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October 5, 2005

Mr. Chris Dopp. PE
City of Battle Creek DPW/Engineering Division
150 South Kendal Street
Battle Creek, Michigan 49015-2271

RE: The City of Battle Creek Materials Testing Services
Willard Beach Porous Pavements
Battle Creek, Michigan
SME Project No. KP50021K

Dear Mr. Dopp:

SME has completed the pavement subgrade evaluation and design for the referenced project. This letter presents a summary of our field evaluation procedures, our findings, and recommendations for porous pavement design and construction.

EXISTING SITE CONDITIONS/PROJECT DESCRIPTION

The project site is located at the existing Willard Beach Park located at 950 Northeast Capital Avenue in Battle Creek, Michigan. We understand the project will consist of reconstruction of the existing pavements to integrate a porous pavement design. A proposed grading plan was not available for our use in developing these pavement recommendations. We assume the final pavement grades will remain generally unchanged after completion of the construction activities. These recommendations should be considered preliminary until we review a final grading/paving plan.

Specific traffic information was not provided for use in developing pavement recommendations. We anticipate traffic at the site to consist of automobiles, light duty passenger trucks, maintenance vehicles, and occasional refuse haulers. Based on the use of a porous pavement section we recommend a uniform pavement section throughout the pavement area. For design of the heavy-duty pavement sections, we have assumed that less than 100,000 Equivalent Single Axle Loads (ESALs) (less than three heavy vehicles per day) will occur over a twenty-year period. Should these traffic assumptions be found incorrect, SME should be contacted and asked to revise these recommendations accordingly.

EVALUATION PROCEDURES

Three soil probes (B1 through B3) were performed by SME on September 7, 2005. The soil probes extended approximately 12 to 16 feet below the existing pavement surface. The approximate locations of the soil probes are shown on the Soil Probe Location Diagram included as an attachment to this letter. The number, locations, and depths of the soil probes were

Plymouth
Bay City
Grand Rapids
Kalamazoo
Lansing
Shelby Township
Toledo

selected by The City of Battle Creek and SME. The soil probes were advanced using an all terrain vehicle (ATV) mounted hydraulic push Geoprobe device.

Groundwater level measurements were recorded immediately after completion of the soil probes at each location. After probing was completed, the soil probes were backfilled with cuttings and the pavement surface was patched with commercial asphalt cold patch. Therefore, long-term groundwater level information is not available from the soil probe locations.

LABORATORY TESTING

The general laboratory testing program consists of performing visual soil classification on the recovered samples, along with moisture content and hand penetrometer tests on portions of cohesive samples obtained. A constant head permeability test was performed on samples of the granular soils encountered for design of the porous pavement system. The test method used for the constant head permeameter was consistent with ASTM D2434-68 (2000), Standard Test Method for Permeability of Granular Soils (Constant Head).

The soil samples were visually classified in general accordance with the Unified Soil Classification System (USCS). The estimated group symbol, according to the USCS, is shown in parentheses following the textural description of the various strata on the soil probe logs. The appended General Notes sheet includes a brief summary of the general method of describing the soil and assigning an appropriate USCS group symbol.

Soil samples retained over a long time, even in sealed jars, liner samples, or plastic bags are subject to moisture loss and are no longer representative of the conditions initially encountered in the field. Therefore, soil samples are normally retained in our laboratory for 60 days and then disposed, unless instructed otherwise.

SUBSURFACE CONDITIONS

Approximately 3.0 to 4.0 inches of asphalt concrete was encountered at soil probes B1 through B3. No aggregate base was encountered underlying the asphalt concrete. Variable textured sand fill was encountered underlying the pavement at soil probe B1 to a depth of 3.5 feet below the ground surface. Natural silty clay was encountered underlying the pavement or sand fill at soil borings B1 and B2 to a depth of 2.5 to 8.5 feet below the ground surface. The estimated shear strength of the natural silty clay ranged from 2.0 ksf to greater than 4.5 ksf, indicating a very stiff to hard condition. The moisture content of the silty clay ranged from 10 to 21 percent. Natural variable textured sand was encountered underlying the sand fill, natural clay, or pavement at soil borings B1 through B3 to the explored depths of the soil borings.

Groundwater

Groundwater was not encountered at the soil probe locations. Hydrostatic groundwater levels should be expected to fluctuate throughout the year, based on variations in precipitation, evaporation, run-off and other factors. The groundwater levels discussed herein, and indicated on the soil probe logs, represent the conditions at the time the measurements were obtained. Groundwater conditions at the time of construction could vary.

The soil descriptions and properties, in addition to groundwater conditions observed by the driller, are presented in the soil probe logs attached to this report. Please refer to the soil probe logs for the detailed soil information at the specific soil probe locations.

ANALYSIS AND RECOMMENDATIONS

Constant Head Permeability Testing

A constant head permeability test was performed on representative granular samples from each of the soil probe locations the depths are indicated in the table below. As stated in the Porous Pavement System Recommendations section of this report, the permeability test results assume the removal of the impermeable silty clay layers encountered at soil probes B1 and B2. The coefficient of permeability obtained, and the corresponding infiltration rate, is presented in the following table.

PERMEABILITY TEST RESULTS				
Sample	Elevation of Tested Sample	USCS Group Symbol	Coefficient. of Permeability (k)	Infiltration Rate
B1	8.5 to 12 Feet Below Existing Grades	SP	1.3×10^{-2} cm/sec	16 in/hr
B2	4.0 to 8.0 Feet Below Existing Grades	SP	1.0×10^{-2} cm/sec	14 in/hr
B3	4.0 to 8.0 Feet Below Existing Grades	SP	1.3×10^{-2} cm/sec	16 in/hr

Based on published empirical correlations between grain size and permeability, and our experience with similar soils, the coefficients of permeability obtained are generally consistent with the permeability characteristics or relatively clean sands, and sand/gravel mixtures. The tested soils can generally be characterized as having medium permeability, and should generally be suitable for infiltration drainage in a porous pavement system.

The design seepage rate may also be dependent on factors not related to the soil coefficient of permeability. Variations in field conditions relative to the laboratory test conditions should be considered when choosing the design seepage rate. Some reduction in the infiltration rate could occur over time due to silting of the basin bottom. SME recommends that once bottom of basin elevation is achieved that in-place percolation tests be performed to confirm laboratory infiltration rates. The basin design for the porous pavement system should take into account several factors such as city township/county/state requirements, and frost penetration. *Additionally, a source for the 1 to 3 inch reservoir material specified below should be determined prior to the design of the project to calculate the void space for design of the basin volume.*

Porous Pavement System Recommendations

Overall, based on the soil borings and the constant head permeability testing, the granular subgrade soils encountered are considered to be suitable for the construction of a porous pavement system. Prior to any construction on the site it is essential that silt fence is installed and maintained on the site to minimize silting of the porous pavement system. SME recommends the silt fence be maintained until any disturbed green areas have fully developed vegetation. Green areas should also be designed to slope away from the porous pavement area.

To reduce the possibility of frost related damage, we recommend the porous pavement section be designed to exceed the depth of frost penetration in the region. Therefore, we recommend designing the basin bottom a minimum 42 inches from the proposed top of pavement elevations. This minimum depth should be maintained even if design volumetric calculations indicate a shallower basin could be used. We recommend the basin extend a minimum of 12 inches beyond the edge of pavement surfaces. We also recommend the basin sidewalls be designed with a 2:1 slope to allow for proper drainage of the pavement system.

Based on the soils encountered at soil probes B1 and B2, we recommend the silty clay be removed and any deficiencies in grade should be replaced with engineered fill consisting of MDOT Class II granular fill. Individual fill layers should not exceed 12 inches in loose thickness and be compacted to a *maximum* of 90 percent of the maximum soil dry density based on the Modified Proctor Test. We recommend compaction be achieved by tracking the material with a bull dozer or making a minimal number of passes using a smooth drum static roller. In cut areas we recommend keeping construction traffic to a minimum so not to compact the underlying natural soils. If the silty clay layer found at boring location B1 is found to be extensive, it may be possible to design this area to drain to adjacent basin areas. We recommend that test pits be performed to evaluate the extent of this area.

The porous asphalt surface should be designed to have a maximum 4 percent slope while the basin bottom should be designed to remain relatively flat with minimal sloping to allow for optimum drainage of accumulated stormwater. Based on the grades observed at the Willard Beach site, the underlying basin bottom will have to be benched using berms. Berms should be designed with 2:1 sloped walls and a 3 foot wide crown as shown in *figure 1*. If it is necessary to use a slope greater than 4 percent it would be necessary to integrate non-porous and porous pavements. If a system of combined porous and non-porous pavements will be used on the project, SME should be contacted and given the opportunity to revise our recommendations accordingly.

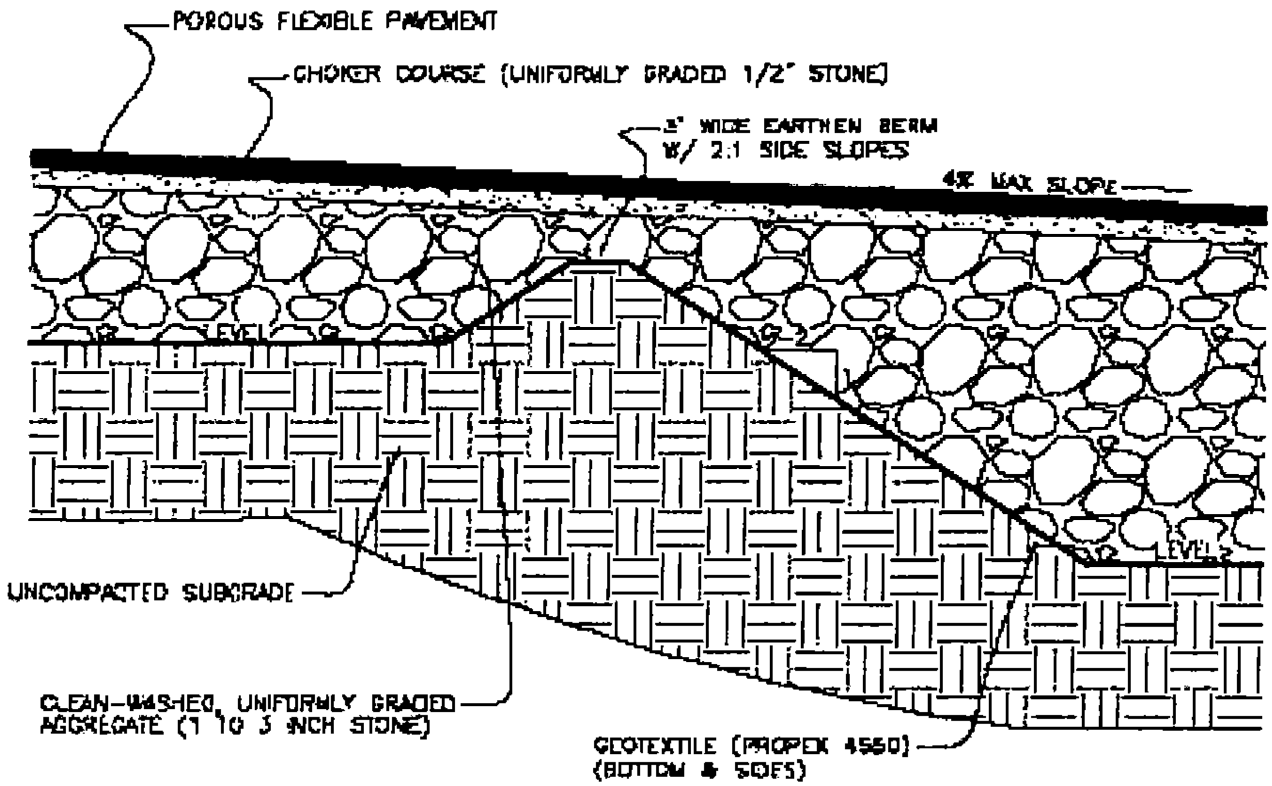

Figure 1: Subgrade Benching

Once the designed elevations and benching are achieved, we recommend a layer of non-woven geotextile fabric consisting of Propex (Amoco) 4550 be installed on the basin bottom and walls allowing for 4 feet of overlap on the top of the basin. The geotextile fabric should be installed according to the manufacturer's instructions. However, care should be taken not to allow construction equipment to come in direct contact with the geotextile fabric. The aggregate for the reservoir coarse should consist of a well-graded crushed concrete or crushed natural aggregate ranging from about 1 to 3 inches in size, with no more than 2 percent passing the No. 200 sieve. *As stated previously, a source for the reservoir material should be determined prior to the design of the project to calculate the void space for design of the basin volume.* The 1 to 3 inch aggregate should be "end dumped" onto the site and pushed overtop of the geotextile fabric layer with a bulldozer. The remaining 4 feet of geotextile fabric around the perimeter of the basin should then be folded onto the top of the reservoir surface. A 2 inch "choker" layer of well-graded ½ inch crushed aggregate with no more than 2 percent passing the No. 200 sieve should be placed at the surface of the reservoir coarse to allow for construction of the porous asphalt concrete section. *All of the aggregate used on this project should be washed. Any material passing the No. 200 sieve in excess of 2 percent will be detrimental to the permeability of the basin bottom and reduce the porous pavement system life.*

Undercutting of impermeable soils, and replacement with engineered fill, may be required in some areas in order to provide a permeable subgrade. Therefore, contingencies for these items should be included in the project budget, and unit prices should be obtained from prospective contractors. A qualified geotechnical/pavement engineer (SME) should determine undercuts based on field conditions during construction.

Recommended Pavement Sections

The recommended pavement section was selected based on the information presented in the previous sections of this report and our experience with low traffic volume pavements in the area. The recommended pavement section is considered the minimum pavement section required to carry the expected light traffic loading previously described. Based on our understanding of the project, the asphalt contractor will be responsible for the design of the porous asphalt mix design. However, we recommend the asphalt concrete mix design incorporate a minimum of 6.0 percent polymer modified asphalt cement consisting of a minimum PG 70-22P. The mix should also be designed with a minimum of 18 percent air voids.

These recommendations assume typical conditions during the June through September construction season. Any substitution of materials or deviation from these stated assumptions should be reviewed to assess potential impact on the recommended design.

The table presents the layer material and thickness recommendations for the porous asphalt concrete sections:

STANDARD-DUTY NEW PAVEMENT AREAS RECOMMENDED MATERIALS AND LAYERS		
LAYER	**MATERIAL**	**THICKNESS (in.)**
Bituminous Wearing	Porous Asphalt	4.0
Choker Course	1/2 Inch Crushed *Washed* Stone	2.0
Reservoir Course	1 to 3 Inch Crushed *Washed* Stone	42.0 (Minimum)

Construction activities should not be planned concurrent with the pavement reconstruction. The asphalt concrete section is not designed to carry construction traffic without damage and patching of porous pavements could be difficult, expensive, and aesthetically unappealing. We recommend SME be contacted if concurrent construction activities are planned.

Inspection and Maintenance

Routine inspections during the service life of the pavement should be included in the project budget. Inspections conducted during the first year of service should coincide with large storm events to check for accumulated water on the pavement surface indicating possible clogging of the asphalt surface. In the case of light to moderate clogging, the pavement surface should be vacuum swept or pressure washed. If vacuum sweeping or pressure washing does not alleviate the problem this may indicate a failure of the porous asphalt surface. As stated previously, silt fencing should also be inspected and maintained until the green areas surrounding the porous pavement area have fully redeveloped vegetation in order to minimize silting of the pavement surface.

Maintenance of the porous pavement system should consist of routine vacuuming of the pavement surface (Minimum of two times year) and reseeding of surrounding green areas to maintain vegetation and minimize silting of the pavement surface. If the park is open during the winter months we do not recommend the use of salt or sand on the pavement surface. We recommend the use of liquid de-icing agents with porous pavements. We also recommend the use of appropriate signage to alert maintenance personnel of porous pavements. Crack sealing and seal coating are detrimental to the design pavement life of a porous pavement system.

Engineered Fill Requirements

Any fill placed within pavement areas, including utility trench backfill, should be an approved material, free of frozen soil, organics, or other deleterious materials. The fill should be spread in level layers not exceeding 12 inches in loose thickness and be compacted to a maximum of 90 percent of the maximum dry density as determined in accordance with the Modified Proctor Test.

Based on the information from the soil probes, the material classified as SP may meet the requirements of MDOT Class II granular material and could be used as engineered fill in undercuts performed to remove impermeable maters. Silty clay encountered in our soil probes should not be used as engineered fill under the pavement system. This material should be removed from the site or used in the green areas.

GENERAL COMMENTS

This letter report has been prepared in accordance with generally accepted geotechnical and pavement engineering practices to assist in the design of this project. This letter report provides recommendations regarding earthwork activities, engineered fill requirements, and pavement recommendations based on the subsurface information collected during this evaluation. If the project design criteria is changed, the conclusions and recommendations contained in this letter report are considered invalid unless the changes are reviewed, and the conclusions of this report are modified or approved in writing by our office.

The discussion and recommendations submitted in this letter are based upon the data obtained from the three soil probes performed at the approximate locations indicated on the soil probe location diagram. This report does not reflect variations, which may occur between or away from the soil probes. The nature and extent of the variations may not become evident until further geotechnical evaluation at the site is performed, or until the time of construction. If significant variations then become evident, it may be necessary for us to reevaluate the recommendations of this report.

In the process of obtaining and testing samples and preparing this report, procedures are followed that represent reasonable and accepted practice in the field of soil and foundation engineering. Specifically, field logs are prepared during the sampling operations that describe field occurrences, sampling locations, and other information. Samples obtained in the field are frequently subjected to additional testing and reclassification in the laboratory, and differences may exist between the field logs and the final logs. The engineer preparing the report reviews the field logs, laboratory classifications, and test data, and then prepares the final logs. Our recommendations are based on the contents of the final logs and the information contained therein.

The site earthwork operations and pavement construction activities should be observed and tested by SME. SME is well suited to verify subgrade soils are stable for placement of engineered fill and pavements, and to verify the engineered fill is properly placed and compacted.

This report and any future addenda or reports should be made available to bidders prior to submitting their proposals and to the successful contractor and subcontractors for their information only and to supply them with facts relative to the subsurface evaluation and laboratory test results. Furthermore, the contractor should be prepared to handle environmental conditions encountered at this site, which may affect the excavation, removal, or disposal of soil; dewatering of excavations; and health and safety of workers. Any Environmental Assessment reports prepared for this property should be made available for review by bidders and the successful contractor.

The scope of our services does not include any environmental assessment of investigations for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater or air, on or below around this site. We will be glad to provide these services if requested.

We appreciate the opportunity to serve you during this phase of the project. If there are any questions concerning this letter, or if we can be of further service, please contact us.

Very truly yours,

SOIL AND MATERIALS ENGINEERS, INC.

J. Art Johnson, CET
Project Manager, Senior Consultant

Written By:

Andrew P. Foster, EIT
Senior Engineer

Reviewed By:

Starr D. Kohn, Ph.D., PE
Vice President

Attachments: Important Information about your Geotechnical Engineering Report
Soil Probe Location Diagram
General Notes
Unified Soil Classification System (USCS)
Soil Probe Logs (B1 through B3)

Enclosure: Two Photocopies

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Important Information About Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

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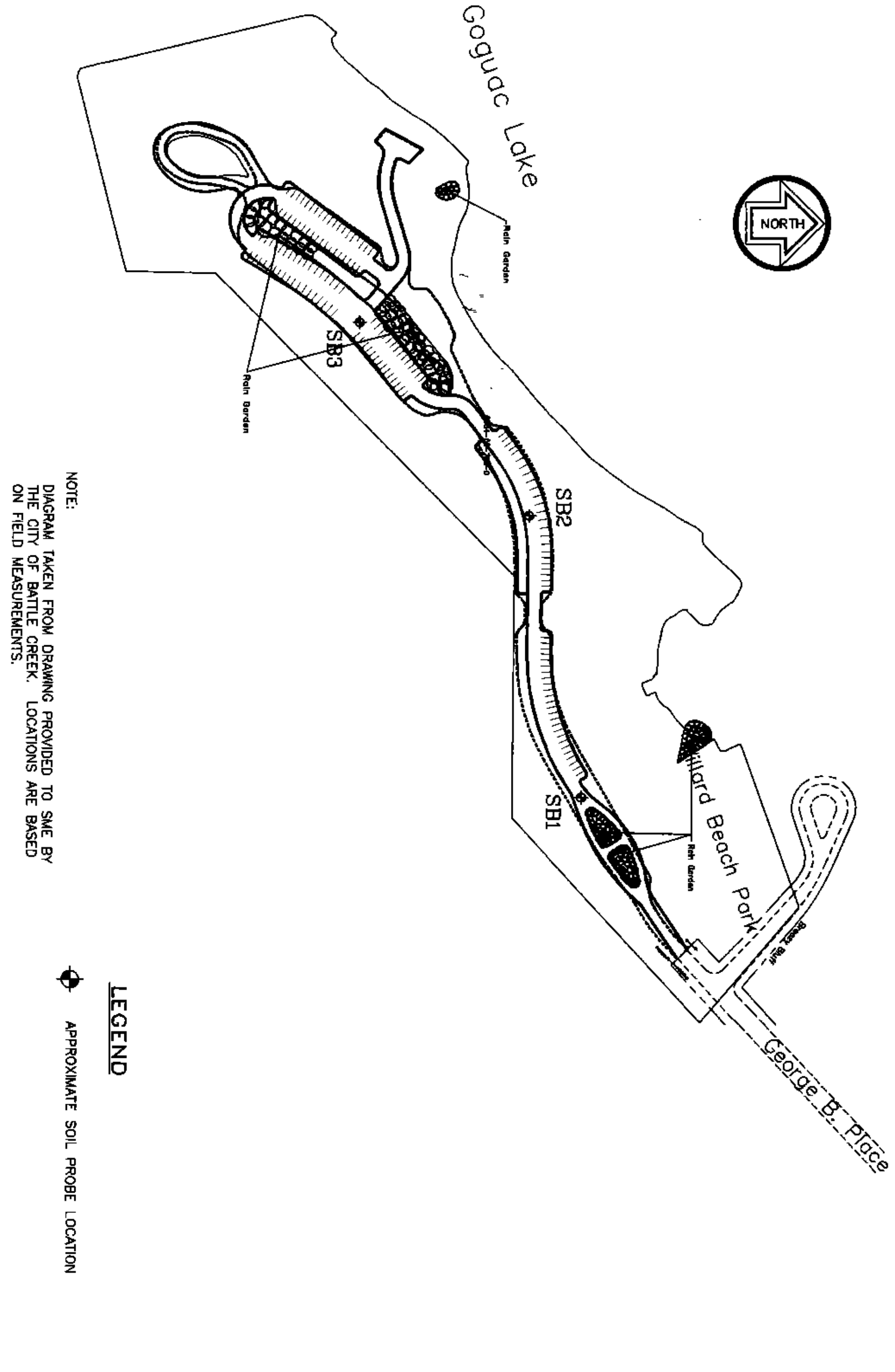

sme

BAY CITY GRAND RAPIDS KALAMAZOO
LANSING PLYMOUTH TOLEDO

DATE: 9/23/05
SCALE: 1" = 200'
DRAFTER: JLS
JOB: KP50021K

SOIL PROBE LOCATION DIAGRAM
WILLARD BEACH
BATTLE CREEK, MICHIGAN

FILE NAME S:DRAWINGS\PAVEMENT\50000\KP50021K.DWG

NTS

soil and materials engineers, inc.

general notes

Drilling and Sampling Symbols

SS -	Split-Spoon-1 3/8" I.D., 2" O.D. except where noted	NR -	No Recovery
LS -	Liner Sample	RC -	Rock Core with diamond bit. NX size, except where noted
AS -	Power Auger Sample	RB -	Rock Bit
ST -	Shelby Tube-2" O.D., except where noted	VS -	Vane Shear
PS -	Piston Sample-3" diameter	PM -	Pressuremeter
WS -	Wash Sample		
HA -	Hand Auger Sample	GP -	Geoprobe
BS -	Bag or Bottle Sample	PID -	Photo Ionization Device
CS -	Continuous Sampler	FID -	Flame Ionization Device

Standard Penetration 'N' - Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch O.D. split spoon, except where noted (based on ASTM D1586).

Particle Sizes

Boulders	-	Greater than 12 inches (305 mm)
Cobbles	-	3 inches (76.2 mm) to 12 inches (305 mm)
Gravel-Coarse	-	3/4 inches (19.05 mm) to 3 inches (76.2 mm)
Fine	-	No. 4 (4.75 mm) to 3/4 inches (19.05 mm)
Sand-Coarse	-	No. 10 (2.00 mm) to No. 4 (4.75 mm)
Medium	-	No. 40 (0.425 mm) to No. 10 (2.00 mm)
Fine	-	No. 200 (0.074 mm) to No. 40 (0.425 mm)
Silt	-	(0.005 mm) to (0.074 mm)
Clay	-	Less than (0.005 mm)

Depositional Features

Parting	-	as much as 1/16 inch (1.6 mm) thick
Seam	-	1/16 inch (1.6 mm) to 1/2 inch (12.7 mm) thick
Layer	-	1/2 inch (12.7 mm) to 12 (305 mm) inch thick
Stratum	-	greater than 12 inches (305 mm) thick
Pocket	-	small, erratic deposit of limited lateral extent
Lens	-	lenticular deposit
Varved	-	alternating seams or layers of silt and/or clay and sometimes fine sand
Occasional	-	one or less per foot (305 mm) of thickness
Frequent	-	more than one per foot (305 mm) of thickness
Interbedded	-	applied to strata of soil or beds of rock lying between or alternating with other strata of a different nature

Groundwater levels indicated on the boring logs are the levels measured in the boring at times indicated. The accurate determination of groundwater levels may not be possible with short term observations especially in low permeability soils. The groundwater levels shown may fluctuate throughout the year with variation in precipitation, evaporation, and runoff.

Classification

Cohesionless Soils (Blows per foot or 0.3m)

Very Loose	:	0 to 4
Loose	:	5 to 9
Medium Dense	:	10 to 29
Dense	:	30 to 49
Very Dense	:	50 to 80
Extremely Dense	:	Over 80

Cohesive Soils

Consistency		Shear Strength
Very Soft	:	0.25 kips/ft^2 (12.0 kPa) or less
Soft	:	0.25 to 0.49 kips/ft^2 (12.0 to 23.8 kPa)
Medium	:	0.50 to 0.99 kips/ft^2 (23.9 to 47.7 kPa)
Stiff	:	1.00 to 1.99 kips/ft^2 (47.8 to 95.6 kPa)
Very Stiff	:	2.00 to 3.99 kips/ft^2 (95.7 to 191.3 kPa)
Hard	:	4.00 kips/ft^2 (191.4 kPa) or greater

Soil Constituents

Trace	:	Less than 5%
Trace to Some	:	5% to 12%
Some	:	12% to 25%
Use Descriptor (ie., Silty, Clayey, etc.)	:	25% to 50%

Soil Description

If clay content sufficiently dominates soil properties, then clay becomes the primary noun with the other major soil constituent as modifier : i.e. silty clay. Other minor soil constituents may be added according to estimates of soil constituents present, i.e., silty clay, trace to some sand, trace gravel.

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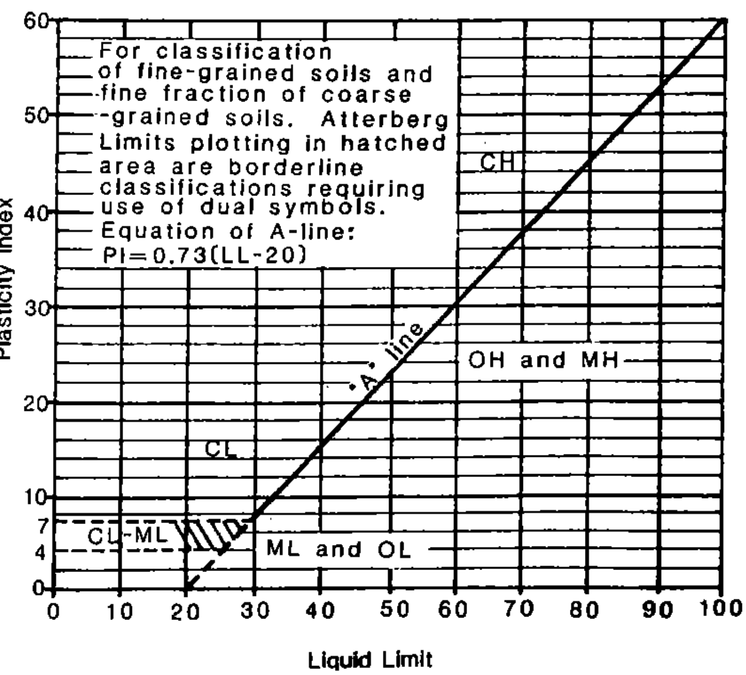
unified soil classification system

Major divisions			Group symbols	Typical names	Laboratory classification criteria		
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5% . . . . . . GW,GP,SW,SP; More than 12% . . . . . . GM,GC,SM,SC; 5 to 12% . . . . . . Borderline cases requiring dual symbols	$Cu = \frac{D_{60}}{D_{10}}$ greater than 4; $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM d / u	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines		$Cu = \frac{D_{60}}{D_{10}}$ greater than 6; $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM d / u	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity chart (below)		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
	Silts and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH	Inorganic clays of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity, organic silts			
	Highly organic soils		Pt	Peat and other highly organic soils			

PLASTICITY CHART



soil and materials engineers, inc.

PROJECT NAME: BC MATLS TESTING SVS - WILLARD BEACH **A/E:**

PROJECT LOCATION: BATTLE CREEK, MI **BY:** BDM/APF **DATE:** 9/7/05 **PROBE** B1

CLIENT: CITY OF BATTLE CREEK **PROJECT NUMBER:** KP50021K **SHEET:** 1

DEPTH (FEET)	SYMBOLIC PROFILE	PROFILE DESCRIPTION GROUND SURFACE ELEVATION=	SAMPLE TYPE/NUMBER INTERVAL	BLOWS PER SIX INCHES	DYNAMIC CONE PENETROMETER (BLOWS/6") ○ 10 20 30 40 50	NATURAL DRY DENSITY – ■ (pcf) 90 100 110 MOISTURE, % -- ◆ ATTERBERG ├─┤ LIMITS 0 10 20 30 40	LEGEND ▽ HAND PENETROMETER TEST ⊠ TORVANE SHEAR TEST ○ UNCONFINED COMPRESSION TEST ▣ VANE SHEAR TEST ╳ REMOLDED VANE SHEAR ⊕ TRIAXIAL TEST SHEAR STRENGTH (KSF) 0.0 1.0 2.0 3.0 4.0 5.0
0		4 Inches of Asphalt Concrete					
		Fine to Coarse Sand- Trace Gravel and Silt- Brown- Moist (SP/Fill)					
3		Silty Clay- Trace to Some Sand- Trace Gravel- Brown and Gray- Very Stiff (CL)				◆	▽
6						◆	▽
9		Fine to Coarse Sand- Trace Gravel and Silt- Gray- Moist (SP)					
12		END OF PROBE AT 12 FEET.					
15							
18							
21							

WATER LEVEL OBSERVATIONS

- GROUNDWATER ENCOUNTERED DURING AUGERING
- GROUNDWATER ENCOUNTERED UPON COMPLETION OF AUGERING

Notes: 1. THE INDICATED STRATIFICATION LINES ARE APPROXIMATE. IN SITU, THE TRANSITION BETWEEN MATERIALS MAY BE GRADUAL.
2. GROUNDWATER WAS NOT ENCOUNTERED.

DRILLER: APF **DRILL METHOD:** Geoprobe **WATER LEVEL DURING AUGERING:** None **WATER LEVEL** **HOURS AFTER COMPLETION:**

RIG: GP **BACKFILL METHOD:** Cuttings **WATER LEVEL UPON COMPLETION:** None **CAVE OF AUGERHOLE AT**

soil and materials engineers, inc.

PROJECT NAME: BC MATLS TESTING SVS - WILLARD BEACH **A/E:**
PROJECT LOCATION: BATTLE CREEK, MI **BY:** BDM/APF **DATE:** 9/7/05 **PROBE** B2
CLIENT: CITY OF BATTLE CREEK **PROJECT NUMBER:** KP50021K **SHEET:** 1

DEPTH (FEET)	SYMBOLIC PROFILE	PROFILE DESCRIPTION / GROUND SURFACE ELEVATION=	SAMPLE TYPE/NUMBER INTERVAL	BLOWS PER SIX INCHES	DYNAMIC CONE PENETROMETER (BLOWS/6") ○ 10 20 30 40 50	NATURAL DRY DENSITY -- ■ (pcf) 90 100 110 / MOISTURE, % -- ◆ ATTERBERG ├─┤ LIMITS 0 10 20 30 40	SHEAR STRENGTH (KSF) 0.0 1.0 2.0 3.0 4.0 5.0
0		3 Inches of Asphalt Concrete					
		Silty Clay- Some Sand- Trace Gravel- Brown- Hard (CL)				◆ (~11)	4.5+ ▽
3		Fine to Coarse Sand- Trace Gravel and Silt- Brown- Moist (SP)					
16		END OF PROBE AT 16 FEET.					

LEGEND
▽ HAND PENETROMETER TEST
⊠ TORVANE SHEAR TEST
○ UNCONFINED COMPRESSION TEST
▣ VANE SHEAR TEST
× REMOLDED VANE SHEAR
⊕ TRIAXIAL TEST

Depth scale: 0, 3, 6, 9, 12, 15, 18, 21

WATER LEVEL OBSERVATIONS
- GROUNDWATER ENCOUNTERED DURING AUGERING
- GROUNDWATER ENCOUNTERED UPON COMPLETION OF AUGERING

Notes:
1. THE INDICATED STRATIFICATION LINES ARE APPROXIMATE. IN SITU, THE TRANSITION BETWEEN MATERIALS MAY BE GRADUAL.
2. GROUNDWATER WAS NOT ENCOUNTERED.

DRILLER: APF **DRILL METHOD:** Geoprobe **WATER LEVEL DURING AUGERING:** None **WATER LEVEL HOURS AFTER COMPLETION:**
RIG: GP **BACKFILL METHOD:** Cuttings **WATER LEVEL UPON COMPLETION:** None **CAVE OF AUGERHOLE AT**

soil and materials engineers, inc.

PROJECT NAME: BC MATLS TESTING SVS - WILLARD BEACH
A/E:
PROJECT LOCATION: BATTLE CREEK, MI
BY: BDM/APF **DATE:** 9/7/05 **PROBE** B3
CLIENT: CITY OF BATTLE CREEK
PROJECT NUMBER: KP50021K **SHEET:** 1

DEPTH (FEET)	SYMBOLIC PROFILE	PROFILE DESCRIPTION / GROUND SURFACE ELEVATION=	SAMPLE TYPE/NUMBER INTERVAL	BLOWS PER SIX INCHES	DYNAMIC CONE PENETROMETER (BLOWS/6") ○ 10 20 30 40 50	NATURAL DRY DENSITY – ■ (pcf) 90 100 110 / MOISTURE, % -- ◆ / ATTERBERG ├─┤ LIMITS 0 10 20 30 40	SHEAR STRENGTH (KSF) 0.0 1.0 2.0 3.0 4.0 5.0
0		3 Inches of Asphalt Concrete					
3							
6		Fine to Coarse Sand- Trace Gravel and Silt- Brown- Moist (SP)					
9							
12		END OF PROBE AT 12 FEET.					
15							
18							
21							

LEGEND
- ▽ HAND PENETROMETER TEST
- ⊠ TORVANE SHEAR TEST
- ○ UNCONFINED COMPRESSION TEST
- ▣ VANE SHEAR TEST
- × REMOLDED VANE SHEAR
- ⊕ TRIAXIAL TEST

WATER LEVEL OBSERVATIONS
- GROUNDWATER ENCOUNTERED DURING AUGERING
- GROUNDWATER ENCOUNTERED UPON COMPLETION OF AUGERING

Notes: 1. THE INDICATED STRATIFICATION LINES ARE APPROXIMATE. IN SITU, THE TRANSITION BETWEEN MATERIALS MAY BE GRADUAL.
2. GROUNDWATER WAS NOT ENCOUNTERED.

DRILLER: APF **DRILL METHOD:** Geoprobe **WATER LEVEL DURING AUGERING:** None **WATER LEVEL HOURS AFTER COMPLETION:**

RIG: GP **BACKFILL METHOD:** Cuttings **WATER LEVEL UPON COMPLETION:** None **CAVE OF AUGERHOLE AT**