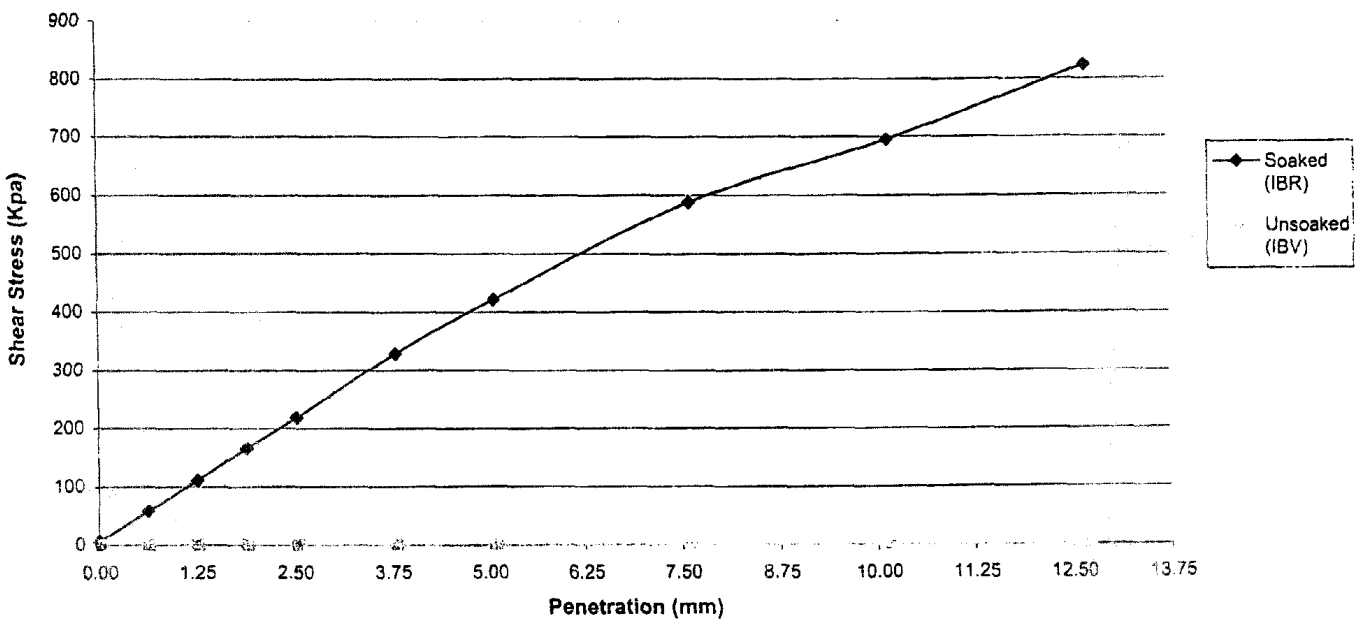
Illinois Bearing Ratio (IBR), Immediate Bearing Value (IBV) Tests

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

IBR &IBV TEST AASHTO T193

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie street,Chicago, IL 60611								
File No.	2355	Date	9/16/2002	Report No	1	Tested By	NP	Checked By	SB

Sample ID	SALS			Dry Density(pcf)	59.0
Source of Material	Stickney WRP			Moisture Content(%)	49.0
Description of Soil	Black Aged Low Solids		Date of Soaking	9/11/02	
Initial Swell Reading	0 143	Final Swell Reading	19 65	Swell Percent	0.56



IBR (%)	@2.54mm	3.17	@5.08mm	4.07	
IBV (%)	@2.54mm		@5.08mm		

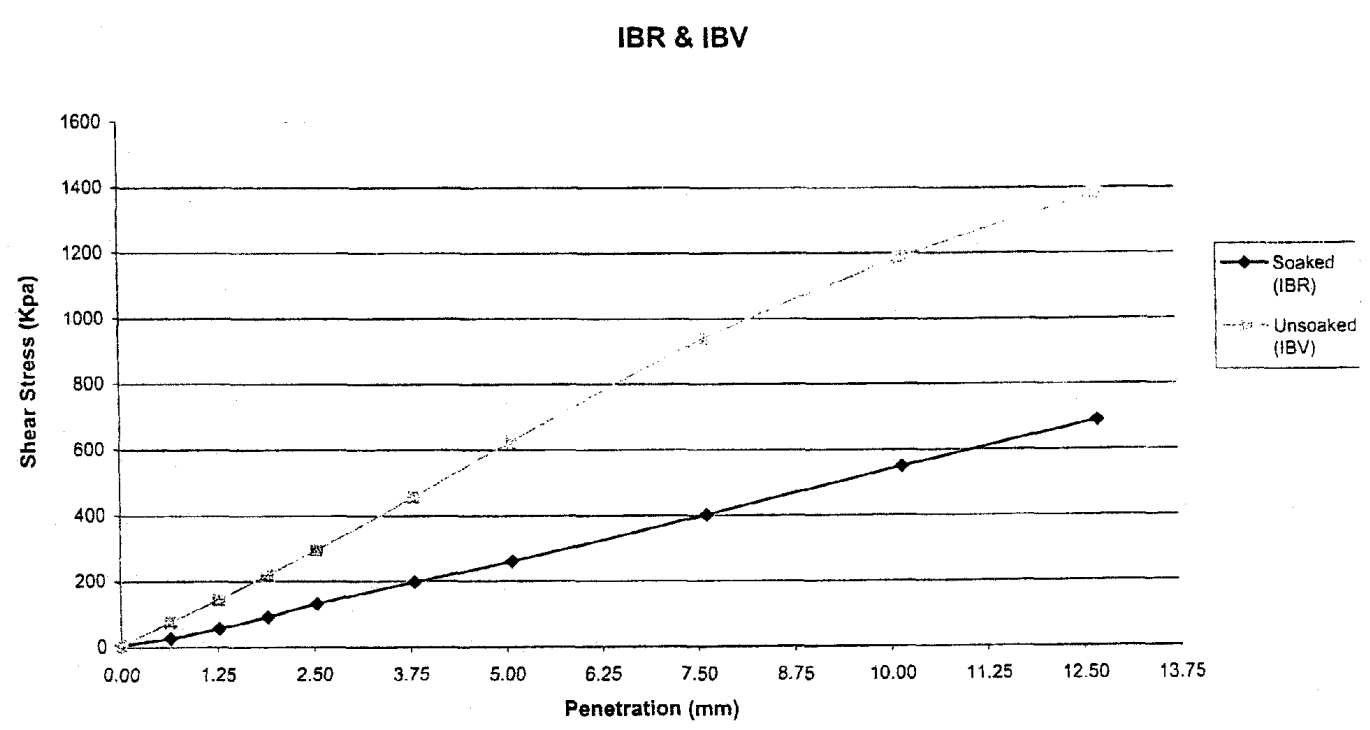
REMARKS :-

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

IBR &IBV TEST AASHTO T19

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie Street,Chicago, IL 60611								
File No.	2355	Date	3/27/2002	Report No	1	Tested By	AK	Checked By	SM

Sample ID	SALS			Dry Density(pcf)	60.0
Source of Material	Stickney WRP			Moisture Content(%)	49.0
Description of Soil	Black Aged Low Solids		Date of Soaking	3/22/02	
Initial Swell Reading	7 27	Final Swell Reading	0 160	Swell Percent	2.53



IBR (%)	@2.54mm	**1.92**	@5.08mm	**2.52**	
IBV (%)	@2.54mm	**4.30**	@5.08mm	**6.05**	

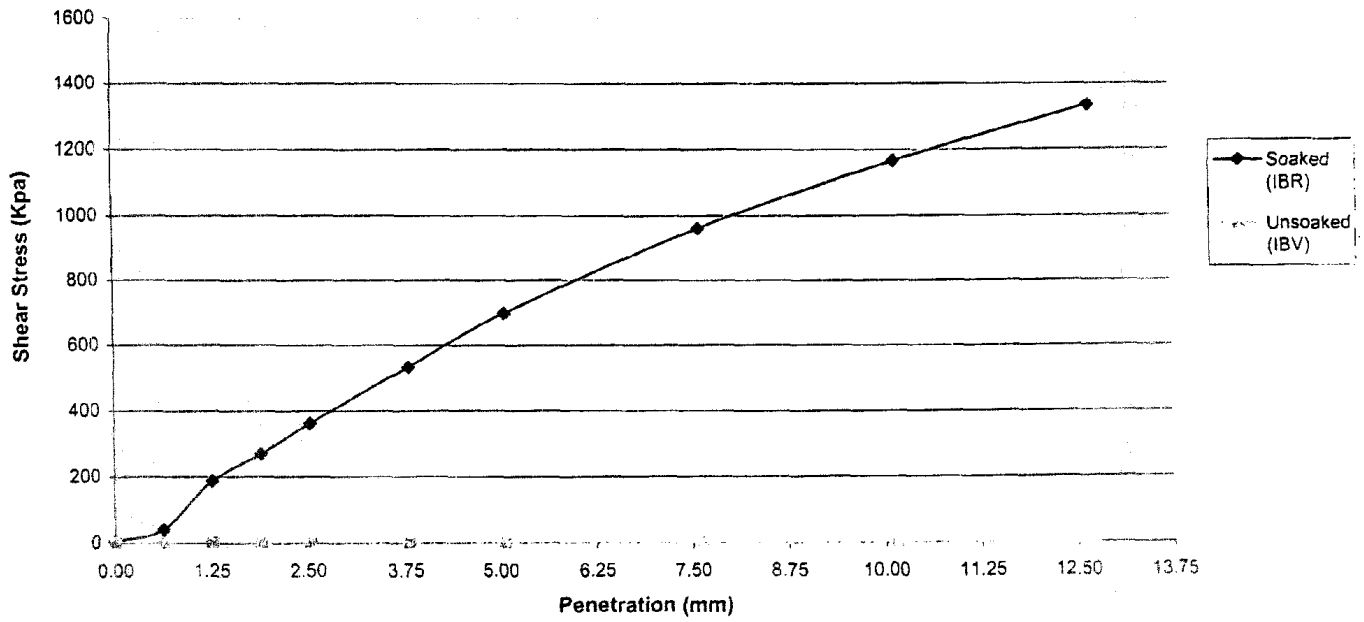
REMARKS :-

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

IBR &IBV TEST AASHTO T193

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie street,Chicago, IL 60611								
File No.	2355	Date	9/16/2002	Report No	1	Tested By	NP	Checked By	SB

Sample ID	SAHS			Dry Density(pcf)	68.0
Source of Material	Stickney WRP			Moisture Content(%)	37.0
Description of Soil	Black Aged High Solids		Date of Soaking	9/11/02	
Initial Swell Reading	0 143	Final Swell Reading	19 65	Swell Percent	0.56



IBR (%)	@2.54mm	**5.25**	@5.08mm	**6.74**	
IBV (%)	@2.54mm		@5.08mm		

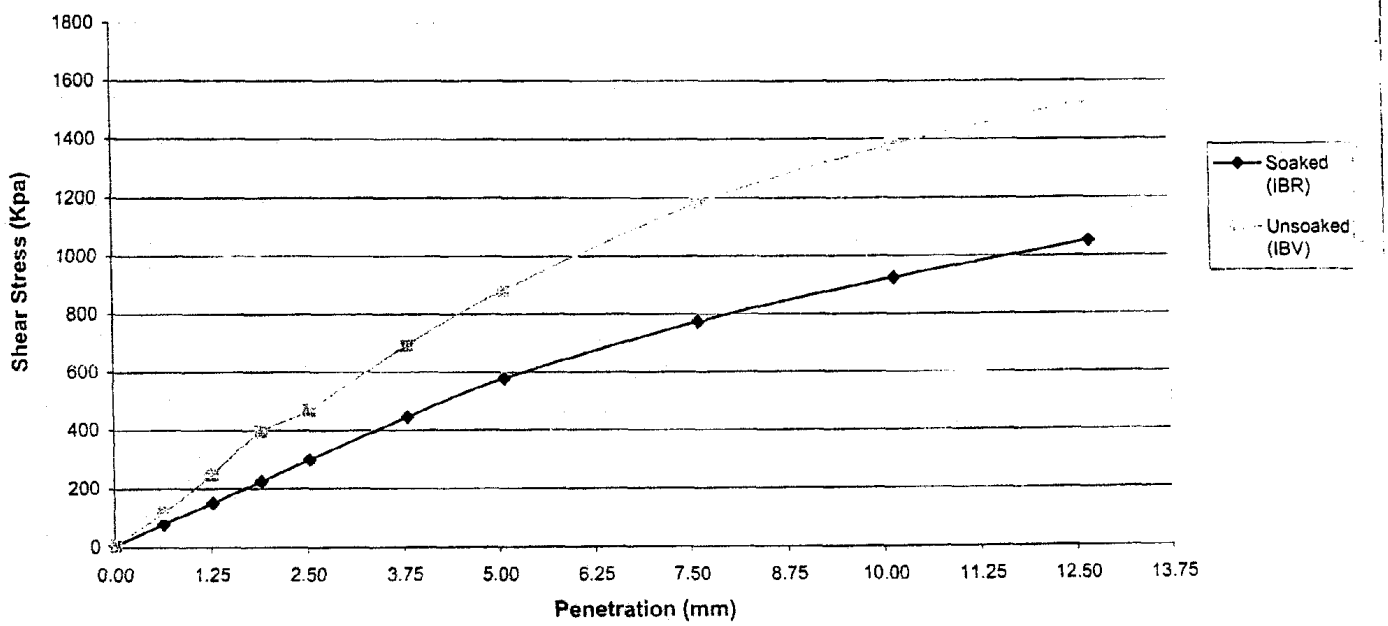
REMARKS :-

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

IBR &IBV TEST AASHTO T193

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District100, East Erie street,Chicago, IL 60611								
File No.	2355	Date	3/27/2002	Report No	1	Tested By	AK	Checked By	SM

Sample ID	RFP10-Ref#2-SAHS-1001			Dry Density(pcf)	72.0
Source of Material	SWRP-Lagoon 24 HASMA			Moisture Content(%)	33.0
Description of Soil	Black Aged High Solids		Date of Soaking	3/22/02	
Initial Swell Reading	10 99	Final Swell Reading	7 50	Swell Percent	1.30



IBR(%)	@2.54mm	4.33	@5.08mm	5.58	
IBV(%)	@2.54mm	6.81	@5.08mm	8.51	

REMARKS:-

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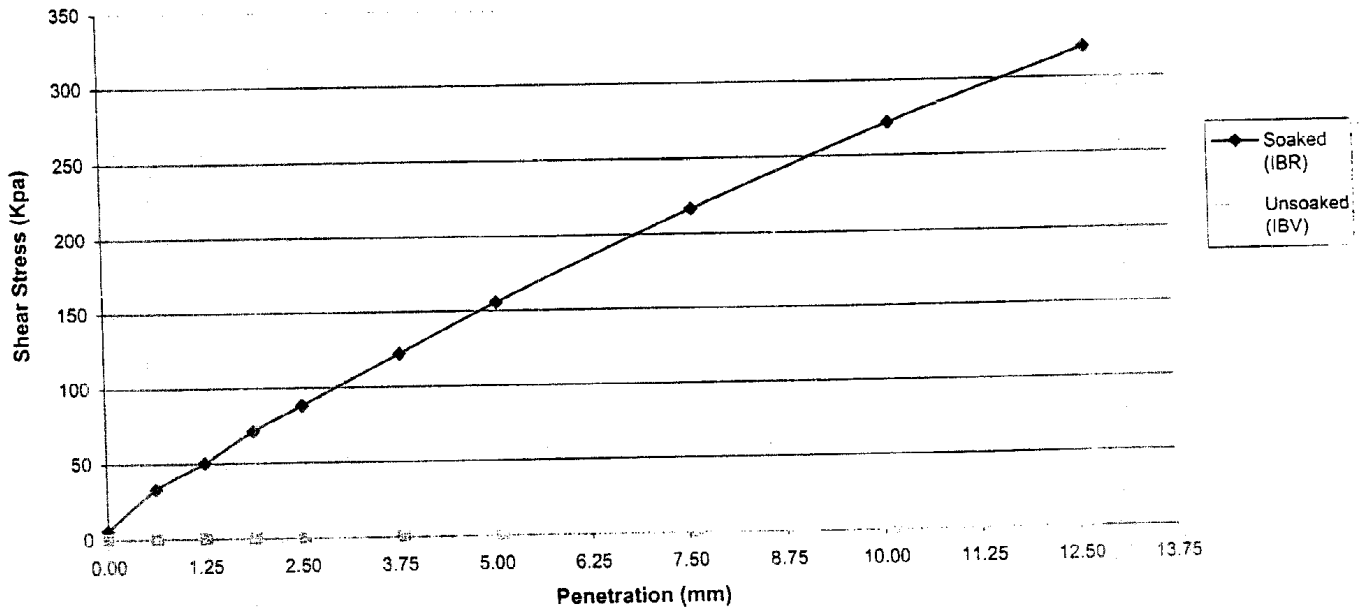
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

IBR &IBV TEST AASHTO T193

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie street,Chicago, IL 60611								
File No.	2355	Date	9/23/2002	Report No	1	Tested By	NP	Checked By	SB

Sample ID	SULS			Dry Density(pcf)	68.0
Source of Material	Stickney WRP			Moisture Content(%)	37.0
Description of Soil	Black Under-aged Low Solids		Date of Soaking	9/18/02	
Initial Swell Reading	19 108	Final Swell Reading	9 106	Swell Percent	4.00

IBR & IBV



IBR (%)	@2.54mm	1.28	@5.08mm	1.50	
IBV (%)	@2.54mm		@5.08mm		

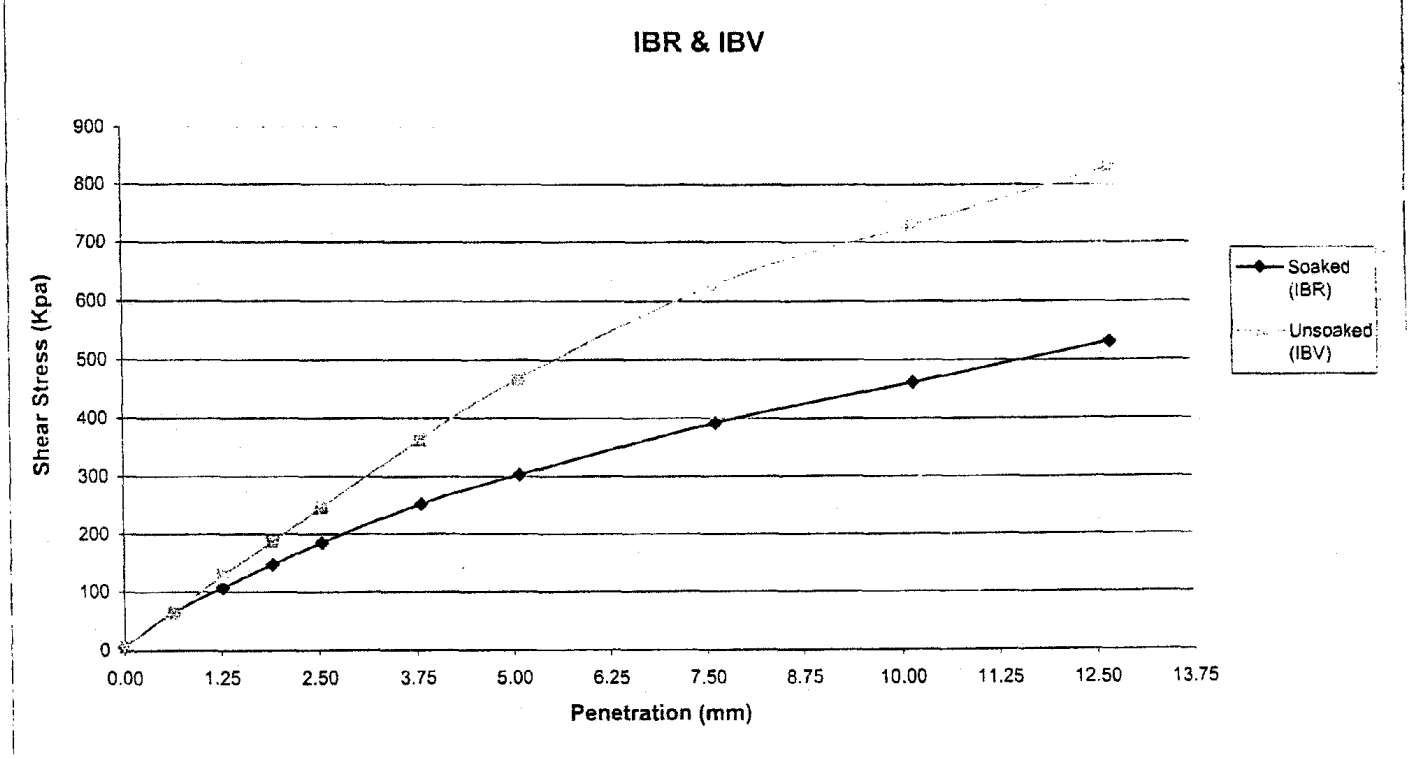
REMARKS :-

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

IBR &IBV TEST AASHTO T193

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District100, East Erie street,Chicago, IL 60611								
File No.	2355	Date	3/27/2002	Report No	1	Tested By	AK	Checked By	SM

Sample ID	SULS			Dry Density(pcf)	58.0
Source of Material	Stickney WRP			Moisture Content (%)	49.0
Description of Soil	Black Under-aged Low Solids		Date of Soaking	3/22/02	
Initial Swell Reading	10-90	Final Swell Reading	3-118	Swell Percent	2.74



IBR (%)	@2.54mm	**2.68**	@5.08mm	**2.93**	
IBV (%)	@2.54mm	**3.57**	@5.08mm	**4.52**	

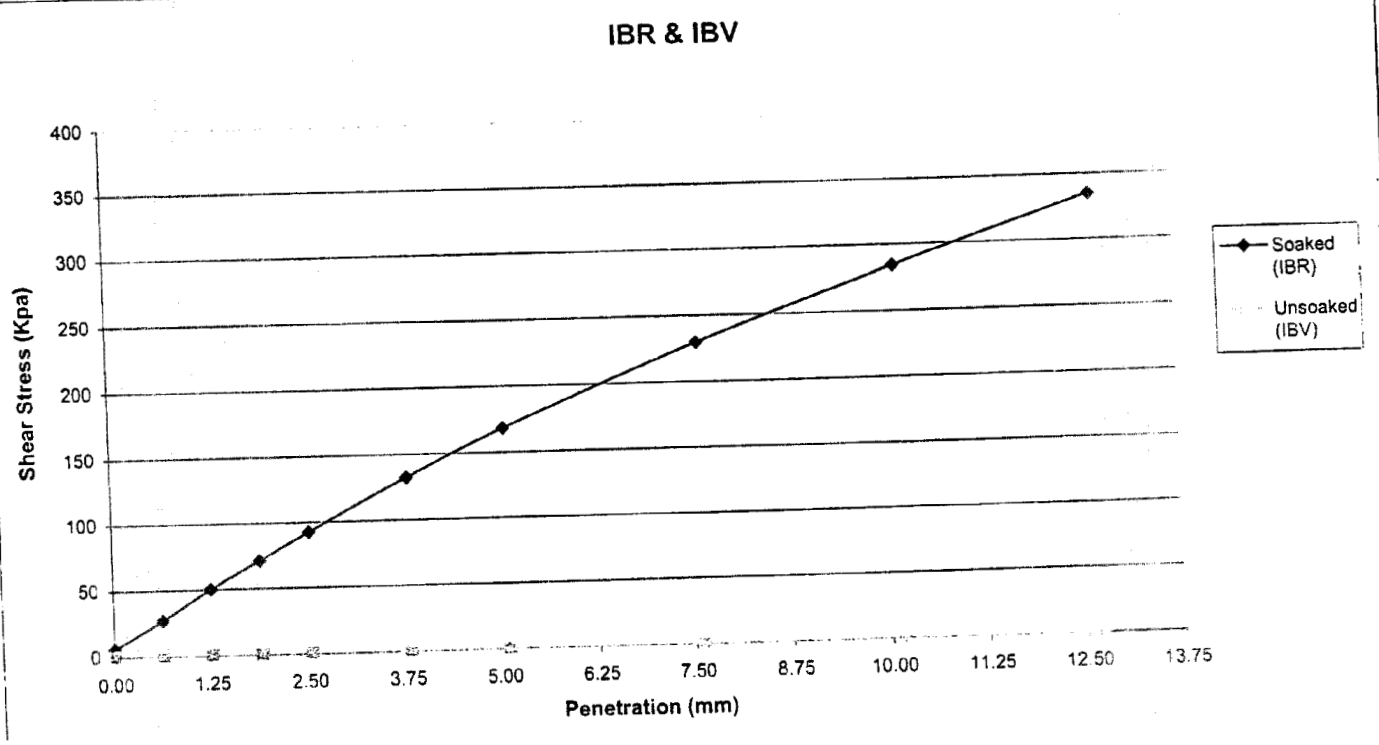
REMARKS:-

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

IBR &IBV TEST AASHTO T193

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie street,Chicago, IL 60611								
File No.	2355	Date	9/16/2002	Report No	1	Tested By	NP	Checked By	SB

Sample ID	SUHS			Dry Density(pcf)	62.0
Source of Material	Stickney WRP			Moisture Content(%)	44.0
Description of Soil	Black Under-aged HighSolids		Date of Soaking	9/12/02	
Initial Swell Reading	19 47	Final Swell Reading	13 172	Swell Percent	2.15



IBR (%)	@2.54mm	1.34	@5.08mm	1.63	
IBV (%)	@2.54mm		@5.08mm		

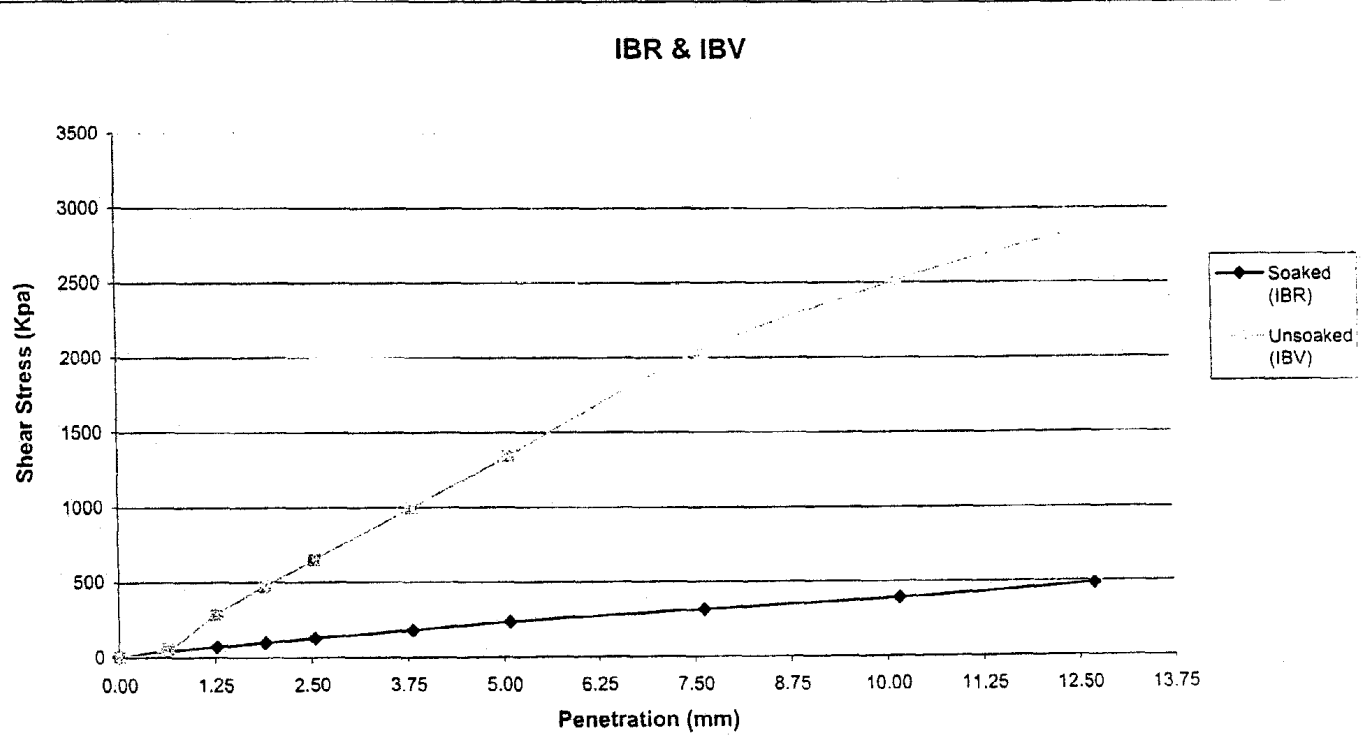
REMARKS :-

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

IBR &IBV TEST AASHTO T19

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District100, East Erie street,Chicago, IL 60611								
File No.	2355	Date	3/30/2002	Report No	1	Tested By	AK	Checked By	SM

Sample ID	SUHS			Dry Density(pcf)	68.0
Source of Material	Stickney WRP			Moisture Content(%)	32.2
Description of Soil	Black Under-aged High Solids		Date of Soaking	3/26/02	
Initial Swell Reading	8-32	Final Swell Reading	0-159	Swell Percent	2.95



IBR(%)	@2.54mm	1.86	@5.08mm	2.26	
IBV(%)	@2.54mm	9.41	@5.08mm	13.00	

REMARKS :-

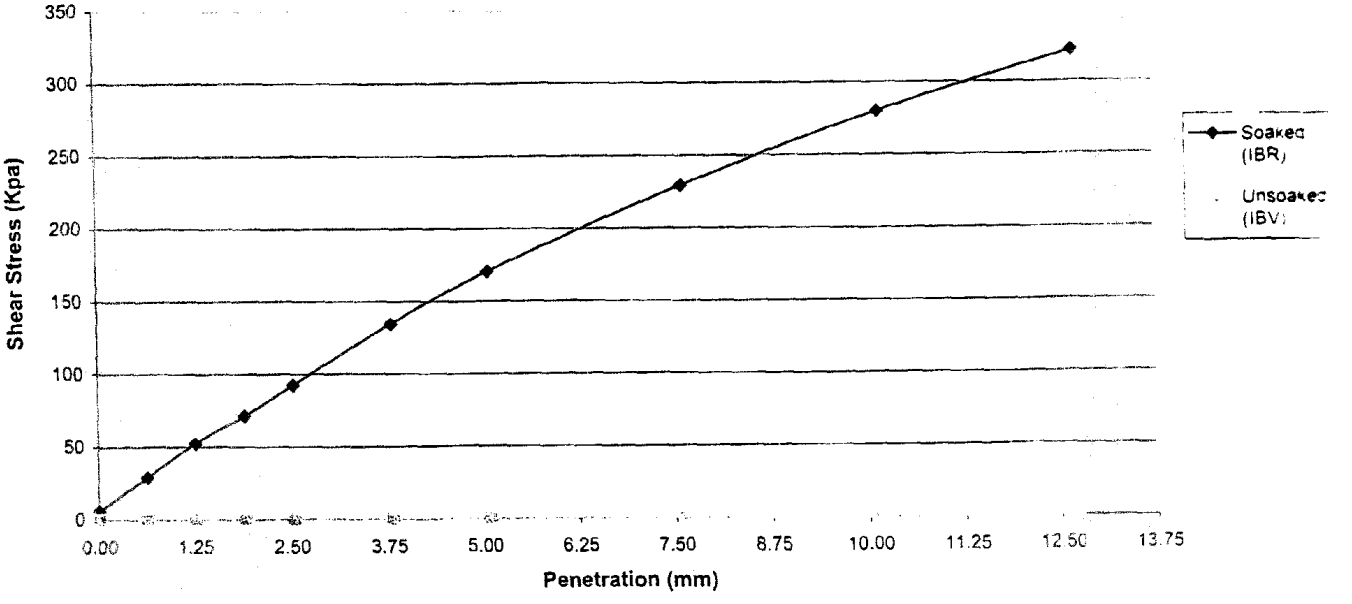
Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

IBR &IBV TEST AASHTO T193

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie street,Chicago, IL 60611								
File No.	2355	Date	9/23/2002	Report No	1	Tested By	NP	Checked By	SB

Sample ID	CAHS			Dry Density(pcf)	62.0
Source of Material	Calumet WRP			Moisture Content(%)	44.0
Description of Soil	Black Under-aged HighSolids		Date of Soaking	9/18/02	
Initial Swell Reading	18 140	Final Swell Reading	15 57	Swell Percent	1.37

IBR & IBV



IBR (%)	@2.54mm	1.34	@5.08mm	1.65	
IBV (%)	@2.54mm		@5.08mm		

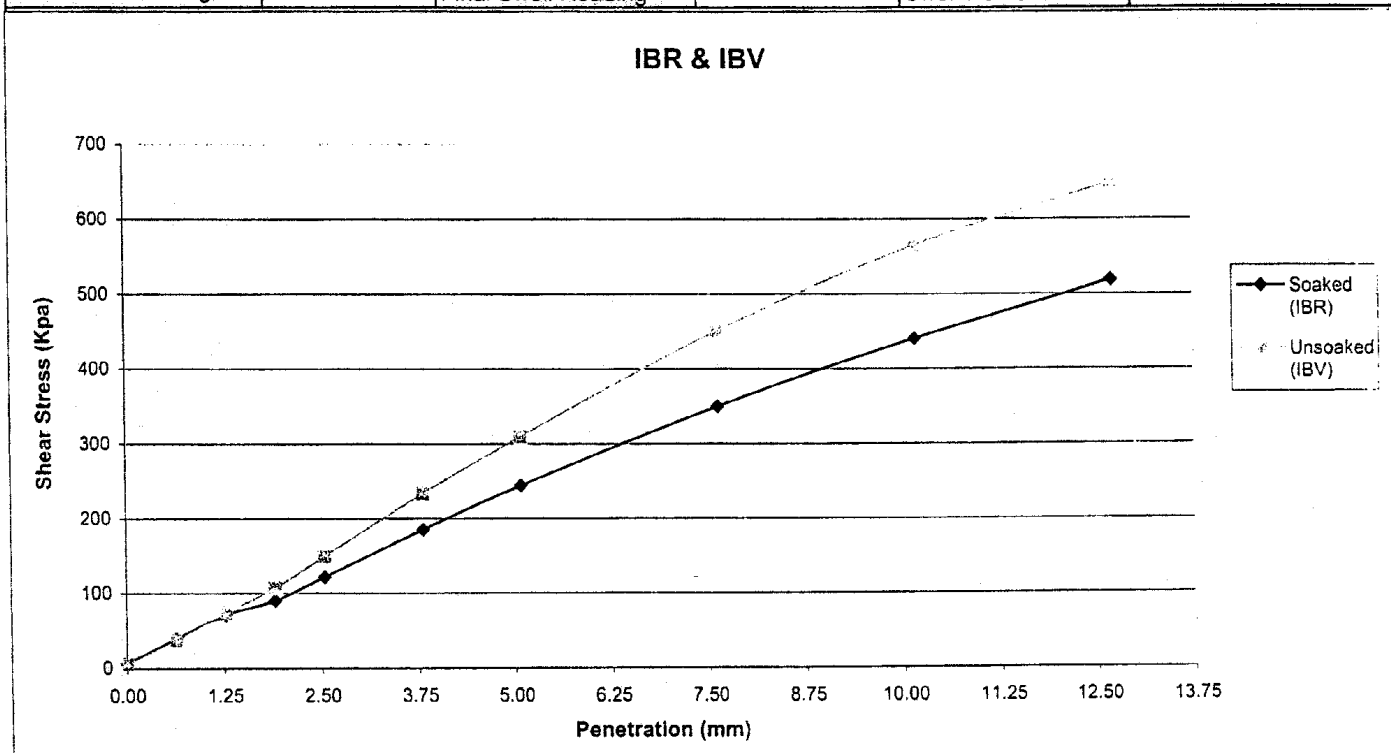
REMARKS :-

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

IBR &IBV TEST AASHTO T193

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District100, East Erie street,Chicago, IL 60611								
File No.	2355	Date	3/29/2002	Report No	1	Tested By	AK	Checked By	SM

Sample ID	CAHS			Dry Density(pcf)	51.0
Source of Material	Calumet WRP			Moisture Content(%)	64.0
Description of Soil	Black Aged High Solids		Date of Soaking	3/22/02	
Initial Swell Reading	9-193	Final Swell Reading	4-142	Swell Percent	2.10



IBR(%)	@2.54mm	**1.77**	@5.08mm	**2.36**	
IBV (%)	@2.54mm	**2.16**	@5.08mm	**2.99**	

REMARKS:-

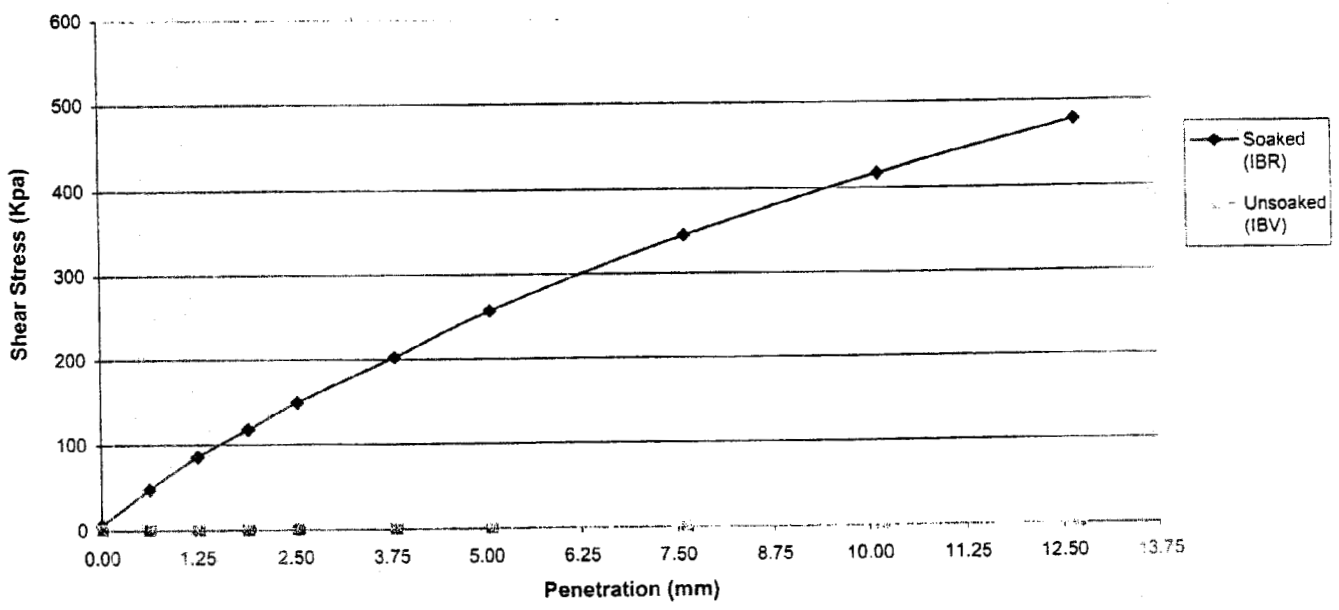
Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

IBR &IBV TEST AASHTO T193

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District, 100 East Erie street,Chicago, IL 60611								
File No.	2355	Date	9/22/2002	Report No	1	Tested By	NP	Checked By	SB

Sample ID	CALS			Dry Density(pcf)	62.0
Source of Material	Calumet WRP			Moisture Content(%)	44.0
Description of Soil	Black Aged HighSolids		Date of Soaking	9/18/02	
Initial Swell Reading	18 115	Final Swell Reading	16 187	Swell Percent	0.66

IBR & IBV



IBR (%)	@2.54mm	**2.16**	@5.08mm	**2.48**	
IBV (%)	@2.54mm		@5.08mm		

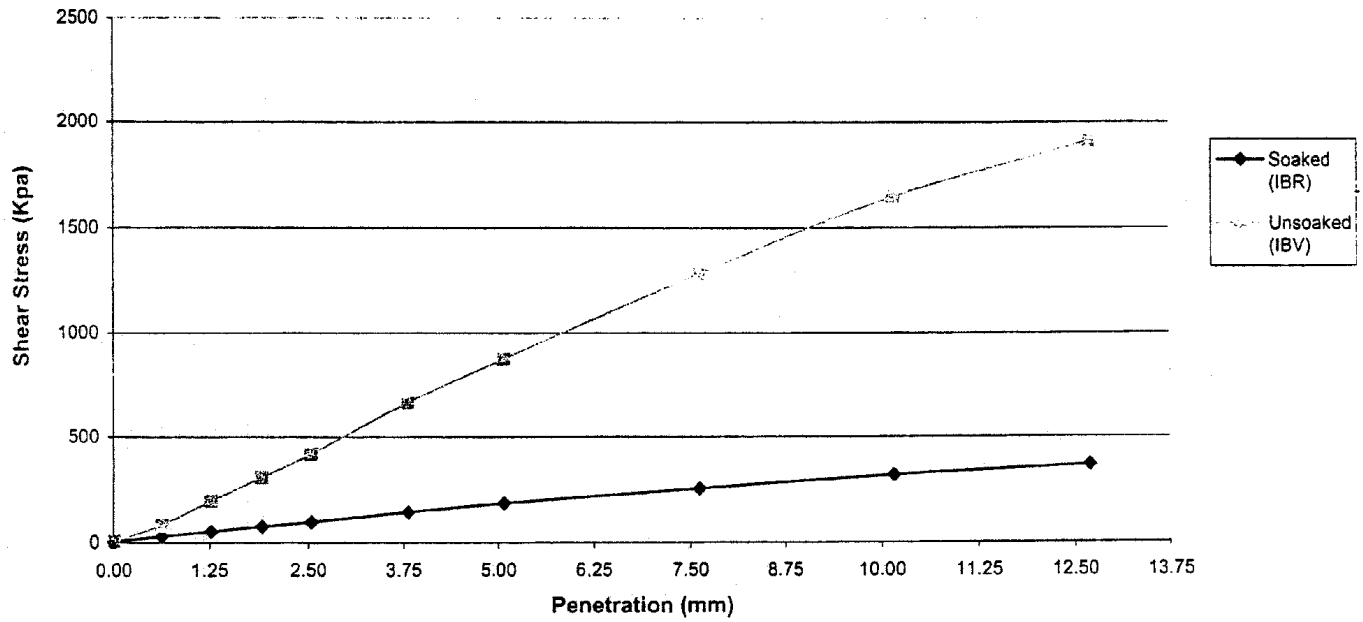
REMARKS :-

Great Lakes Soil & Environmental Consultants, Inc.
333 Shore Drive., Burr Ridge, IL 60521. Ph: (630) 321-0944 Fax: (630) 321-0945

IBR &IBV TEST AASHTO T193

Project	Geotechnical Characterization of Biosolids								
Client	Metropolitan Water Reclamation District100, East Erie street,Chicago, IL 60611								
File No.	2355	Date	3/27/2002	Report No	1	Tested By	AK	Checked By	SM

Sample ID	CALS			Dry Density(pcf)	60.0
Source of Material	Calumet WRP			Moisture Content(%)	45.0
Description of Soil	Black Aged Low Solids		Date of Soaking	3/22/02	
Initial Swell Reading	10-96	Final Swell Reading	19-169	Swell Percent	4.25



IBR(%)	@2.54mm	1.40	@5.08mm	1.79	
IBV(%)	@2.54mm	6.05	@5.08mm	8.45	

REMARKS:-