Information To Build On
Engineering • Consulting • Testing

GEOTECHNICAL EXPLORATION AND ENGINEERING REPORT

FOR THE PROPOSED:

FORT GRATIOT MUNICIPAL CENTER
3720 KEEWAHDIN ROAD
FORT GRATIOT TOWNSHIP
ST. CLAIR COUNTY, MICHIGAN

GEOTECHNICAL EXPLORATION
AND
ENGINEERING REPORT

psi Information To Build On
Engineering • Consulting • Testing

FOR THE PROPOSED:

FORT GRATIOT MUNICIPAL CENTER
3720 KEEWAHDIN ROAD
FORT GRATIOT TOWNSHIP
ST. CLAIR COUNTY, MICHIGAN

PREPARED FOR:

HURON CONSULTANTS
3811 24TH AVENUE, SUITE A
FORT GRATIOT, MICHIGAN 48059

BY:

PROFESSIONAL SERVICE INDUSTRIES, INC.
45749 HELM STREET
PLYMOUTH, MICHIGAN 48170
(734) 453-7900

FEBRUARY 4, 2014

PSI PROJECT NO. 0381704

Information To Build On
Engineering • Consulting • Testing

February 4, 2014

Mr. Eric J. Ostling, P.E., CFM
Civil Professional Engineer
Huron Consultants
3811 24th Avenue, Suite A
Fort Gratiot, MI 48059

RE: Geotechnical Exploration and Engineering Report
Proposed Fort Gratiot Municipal Center
3720 Keewahdin Road
Fort Gratiot Township, St. Clair County, Michigan
PSI Project No. **0381704**

Dear Mr. Ostling:

PSI has completed our geotechnical exploration and engineering report for the proposed Fort Gratiot Municipal Center to be constructed at 3720 Keewahdin Road in Fort Gratiot Township, St. Clair County, Michigan. This report presents the results of our observations and analysis and our recommendations for the proposed site development.

PSI appreciates the opportunity to perform this geotechnical study and to assist you and the design team on this project. If you have any questions regarding this report, or if we may be of further service, please contact our office.

Respectfully,
PROFESSIONAL SERVICE INDUSTRIES, INC.,

Jeffrey D. Hestwood, P.E.
Senior Project Engineer

Arif Cekic, Ph.D., P.E.
Geotechnical Department Manager

2 cc: Enc.
1 pc: Via PDF

TABLE OF CONTENTS

GEOTECHNICAL EXPLORATION AND ENGINEERING REPORT
PROPOSED FORT GRATIOT MUNICIPAL CENTER
FORT GRATIOT TOWNSHIP, ST. CLAIR COUNTY, MICHIGAN

EXECUTIVE SUMMARY

PSI has completed our geotechnical exploration and engineering report for the proposed Fort Gratiot Municipal Center to be constructed at 3720 Keewahdin Road in Fort Gratiot Township, St. Clair County, Michigan. PSI understands that the western portion of the proposed building will be a partial steel-framed structure with 20-foot high exterior masonry bearing walls with concrete slab-on-grade floor and will be used to house fire fighting vehicles. PSI understands that the eastern portion of the proposed building will be a lightly-loaded wood-framed structure with concrete slab-on-grade floor and a partial 1,400 square foot basement located in the approximate center of the proposed structure. Specific details relative to the proposed structural loads were not provided. For the purposes of our analysis, PSI assumes that the maximum anticipated column load may be on the order of 75 to 100 kips and the maximum lineal wall loads may be on the order of 3 to 5 kips per lineal foot (klf) within the high-walled portion of the building and 1 to 2 klf within the remaining wood-framed portion of the building. A total of eleven (11) soil test borings were performed within the proposed development area and selected samples were tested in the laboratory.

Old fill or apparent old fill consisting predominately of dark gray, dark grayish brown and black silty sand, silty clayey sand and sandy with variable percentages of gravel, organics, glass, concrete rubble, slag and foundry brick was encountered below the existing pavement section or topsoil at the locations of Borings B-6 through B-9. The deleterious old fill or apparent fill extended to depths ranging from approximately 6.5 to 9 feet below the existing ground or pavement surface. Standard Penetration Resistance (N) values within the deleterious old fill or apparent fill typically ranged from 2 to 14 blows per foot. A higher N-value in excess of 50 blows per foot was encountered within the apparent concrete rubble at the location of Boring B-8. The Loss-On-Ignition (LOI) values of the tested samples of the deleterious old fill from Borings B-6 and B-7 ranged from 5.5 to 7.2 percent (which is characterized as high).

A stratum of apparently native dark gray to dark brown amorphous peat with wood was encountered below the near-surface fill the locations of Borings B-7, B-8 and B-9. The peat was underlain by a stratum of brown organic silt or marl with wood at the location of Boring B-7. The peat and marl strata extended to depths ranging from approximately 12 to 14 feet below the existing ground or pavement surface. Standard Penetration Resistance (N) values within the native soils with organics ranged from 2 to 6 blows per foot. The Loss-On-Ignition (LOI) values of the tested samples of the peat and marl strata from Borings B-7, B-8 and B-9 ranged from 24.1 to 45.9 percent (which is characterized as very high).

A stratum of apparently native light brown to light yellowish brown fine silty sand was encountered below the surficial topsoil at the locations of Borings B-2 through B-5, B-11. The silty sand stratum extended to relatively shallow depths ranging from approximately 1.5 to 4 feet below the existing ground surface. A stratum of mottled to laminated orange brown, light grayish brown and gray silty was encountered below the surficial topsoil or fine silty sand stratum at the locations of Borings B-1 through B-5, B-10 and B-11 and below the old fill at the location of Boring B-6. The silty clay stratum extended to depths typically ranging from approximately 4 to 7 feet below the existing ground surface. A stratum of hard mottled brown and gray to grayish brown sandy clay with variable percentages of gravel was encountered below the mottled silty clay stratum at the locations of Borings B-1 through B-5 and B-10. The brown to grayish brown sandy clay strata extended to depths ranging from approximately 9 to 11.5 feet below the existing ground surface at the locations of Borings B-1 through B-5 and the explored depth of approximately 10 feet at the location of Boring B-10. A stratum of stiff to very stiff gray sandy clay was encountered below the hard brown to grayish brown sandy clay, old fill and native soils with organics at each of the boring locations performed. The gray sandy clay stratum extended through the explored depth of approximately 15 to 30 feet.

Native organics soils and uncontrolled old fills, especially those containing organics and deleterious materials, may experience significant volume changes resulting in excessive foundation settlement and poor foundation, floor slab and pavement performance including faulting and cracking, when subjected to loads from foundations, floor slabs and pavements placed over them. Due to the variability of the fill soils and N-values, the engineering characteristics of the fill soils, including bearing capacity and settlement potential, are likely to be extremely variable. In addition, it is possible that voids may be present in areas of the fill containing significant quantities of concrete rubble or debris. **Therefore, in PSI's opinion, the existing old fill and underlying native soils with organics are not considered to be suitable for direct support of at-grade structures including building foundations, floor slabs and pavements supporting the proposed heavy vehicle loads.**

PSI recommends that the existing uncontrolled fill and underlying native soils with organics (i.e. peat and marl) be over-excavated in its entirety from below the proposed building footprint and pavement areas and be backfilled with properly compacted engineered fill, well-graded granular materials or lean concrete or the foundations should be extended to a suitable underlying natural soil stratum (if available).

Difficulty with groundwater seepage and subgrade instability should be anticipated during undercut excavation operations associated with the removal of the existing deleterious old fill and underlying native soils with organics. The Contractor should be prepared to perform site-dewatering measures to allow earthwork, subgrade preparation (including undercut excavations associated with removal and replacement of the existing old fill), proof-rolling, foundation excavation and construction to take place under relatively dry conditions. PSI recommends that the Contractor verify the actual groundwater and seepage conditions at the time of the construction activities and propose a groundwater control method(s) for the

Engineer's approval, including the disposal of discharge water.

Where the undercut is performed within a relatively dry excavation, the excavation bottom may be stabilized with a woven geotextile and a layer of well graded crushed concrete or well graded coarse aggregate such as MDOT 4AA, 6AA or MDOT 21AA to facilitate the placement and compaction of the granular backfill required to achieve the designed site grades.

Following proper site preparation as outlined above and in Section 3.1 of the following report, PSI recommends that the proposed structure be supported on conventional spread footing foundations designed for a **net allowable bearing pressure of up to 2,500 pounds per square foot (psf)** bearing at typical frost depth below the finished exterior site grades on the native very stiff to hard clay soils or on newly placed and properly compacted engineered fill materials following the removal and replacement of unsuitable soil materials. PSI estimates that total settlement of the native soils and properly compacted engineered fill may be on the order of 1 inch or less due to loads exerted by the proposed building foundations.

PSI anticipates that the proposed floor slab and exterior site pavements may be grade supported on the native clay soils or on newly placed and properly compacted engineered fill. While groundwater was not encountered at the locations of Borings B-1 and B-2 (performed in the area of the proposed basement), the long-term piezometric level may be located at a depth of approximately 11 feet below the existing ground surface or an elevation of approximately 596 feet, based on the change in color of the soil from brown to gray. Therefore, depending on the elevation of the basement level floor slab, the floor should be protected against hydrostatic uplift forces and the potential infiltration of groundwater.

The suitability of the proposed flexible and rigid pavement sections have been checked using the DARWin Pavement Design and Analysis System. This program embodies the methodology of the 1993 AASHTO Guide for the Design of Pavement Structures. The proposed pavement sections are suitable based on the assumed traffic usage and subgrade soil conditions encountered.

Deleterious old fill and native soils with organics are anticipated to be present within the proposed detention pond sidewalls. **These soils are not considered suitable for support of the proposed detention pond excavation side walls or for support of embankment fill placed over them.** PSI recommends that these soils be over excavated and the detention pond sidewalls be constructed of newly placed and properly compacted engineered fill.

This Executive Summary should not be considered separately from the entire text of this report with all the conclusions and qualifications mentioned herein. Details of our analysis and recommendations are given in the following sections of this report.

1.0 PROJECT INFORMATION

1.1 Project Authorization

Professional Service Industries, Inc. (PSI) has completed a geotechnical exploration and engineering report for the proposed Fort Gratiot Municipal Center to be constructed at 3720 Keewahdin Road in Fort Gratiot Township, St. Clair County, Michigan. PSI's work was authorized by Mr. Eric J. Ostling, Civil Professional Engineer for Huron Consultants on December 9, 2013. PSI's work was performed in general accordance with PSI Proposal No. 0381-13166 dated December 3, 2013.

1.2 Project Description

Initial project information was provided by Mr. Eric J. Ostling, P.E., CFM, Civil Professional Engineer for Huron Consultants in a request for proposal via email on November 19, 2013. Additional site and project information (including the requested boring locations) was obtained from the *"Topographic Survey & Demolition Plan"* prepared by Huron Consultants dated December 5, 2013. Huron Consultants also provided PSI with drawings titled *"Site Plan"*, Sheet C-1; *"Grading Plan"*, Sheet C-2 and *"Utility Plan"*, Sheet C-3 dated January 20, 2014 via email on January 23, 2014.

PSI understands that the proposed project consists of the construction of an approximately 20,000 square foot Municipal Center building at 3720 Keewahdin Road in Fort Gratiot Township, St. Clair County, Michigan. PSI understands that the western portion of the proposed building will be a partial steel-framed structure with 20-foot high exterior masonry bearing walls with concrete slab-on-grade floor and will be used to house fire fighting vehicles. PSI understands that the eastern portion of the proposed building will be a lightly-loaded wood-framed structure with concrete slab-on-grade floor and a partial 1,400 square foot basement located in the approximate center of the proposed structure. Specific details relative to the proposed structural loads were not provided. For the purposes of our analysis, PSI assumes that the maximum anticipated column load may be on the order of 75 to 100 kips and the maximum lineal wall loads may be on the order of 3 to 5 kips per lineal foot (klf) within the high-walled portion of the building and 1 to 2 klf within the remaining wood-framed portion of the building.

The project will also include construction of perimeter asphalt and concrete pavement driveways along the east, north and west sides of the proposed building. The perimeter pavements will support heavy pumper truck traffic weighing approximately 66,300 pounds. Forty-four (44) automobile parking spaces will be provided off the perimeter driveways on the northeast and west sides of the proposed building. An automobile parking lot with sixty (60) vehicle spaces will also be constructed on the south side or front of the proposed building.

The finished floor elevation of the proposed building will be 608.0 feet and the depth of the partial basement will be approximately 10 feet or a lower level finished floor elevation of approximately 598.0 feet. Based on the site grading plan and topographic drawings provided, PSI anticipates that less than 2 feet of cut/engineered fill will be required to achieve the majority of the proposed building's finished floor elevation and exterior pavement grades (exclusive of any additional cut/fill associated with removal of unsuitable soil sections).

The geotechnical recommendations presented in this report are based on the available project information, and the results of our geotechnical exploration described in this report. If any of the noted information is considered incorrect or is changed, please inform PSI in writing so that we may amend the recommendations presented in this report if appropriate and if desired by the client. PSI will not be responsible for the implementation of its recommendations when it is not notified of changes in the project.

1.3 Purpose and Scope of Services

The purpose of this study was to explore the subsurface conditions at the site to provide the geotechnical parameters required to prepare recommendations for the design and construction of the foundations for the proposed building addition. PSI's authorized scope of services included drilling a total of eleven (11) soil test borings, laboratory testing of selected samples, an engineering evaluation of the data generated, and the preparation of a geotechnical report.

This report presents available project information, briefly outlines the testing procedures, describes the site and supplementary subsurface conditions, and provides recommendations regarding the following:

- Earthwork considerations for site development.
- Foundation type, depth, net allowable bearing pressure and estimate of potential settlement.
- Criteria for floor slab and pavement subgrade preparation and support.
- Lateral earth pressures for design of below grade walls and retaining walls.
- Comments regarding geotechnical factors that may impact earthwork, foundation construction, subgrade preparation, and performance of the proposed foundations and pavements.

The geotechnical scope of services did not include an environmental assessment for determining the presence or absence of wetlands, hazardous or toxic materials in the soil, bedrock, surface water, groundwater or air on, below or around this site. Any statement in this report or on the boring logs regarding odors, colors, and unusual or suspicious items or conditions are strictly for informational purposes. Prior to the development of any site, an environmental assessment is advisable.

PSI did not provide any service to investigate or detect the presence of moisture, mold or other biological contaminates in or around any structure, or any service that was designed or intended to prevent or lower the risk of the occurrence of the amplification of the same. Huron Consultants acknowledges that mold is ubiquitous to the environment with mold amplification occurring when building materials are impacted by moisture. Huron Consultants further acknowledges that site conditions are outside of PSI's control, and that mold amplification will likely occur, or continue to occur, in the presence of moisture. As such, PSI cannot and shall not be held responsible for the occurrence or recurrence of mold amplification.

2.0 SITE AND SUBSURFACE CONDITIONS

2.1 Site Location and Description

The project site is located at 3720 Keewahdin Road in Fort Gratiot Township, St. Clair County, Michigan. The general site location is shown on the Site Vicinity Map in the Appendix as Figure No. 1.

At the time of PSI's geotechnical exploration, the existing Township Hall building structure was present within the south west portion of the site. The building was surrounded with bituminous pavement. Other smaller commercial, residential and shed structures were present within the eastern portion of the site. The remainder of the site was snow-covered at the time of our filed exploration but appeared to consist predominately of grass and weeds with isolated to moderate tree cover. The elevation of the existing ground surface within the area of the proposed development was relatively flat to gently sloping downward towards the north and west. The ground surface exhibited a total difference in topography across the majority of the proposed development area of approximately 2 to 3 feet based on visual observations and elevation information indicated on the topographic drawing provided.

2.2 Field and Laboratory Services

PSI's field exploration program consisted of drilling a total of eleven (11) soil borings. Borings B-1 through B-7 were drilled to depths ranging from approximately 20 to 30 feet below the existing site grades within or near the proposed building footprint. Borings B-8 through B-11 were drilled to depths ranging from approximately 10 to 15 feet below the existing site grades within the proposed pavement and storm water detention basin areas.

Huron Consultants selected the number, location and initially proposed depths of the borings and staked the boring locations in the field in advance of PSI's fieldwork. The approximate boring locations are provided on the Boring Location Plan, Figure No. 3 in the Appendix, which was reproduced from the previously referenced Site Plan provided by Huron Consultants.

PSI's drilling operations were performed on January 3, 14 and 15, 2014. Both a truck-mounted and an All-Terrain Vehicle (ATV)-mounted drill rig were used to perform the soil borings utilizing 3¼ -inch diameter continuous flight hollow-stem augers to advance the boreholes. Standard Penetration Tests (SPT) were conducted and soil samples were obtained using split spoon sampling procedures at regular intervals not exceeding five (5) feet. Drilling and sampling techniques were performed in general accordance with ASTM Standard D1586. After completion of the drilling operations, the borings were backfilled with auger cuttings and the pavement surface was patched with bituminous cold patch material.

The elevation of the ground surface at the boring locations was provided by Huron Consultants via email on January 16, 2014. References to depths in this report and on the attached Boring Logs are from the existing ground surface unless otherwise noted.

Selected soil samples were tested in the laboratory to determine soil properties for PSI's engineering evaluation. Laboratory testing on the soil samples obtained during the field exploration included natural moisture content, Loss-On-Ignition (LOI), Atterberg limits, unit weight, unconfined compression and estimating the unconfined compressive strength of the limited cohesive soils encountered using a calibrated hand penetrometer. The results of the unconfined compression tests are included in the Appendix. The moisture content, LOI, unit weight and hand penetrometer test results are indicated on the Boring Logs opposite the depths at which the samples were obtained. The laboratory tests were performed in general accordance with applicable ASTM procedures.

The unused portions of the recovered soil samples obtained during PSI's geotechnical exploration will be placed in storage at PSI's Plymouth Township facility. Unless otherwise requested in writing, the samples will be discarded after 60 days from the submission of the final report.

2.3 Subsurface Conditions

A generalized soil description encountered in the borings, beginning at the bottom of the surficial topsoil and pavement section and proceeding downward, is as follows:

> ***Stratum 1: Old Fill/Native Soils with Organics.*** Old fill or apparent old fill consisting predominately of dark gray, dark grayish brown and black silty sand, silty clayey sand and sandy with variable percentages of gravel, organics, glass, concrete rubble, slag and foundry brick was encountered below the existing pavement section or topsoil at the locations of Borings B-6 through B-9. The deleterious old fill or apparent fill extended to depths ranging from approximately 6.5 to 9 feet below the existing ground or pavement surface. Standard Penetration Resistance (N) values within the

deleterious old fill or apparent fill typically ranged from 2 to 14 blows per foot. A higher N-value in excess of 50 blows per foot was encountered within the apparent concrete rubble at the location of Boring B-8. The Loss-On-Ignition (LOI) values of the tested samples of the deleterious old fill from Borings B-6 and B-7 ranged from 5.5 to 7.2 percent (which is characterized as high). The moisture contents of the tested soil samples from the deleterious old fill or apparent fill ranged from 14 to 74 percent. The samples visually appeared to be in a moist to wet condition when examined in the laboratory.

A stratum of apparently native dark gray to dark brown amorphous peat with wood was encountered below the near-surface fill the locations of Borings B-7, B-8 and B-9. The peat was underlain by a stratum of brown organic silt or marl with wood at the location of Boring B-7. The peat and marl strata extended to depths ranging from approximately 12 to 14 feet below the existing ground or pavement surface. Standard Penetration Resistance (N) values within the native soils with organics ranged from 2 to 6 blows per foot. The Loss-On-Ignition (LOI) values of the tested samples of the peat and marl strata from Borings B-7, B-8 and B-9 ranged from 24.1 to 45.9 percent (which is characterized as very high). The moisture contents of the tested soil samples from the native soils with organics ranged from 111 to 234 percent.

Stratum 2: Silty Sand/Mottled Silty Clay. A stratum of apparently native light brown to light yellowish brown fine silty sand was encountered below the surficial topsoil at the locations of Borings B-2 through B-5, B-11. The silty sand stratum extended to relatively shallow depths ranging from approximately 1.5 to 4 feet below the existing ground surface. A stratum of mottled to laminated orange brown, light grayish brown and gray silty was encountered below the surficial topsoil or fine silty sand stratum at the locations of Borings B-1 through B-5, B-10 and B-11 and below the old fill at the location of Boring B-6. The silty clay stratum extended to depths typically ranging from approximately 4 to 7 feet below the existing ground surface. Standard Penetration Resistance (N) values within the near-surface silty clay stratum typically ranged from 7 to 15 blows per foot. The unconfined compressive strength of the near-surface mottled silty clay stratum ranged from approximately 1.25 to greater than 4.5 tons per square foot (tsf), thereby indicating consistencies of stiff to hard. The moisture contents of the tested soil sample from the mottled silty clay stratum ranged from 16 to 18 percent. The samples visually appeared to be in a moist condition when examined in the laboratory. An Atterberg limit test performed on a composite sample of the brown silty clay stratum prepared from Borings B-1, B-4 and B-5 indicates the soil to be moderate in plasticity with a Liquid Limit (LL) of 37 and a Plastic Limit (PL) of 15.

Stratum 3: Brown Sandy Clay. A stratum of mottled brown and gray to grayish brown sandy clay with variable percentages of gravel was encountered below the mottled silty clay stratum at the locations of Borings B-1 through B-5 and B-10. The brown to grayish brown sandy clay strata extended to depths ranging from approximately 9 to 11.5 feet below the existing ground surface at the locations of Borings B-1 through B-5 and the explored depth of approximately 10 feet at the location of Boring B-10. Standard Penetration Resistance (N) values within the brown to grayish brown sandy clay stratum ranged from 16 to 27 blows per foot. The unconfined compressive strength of the brown to grayish brown sandy clay stratum was typically greater than 4.5 tons per square foot (tsf), thereby indicating a consistency of hard. The moisture contents of the tested soil samples from the brown to grayish brown sandy clay stratum ranged from 13 to 17 percent. The samples visually appeared to be in a moist condition when examined in the laboratory.

Stratum 4: Gray Sandy Clay. A stratum of gray sandy clay was encountered below the hard brown to grayish brown sandy clay, old fill and native soils with organics at each of the boring locations performed. The gray sandy clay stratum extended through the explored depth of approximately 15 to 30 feet. Standard Penetration Resistance (N) values within the gray sandy clay stratum ranged from 4 to 25 blows per foot. The unconfined compressive strength of the gray sandy clay stratum typically ranged from approximately 1.5 tsf to 3.75 tsf, thereby indicating consistencies of stiff to very stiff. The moisture contents of the tested soil samples from the gray sandy clay stratum typically ranged from 14 to 18 percent. The samples visually appeared to be in a moist to very moist condition when examined in the laboratory. An Atterberg limit test performed on a composite sample of the gray sandy clay stratum prepared from Borings B-1, B-2 and B-3 indicates the soil to be moderate in plasticity with a Liquid Limit (LL) of 28 and a Plastic Limit (PL) of 14.

The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The Boring Logs should be reviewed for specific information at individual boring locations. These records include soil descriptions, stratification, penetration resistance, location of the samples, and laboratory test data. The soil Boring Logs are presented in the Appendix.

The stratification shown on the Boring Logs represent the conditions only at the actual boring locations. Variations may occur and should be expected between boring locations. The stratification represents the approximate boundary between subsurface materials; however, the actual transition may be gradual. Water level information obtained during field operations is also shown on the Boring Logs. The Boring Logs were prepared on the basis of the laboratory testing and supplemental visual engineering classification, as well as the field logs of the soil conditions encountered.

2.4 Groundwater Information

The driller visually looked for indications of groundwater seepage both during and after the drilling operations. Relatively shallow groundwater or perched water was encountered during drilling at depths ranging from approximately 1.4 to 2 feet below the existing ground surface at the locations of Borings B-7 and B-11 and a depth of approximately 8 feet at the location of Boring B-9. Groundwater or perched water was not encountered during drilling or following completion of drilling at the remaining boring locations performed.

It is possible for the groundwater table to vary within the depths explored during other times of the year depending upon climatic conditions (seasonal fluctuation). Groundwater monitoring wells are required to accurately define the position and fluctuation of the groundwater table, especially if a boring is drilled in cohesive soil, where several days or weeks may be required for the groundwater to reach a static level. The installation of such monitoring wells was not included in the scope of services for this project. The change in color of the soil from brown to gray may indicate the long-term minimum piezometric level in the area. Based on the borings performed, the long-term piezometric level may be located at a depth of approximately 9 to 11.5 feet below the existing ground surface or an elevation of approximately 595 to 600 feet.

2.5 Site Seismic Classification

St. Clair County, Michigan lies in the Central Stable Tectonic Region and in the Seismic Zone 1 of probable seismic activity of the Building Officials Congress of America (BOCA), National Building Code and the Uniform Building Code (UBC), as indicated on the Earthquake Hazard Risk Map included as Figure No. 2 in the Appendix. This zone indicates that minor damages due to occasional earthquakes might be expected in this area. In the 2009 Michigan Building Code (MBC), the State of Michigan has adopted the provisions of the International Building Code (IBC). The IBC requires a Site Class be established for the calculation of earthquake design forces. This class is a function of soil or rock type as well as the depth of soil, strata types and strength/consistency for the uppermost 100 feet of the subsurface profile. Soil borings at the project site extended to a maximum depth of approximately 30 feet below the existing ground surface. Based on regional geologic mapping and past experience in the general project area, PSI anticipates that the subsurface conditions below the explored depth may generally consist of glacial drift consistent or stiffer than the soils encountered through the depth explored underlain by the Antrim Shale bedrock formation at a depth of approximately 100 feet or greater. Based on our review of the available data, assumption of similar soil conditions below the explored depth, the Standard Penetration Test (SPT) N-values and unconfined compressive strength tests, we recommend that the seismic design for this project be based on **Site Class D** as defined in the 2012 IBC Section 1613.3.2.

The 2002 USGS NEHRP probabilistic ground motion values for the site interpolated between the nearest four grid points from latitude 43.03944 and longitude -82.48473, are as follows (based on Site Class D):

Period (seconds)	2% Probability of Event in 50 years* (%g)	Site Coefficients	Max. Spectral Acceleration Parameters	Design Spectral Acceleration Parameters	
PGA	4.49	Na	Na	Na	
0.2 (S_s)	10.26	$F_a = 1.60$	$S_{ms} = 0.164$	$S_{Ds} = 0.109$	$T_0 = 0.119$
1.0 (S_1)	4.05	$F_v = 2.40$	$S_{m1} = 0.097$	$S_{D1} = 0.065$	$T_s = 0.596$

$S_{ms} = F_a S_s$ $S_{Ds} = 2/3 * S_{ms}$ $T_0 = 0.2 * S_{D1}/S_{Ds}$
$S_{m1} = F_v S_1$ $S_{D1} = 2/3 * S_{m1}$ $T_s = S_{D1}/S_{Ds}$

The site coefficients F_a and F_v were interpolated from the 2012 IBC Tables 1613.3(1) and 1613.3(2) as a function of the site classification and the mapped spectral response acceleration at the short (S_s) and 1 second (S_1) periods.

Based on the spectral response acceleration coefficients S_{Ds} and S_{D1} above, the Seismic Design Category for this site is **Category A** for occupancy categories I through IV as prescribed by 2012 IBC Tables 1613.3.5(1) and 1613.3.5(2).

3.0 EVALUATION AND RECOMMENDATIONS

PSI has made our analysis based on the information developed during this exploration. The resulting recommendations are given in the following sections. If our estimations or understandings of the project are considered incorrect or if conditions during construction are significantly different from those described in this report, please contact PSI immediately in writing so that we may amend our recommendations presented in this report if appropriate and if desired by the client.

3.1 General Site Preparation and Fill Placement

Prior to site grading activities or excavation for foundation elements, PSI recommends that existing underground utilities and structures be identified and rerouted or properly abandoned in-place. Existing underground utilities that are not re-routed or abandoned should be adequately marked and protected to minimize the potential for damage during construction activities.

PSI recommends that the existing topsoil, trees (including their root systems), concrete sidewalks and asphalt pavement be stripped from the proposed building footprint and proposed new pavement areas. In addition the existing building structures, including their foundations and floor slabs should be demolished and all debris removed from the site.

Depressions resulting from the removal of these items should be backfilled with engineered fill or specified materials, such as lean concrete or grout, to the final design grade.

Old fill or apparent old fill consisting predominately of dark gray, dark grayish brown and black silty sand, silty clayey sand and sandy with variable percentages of gravel, organics, glass, concrete rubble, slag and foundry brick was encountered below the existing pavement section or topsoil at the locations of Borings B-6 through B-9. A stratum of apparently native dark gray to dark brown amorphous peat with wood was encountered below the near-surface fill the locations of Borings B-7, B-8 and B-9. The peat was underlain by a stratum of brown organic silt or marl with wood at the location of Boring B-7.

Native organics soils and uncontrolled old fills, especially those containing organics and deleterious materials, may experience significant volume changes resulting in excessive foundation settlement and poor foundation, floor slab and pavement performance including faulting and cracking, when subjected to loads from foundations, floor slabs and pavements placed over them. Due to the variability of the fill soils and N-values, the engineering characteristics of the fill soils, including bearing capacity and settlement potential, are likely to be extremely variable. In addition, it is possible that voids may be present in areas of the fill containing significant quantities of concrete rubble or debris. **Therefore, in PSI's opinion, the existing old fill and underlying native soils with organics are not considered to be suitable for direct support of at-grade structures including building foundations, floor slabs and pavements supporting the proposed heavy vehicle loads.**

PSI recommends that the existing uncontrolled fill and underlying native soils with organics (i.e. peat and marl) be over-excavated in its entirety from below the proposed building footprint and pavement areas and be backfilled with properly compacted engineered fill, well-graded granular materials or lean concrete or the foundations should be extended to a suitable underlying natural soil stratum (if available). Based on the borings performed, the deleterious old fill or apparent fill extended to depths ranging from approximately 6.5 to 9 feet below the existing ground or pavement surface and the underlying peat and marl strata extended to depths ranging from approximately 12 to 14 feet below the existing ground or pavement surface. However, the thickness of the uncontrolled fill and buried native soils with organics and the required undercut depth is likely to vary across the site from that encountered at the individual boring locations performed.

Where the removal of localized unsuitable bearing material is performed beneath the proposed footings and the excavation is backfilled with compacted fill materials, the excavation must extend laterally beyond the perimeter of the foundation for a distance equal to one-half of the thickness of the engineered backfill placed below the footing bottom. The over excavation is necessary for proper support of lateral loads exerted through the new fill by the foundations.

Difficulty with groundwater seepage and subgrade instability should be anticipated during undercut excavation operations associated with the removal of the existing deleterious old fill and underlying native soils with organics. The Contractor should be prepared to perform site-dewatering measures to allow earthwork, subgrade preparation (including undercut excavations associated with removal and replacement of the existing old fill), proof-rolling, foundation excavation and construction to take place under relatively dry conditions. PSI recommends that the Contractor verify the actual groundwater and seepage conditions at the time of the construction activities and propose a groundwater control method(s) for the Engineer's approval, including the disposal of discharge water.

Where the undercut is performed within a relatively dry excavation, the excavation bottom may be stabilized with a woven geotextile and a layer of well graded crushed concrete or well graded coarse aggregate such as MDOT 4AA, 6AA or MDOT 21AA to facilitate the placement and compaction of the granular backfill required to achieve the designed site grades.

Alternately, it may be possible to simultaneously excavate the unsuitable soils and backfill the excavation without dewatering. The usual procedure for this type of excavation is to remove the unsuitable soils by backhoe or dragline without de-watering while the embankment or backfill materials are simultaneously extended outward across the excavation as the unsuitable soils are removed from the front of the advancing embankment or fill materials. The rate of advancement of the backfill should match the rate of soil removal. The excavation width should match the width of the unsuitable soils to be removed. However, the compactive effort of fill materials dumped into several feet of water is limited and generally not recommended below foundation elements. Because the unsuitable soils are often removed and replaced under saturated conditions (or even under water in extreme conditions), the effectiveness of this procedure is highly dependent on the Contractor's workmanship and experience. The Contractor should be pre-qualified for this work and be able to demonstrate past successful performance on similar projects.

PSI recommends that the excavation and backfill placed in the bottom of the undercut excavation and below the water table meet the requirements of swamp backfill, Section 205.03.D of the 2012 MDOT Standard Specifications. Prior to commencement of the excavation, PSI recommends that a sufficient quantity of swamp backfill be stockpiled immediately adjacent to the excavation so it may readily be end-dumped and spread outward across the excavation. In addition, PSI recommends that the Contractor excavate a quantity of material that can be backfilled on the same day. PSI recommends that vibratory compactive techniques not be used until the fill has been placed a minimum of 2 to 3 feet above the prevailing water level at the time of construction. PSI recommends that additional engineered fill required to establish the proposed foundation bearing elevation and placed above the water table consist of on-site or imported environmentally clean material, free of organic matter, frozen soil, or other deleterious material. Cohesive soils should not be used as backfill materials below the water table and should be used only if it can be demonstrated that a stable fill structure can be achieved with the cohesive soil materials used.

After site stripping and undercutting unstable soil sections (as necessary), the exposed soils should be thoroughly proof rolled/compacted with a large, heavy rubber-tired vehicle prior to the placement of new engineered fill or backfill required to achieve the proposed subgrade elevation. Areas that exhibit instability or are observed to rut or deflect excessively under the moving load should be further undercut, stabilized by aeration, drying (if wet) and additional compaction to attain a stable finished subgrade. The proof rolling/compacting and undercutting activities should be performed during a period of dry weather and should be performed under the supervision of the Geotechnical Engineer's representative. Where subgrade conditions are not improved through aeration, drying and compaction, or where undercut and replacement is considered impractical due to the underlying soil and groundwater conditions, it will likely be necessary to stabilize localized areas of subgrade instability (or undercut excavation bottoms) with a woven geotextile, geogrid and a layer of well graded crushed concrete or well graded coarse aggregate such as MDOT 4AA, 6AA or 21AA. The need for the use of geotextile, geogrid and the thickness and gradation requirements of the crushed aggregate layer required should be determined at the time of the subgrade preparation, based on the condition of the exposed subgrade at the time of construction. The subgrade should be stabilized prior to placement of engineered fill or aggregate base course.

New fill supporting at-grade structures should be an environmentally clean material, free of organic matter, frozen soil, or other deleterious material. The material proposed to be used as engineered fill should be evaluated and approved for use by a PSI geotechnical engineer or his representative prior to placement in the field. Based on the borings performed, the existing uncontrolled fill soils appeared to be free of organic soils and deleterious materials and may be suitable for reuse as engineered fill. However, the composition of the uncontrolled fill is likely to vary across the site from that encountered at the individual boring locations performed.

Fill materials should be placed in maximum horizontal lifts of 8 inches of loose material and should be compacted within the range of ±2% of the optimum moisture content value. Moisture contents should be adjusted to the proper levels prior to placement and compaction. Adequate compaction will not be achieved if the fill is in a saturated condition. Wet soils may require drying or mixing with dry soil to facilitate compaction. If water must be added to dry soil, it should be uniformly applied and thoroughly mixed into the soil by disking or scarifying prior to compaction.

The structural fill should be compacted to 95% of the Modified Proctor maximum dry density as determined per ASTM D1557. The edges of compacted fill should extend at least 10 feet beyond the edges of the proposed pavements prior to sloping. Care should be taken to apply adequate compaction effort throughout the fill, including at the toe of slopes. Where the engineered fill is placed over an existing slope, the slope should be benched in order to avoid creating a weaker sliding plane. Each lift of engineered fill should be tested for conformance to the project density requirements by a representative of PSI prior to placement of subsequent lifts. A minimum of one test per 2,500 square feet of building area and one test per 5,000 square feet of parking area should be performed for each lift, unless otherwise specified by the engineer. The moisture/density relationship (Proctor) of the material to be used as engineered fill should be evaluated by a PSI geotechnical engineer or his representative prior to placement in the field. PSI recommends one Proctor test for every 5,000 cubic yards (cyds) of fill up to 25,000 cyds and one test per each 50,000 cyds of fill thereafter or change of material.

PSI recommends that imported granular soils conform to the gradation requirements of MDOT Class II granular material. In addition, free-draining, non-plastic granular material such as MDOT Class II granular material is recommended for use as backfill against foundations and below grade walls. PSI recommends that imported cohesive soils used as engineered fill below at-grade structural elements have a liquid limit less than 40 percent and a plasticity index in the range of 10 to 25. A sheep's foot roller is recommended for compaction if cohesive soils are used. Vibratory compaction equipment should be used for compaction in granular soils. Small, hand-operated compaction equipment should be used in confined spaces and against below-grade walls and foundations.

Organic soils, old fill and other deleterious materials, which are removed or uncovered during site grading and subgrade undercut operations, foundation and utility excavations at this site, must be wasted in non-load bearing areas such as landscaped areas or removed from the site as directed by the project's engineer and should not be reused as engineered fill in other areas of the site. It would not be unusual for the composition and thicknesses of the uncontrolled fill to vary within the site area from that encountered at the individual boring locations. If it is desired to excavate and dispose of the existing uncontrolled fill and rubble off-site, PSI recommends that additional test pit excavations be performed by the Contractor to quantify the thickness and material composition of the existing fill and associated costs of removal and disposal.

3.2 Foundation Recommendations

Based on the borings performed, the soils exposed at the bottom of the foundation excavations are generally anticipated to consist of native very stiff to hard mottled silty clay with sand or sandy clay soils. These soils are anticipated to be suitable for support of lightly to moderately-loaded structures (similar to the proposed Municipal Center building) on conventional shallow spread footing foundations. However, apparent old fill and native soils with organics (i.e. peat and marl) was encountered at the boring locations performed along the west wall of the proposed building (Borings B-6 and B-7). In PSI's opinion, the existing old fill and buried native soils with organics are not considered suitable for direct support of at-grade structures including building foundations and floor slabs. PSI recommends that the existing old fill and buried organic soils be over-excavated in their entirety from below the proposed building footprint and be backfilled to the foundation bearing level with properly compacted engineered fill or well-graded granular materials or the foundations should be extended to a suitable underlying natural soil stratum (if available). The lateral extent of these soils below the proposed building footprint is unknown at this time

Following proper site preparation as outlined above and in Section 3.1 of this report, PSI recommends that the proposed structure be supported on conventional spread footing foundations designed for a **net allowable bearing pressure of up to 2,500 pounds per square foot (psf)** bearing at typical frost depth below the finished exterior site grades on the native very stiff to hard clay soils or on newly placed and properly compacted engineered fill materials following the removal and replacement of unsuitable soil materials. PSI estimates that total settlement of the native soils and properly compacted engineered fill may be on the order of 1 inch or less due to loads exerted by the proposed building foundations. Differential settlement between two, newly constructed adjacent columns or wall segments bearing on similar soils may be up to approximately 50% of the total settlement. Where adjacent foundations bear on dissimilar subgrades or were layers of weaker soils are present within the primary zone of influence below the foundations differential settlement may be 75% or more of the estimated total settlement.

Exterior footings and footings in unheated areas should be located at a minimum depth of 42 inches below the final exterior grade for proper protection against frost during normal winters. Interior footings may be supported at a shallower depth, while providing necessary clearance for pavement and utility construction, provided they are bearing on suitable, undisturbed native soils or properly placed and compacted engineered fill. A minimum depth of 24 inches is recommended for stability. If the structures are to be constructed during the winter months or if footings will likely be subjected to freezing temperatures after foundation construction, then all footings should be adequately protected from freezing.

Minimum dimensions of 30 inches for column footings and 18 inches for continuous footings and trench footings should be used in foundation design to minimize the possibility of a local bearing capacity failure. In addition, PSI recommends that continuous footings be suitably reinforced to make them as rigid as possible.

Trench foundation side walls, if used, should be excavated straight and vertical to reduce the risk of frozen soil adhering to the concrete and raising the foundation. However, the use of forms will most likely be necessary to prevent the creation of an enlarged area of concrete (mushroom) where foundation excavations extend through granular soils as was encountered at the boring locations performed at this site.

PSI recommends that exposed foundation excavation inverts be observed and tested by a representative of PSI prior to steel or concrete placement to document that the observed conditions are consistent with the geotechnical report. The foundation excavation should be observed and concrete placed as quickly as possible to avoid exposure of the footing bottoms to wetting and drying. Surface run-off water should be drained away from the excavations and not be allowed to pond. The foundation concrete should be placed during the same day the excavation is made. If it is required that footing excavations be left open for more than one day, they should be protected to reduce evaporation or entry of moisture.

3.2.2 Alternate Foundation Systems/Ground Improvement

As an alternate to removal and replacement of the existing old fill and buried native soils with organics, these unsuitable soils may remain in-place below the proposed building structure (and concrete slab-on-grade as well) where the proposed building is supported on either a deep foundation system such as helical piles or on an intermediate foundation such as spread footing foundations together with ground improvement such as Rammed-Aggregate Piers (RAP) or stone columns.

RAP elements are typically installed by either drilling a 20 to 30-inch diameter cavity or driving a variable-diameter mandrel into the soil, displacing the soil laterally to form a cavity. The cavity is filled by ramming thin lifts of aggregate within the cavity. During the installation process, high frequency impact ramming energy applied to each lift both densifies the aggregate and surrounding soil and forces the aggregate laterally into the sidewalls of the hole further stiffening the stabilized composite soil mass. The capacity of helical screw piles or anchors, similar to those manufactured by Atlas Systems, Inc. will be a function of the overburden pressure, soil friction angle and soil shear strength as well as the number and size of the helixes used. PSI anticipates that the RAP/Geo-Pier or helical pile elements would be installed along the proposed building's perimeter load-bearing walls, below the isolated interior column locations and on a grid below the proposed floor slab.

The installation of RAP or helical anchors will reduce the amount of excavated old fill and organic soils that has to be removed to an appropriate off-site disposal location should the owner decide to perform mass excavation and removal of the unsuitable soils from below the proposed building footprint. However, the borings indicated the presence of concrete debris that may slow or prevent installation of RAP or helical anchors. Therefore, Contractors would need to come to the site prepared to predrill, over excavate or break apart debris encountered during installation. The presence of deleterious materials within the fill may make these ground improvement options unfeasible.

RAP, helical pile or anchor elements are generally designed and installed by a design-build specialty contractor. If the RAP or helical pile/anchor option is of interest, PSI would be pleased to contact/work with an installation Contractor to better define the feasibility and scope of work for this site and to provide a specific allowable bearing capacity and estimated settlement for use in the foundation design as well as the associated costs. If alternative foundations or ground improvement is performed within a portion of the proposed building, PSI recommends the specialty contractor and Structural engineer evaluate the feasibility of supporting portions of the proposed building on different foundation systems.

3.3 Floor Slab-on-Grade Recommendations

PSI anticipates that the proposed floor slab may be grade supported on the native clay soils or on newly placed and properly compacted engineered fill. Prior to placement of slab-on-grade floors, the subgrade soil below the proposed floor slab should be scarified and compacted to 95% of its maximum dry density as determined per ASTM D1557, for a minimum depth of 12 inches below the final graded surface.

PSI recommends that the vertical subgrade modulus, k be limited to 125 pounds per cubic inch, as determined by a 1-foot by 1-foot plate load test, in floor slab-on-grade design calculations. PSI recommends that a minimum of 4 inches of free-draining, compacted aggregate be placed beneath the floor slab-on-grade to facilitate fine grading and provide increased support for the slabs-on-grade as well as to provide a capillary break below the floor slab. The compacted aggregate should comply with the recommendations of the current version of ACI 302.1, "Concrete and Slab Construction." In areas with carpet, tile or other moisture-sensitive floor finishes, a vapor retarder should be properly placed in accordance with ACI 302.1, local building codes and the flooring manufacturer's recommendations.

The proposed floor slab should have an adequate number of joints to reduce cracking resulting from any differential movement and volume changes during curing. Slab-on-grade floors should not be rigidly connected to the proposed building columns, walls, or foundations. Proper joints should be provided at the junctions of the slab and foundation system so that a limited amount of independent movement can occur without causing distress.

PSI understands that a partial 1,400 square foot basement will be located in the approximate center of the proposed structure. While groundwater was not encountered at the locations of Borings B-1 and B-2 (performed in the area of the proposed basement), the long-term piezometric level may be located at a depth of approximately 11 feet below the existing ground surface or an elevation of approximately 596 feet, based on the change in color of the soil from brown to gray. Therefore, depending on the elevation of the basement level floor slab, the floor should be protected against hydrostatic uplift forces and the potential infiltration of groundwater.

3.4 Lateral Earth Pressure Recommendations

The basement level walls should be designed as retaining structures. The Lateral earth pressure for use in the design of below-grade basement walls and retaining walls will vary depending on the type of wall, the type of backfill material, how the backfill is compacted and the drainage provisions employed. Clean granular soil, similar to MDOT Class II sand, is recommended as the backfill material against retaining structures to minimize lateral earth pressures. Based on the use of MDOT Class II sand, an active earth pressure coefficient of 0.33 and a passive earth pressure coefficient of 3.0 may be used for free standing retaining walls (free head). For restrained walls (fixed head), an at-rest earth pressure coefficient of 0.50 may be used.

The equivalent fluid unit weights presented below provides recommended lateral earth pressures for the design of these walls. The table assumes the use of hand compacted MDOT Class II sand placed on a level surface directly behind the wall and having a moist unit weight of 125 pcf and an internal friction angle of 30 degrees. The values do not include the influence of excess structural compaction or surcharge loads from heavy compaction equipment operating immediately adjacent to the wall, adjacent foundations or other surface loads in or adjacent to the wall backfill, as well as sloped backfill surfaces. Retaining walls should also be designed to resist these surcharge loads, if present. PSI can provide assistance in evaluating the magnitude of design surcharge loads, if requested.

Equivalent Fluid Pressure

Backfill Type	Fixed-Head (At-Rest)	Free-Head (Active)
Granular Material With drainage	60	40
Granular Material Without drainage	90	80

Backfill of foundation walls and retaining walls must consist of free draining granular materials, conforming to the requirements of MDOT Class II granular material. The backfill materials should be placed in 8-inch thick loose layers and compacted to 95 percent of the Modified Proctor maximum dry density as determined per ASTM D1557.

PSI recommends that the backfill directly behind the walls be compacted with light, hand-held compactors. Heavy compactors and grading equipment should not be allowed to operate within 5 to 10 feet of the walls during backfilling to avoid developing excessive temporary or long-term lateral soil pressures. A reduction in the lift size may be necessary to achieve proper compaction with hand-operated compactors. PSI recommends that a representative of the geotechnical engineer be present to monitor the wall foundation excavations and fill placement.

PSI recommends that the below-grade walls have an exterior waterproofing substance or bentonite panels applied to the wall prior to backfilling and should contain a water stop between the poured walls and the foundation base slab. In addition, PSI recommends that below grade walls and retaining walls be provided with positive foundation drainage. A typical below-grade wall, retaining wall or foundation drain would consist of a minimum 4-inch flexible or rigid perforated pipe, protected by a proper filter medium (clean, coarse granular fill), and a non-woven geotextile fabric for long-term protection against siltation. The non-woven filter fabric should encircle or wrap the entire system, not the perforated pipe itself. Where a foundation drainage system is not to be provided, PSI recommends that the below grade basement walls be designed for the "granular material without drainage" condition outlined in the table above.

3.5 Pavement Recommendations

The project will also include construction of perimeter asphalt and concrete pavement driveways along the east, north and west sides of the proposed building. The perimeter pavements will support heavy pumper truck traffic weighing approximately 66,300 pounds. Automobile parking spaces will be provided off the perimeter driveways on the northeast and west sides of the proposed building. An automobile parking lot will also be constructed on the south side or front of the proposed building. PSI understands that it is currently proposed to support the heavy fire truck traffic on a 9-inch thick asphalt section over 4 inches of aggregate base. A 9-inch thick reinforced concrete pavement section will be provided on either side of the proposed vehicle garage (entrance and exit drives/exterior truck parking area). PSI understands that it is currently proposed to support the passenger vehicle traffic on a 5-inch thick asphalt section over 8 inches of aggregate base.

20-year light-duty and heavy-duty flexible pavement designs were determined utilizing the DARWin Pavement Design and Analysis System. This program embodies the methodology of the 1993 AASHTO Guide for the Design of Pavement Structures. Specific pavement design parameters or traffic volume data were not provided (with the exception of the maximum weight of the fire trucks). The number of heavy trucks and axle loadings can significantly affect the 18-kip ESAL value over the design life of the pavement. Depending on the axle load distribution and the use of single or dual axles, the 18-kip ESAL loads per fire truck vehicle can range from approximately 0.89 ESALs/truck to greater than 4.0 ESALs per truck. For the purposes of this report, PSI has used a value of 250,000 18-kip ESAL's over the design period in our analysis of the heavy duty flexible and rigid pavement sections to be used in the proposed perimeter fire truck driveway and exterior heavy duty truck parking area. PSI recommends that the pavement design be prepared based on the actual anticipated number of 18-kip ESAL's using the pavement over the design period determined from actual traffic data and vehicle loading. PSI has used a nominal value of 50,000 18-kip ESAL's over the design period for a light-duty flexible pavement section to be used in general passenger vehicle parking areas.

PSI's scope of services did not include extensive sampling and laboratory CBR testing of the existing subgrade soils or potential sources of imported fill for the specific purpose of a detailed pavement analysis for the proposed pavements. Based on our experience with similar soils, PSI has estimated a CBR value of 2.5 to 3.5 for the subgrade soils consisting predominately of deleterious old silty sand and clay fill encountered at the boring locations performed. Based on this value, an effective roadbed soil resilient modulus of 3,500 psi was used in the pavement design. The effective roadbed soil resilient modulus takes into account the seasonal effects on the subgrade and base materials, including weakening during the spring thaw and frozen conditions during the winter months. Other design parameters used in the heavy duty flexible pavement design include a terminal serviceability of 2.5, an initial serviceability of 4.5, reliability of 95%, subgrade drainage coefficient of 0.75, and a standard deviation of 0.49. Design parameters used in the light-duty flexible pavement design include a terminal serviceability of 2.0, an initial serviceability of 4.2, reliability of 90%, subgrade drainage coefficient of 0.75, and a standard deviation of 0.49. For the soil conditions and anticipated traffic loads, DARWin has calculated minimum required flexible design structural numbers of 2.81 and 3.88 for the standard duty and heavy duty pavement sections, respectively.

Based on the DARWin Pavement Design outputs and local practices, PSI recommends the following minimum pavement sections:

Recommended Light Duty Flexible Pavement Section (50,000 ESALs)				
Pavement Material	**Section Thickness (inches)**	**Structural Layer Coefficient**	**Drainage Coefficient**	**Structural Number**
Bituminous Surface Course	2.5	0.42	1.0	1.05
Bituminous Leveling Course	2.5	0.42	1.0	1.05
Aggregate Base Course (MDOT 21AA Limestone)	8.0	0.14	0.75	0.84
			Total SN = 2.94>2.81	

Recommended Heavy Duty Flexible Pavement Section (250,000 ESALs)				
Pavement Material	**Section Thickness (inches)**	**Structural Layer Coefficient**	**Drainage Coefficient**	**Structural Number**
Bituminous Surface Course	2.5	0.42	1.0	1.05
Bituminous Leveling Course	4.5	0.42	1.0	1.89
Bituminous Base Course	2.0	0.36	1.0	0.72
Aggregate Base Course (MDOT 21AA Limestone)	4.0	0.14	0.75	0.42
			Total SN = 4.08>3.88	

The flexible pavement design should incorporate high quality, high stability plant mixes being supplied with design properties and aggregate gradation meeting or exceeding the requirements as outlined in the 2012 MDOT Standard Specification Section 501. The crushed aggregate base course should conform to the requirements of MDOT Class 21AA.

A rigid concrete pavement section has also been determined using the DARWin Pavement Design and Analysis System for use at the proposed fire truck's garage entrance and exit drive/exterior truck parking area. Design parameters used in the rigid pavement design include a standard deviation of 0.39, concrete modulus of elasticity of 4.2×10^6 psi, concrete modulus of rupture of 670 psi and a mean effective k value of 70 psi/in. The mean effective k modulus takes into account the thickness of the base materials and the slab as well as seasonal effects on the subgrade and base materials, including weakening during the spring thaw and frozen conditions during the winter months.

The recommended minimum pavement section is shown on the following table:

Recommended Minimum Heavy Duty Rigid Pavement Section (250,000 ESALs)	
Pavement Material	**Section Thickness (inches)**
Type I Portland Cement Concrete	6.0
MDOT 21AA Aggregate Base Course	4.0

The concrete mix design should consist of a minimum 6-bag, normal weight concrete with a minimum 28-day compressive strength of 3,500 psi when tested in accordance with ASTM C39. The concrete should contain an air entrainment admixture to resist the effects of freezing and thawing. The pavement should suitably reinforced and doweled at construction joints to permit the proper transfer of loads. The design of dowel tie bar and joint locations are to be determined by Huron Consultant's structural engineer.

It should be recognized that all pavements require regular maintenance and occasional repairs to keep the pavements in a serviceable condition. Of particular value is a timely sealing of joints and cracks, which if left un-repaired, can serve to permit water to enter the pavement section and cause rapid deterioration of the pavement during freeze-thaw cycles. The need for such maintenance and repair is not necessarily indicative of premature pavement failure. However, if appropriate maintenance and repairs are not performed on a timely basis, the serviceable life of the pavement can be reduced significantly.

The pavement surface should be adequately sloped to promote good surface drainage and to reduce water infiltration into the base course. Water should not be allowed to pond behind curbs and saturate the pavement base stone. Where open grade base course is used, an edge drain system will be required to remove water infiltration within the base course. Consideration should also be given to the placement of additional finger drains radiating outward from the catch basins at the base course/subgrade interface.

Engineered fill or backfill required to achieve the proposed pavement subgrade elevation should be placed and properly compacted as outlined in Section 3.1 of this report. The subgrade soil below existing cut and at-grade areas of the proposed pavements should be scarified and compacted to 95% of its maximum dry density as determined per ASTM

D1557, for a minimum depth of 12 inches below the final graded surface.

3.6 Detention Pond Recommendations

The proposed project will also include the construction of a storm water detention pond within the western portion of the site. The bottom of the proposed detention pond will be located at an elevation of approximately 595.5 feet or a depth of approximately 12 feet below the existing site grade.

Based on Boring B-9 (which was performed in the area of the proposed detention pond) the soil exposed at the bottom of the proposed pond is anticipated to consist predominately of medium stiff to stiff gray clay soils. PSI estimates the clay soils to have a hydraulic conductivity, k (soil permeability) on the order of approximately 1×10^{-7} to 1×10^{-8} cm/sec. Based on the relatively low permeability of the native clays at this site, it may not be necessary to place an artificial geo membrane liner within the detention pond bottom to maintain the normal pool elevation.

However, based on the borings performed within and adjacent to the area of the proposed detention pond, deleterious old fill and native soils with organics are anticipated to be present within the proposed detention pond sidewalls. **These soils are not considered suitable for support of the proposed detention pond excavation side walls or for support of embankment fill placed over them.** PSI recommends that these soils be over excavated and the detention pond sidewalls be constructed of newly placed and properly compacted engineered fill. In PSI's opinion, a side slope configuration of 3:1 (Horizontal: Vertical) or flatter should be suitable for the native clay soils encountered or newly placed and properly compacted engineered fill, provided they are stable at the time of construction and are suitably protected from erosion.

The structural embankment fill should be placed in maximum horizontal lifts of 8 inches of loose material and should be compacted within the range of ±2% of the optimum moisture content value as determined by ASTM D1557. Moisture contents should be adjusted to the proper levels prior to placement and compaction. Adequate compaction will not be achieved if the fill is in a saturated condition. Wet soils may require drying or mixing with dry soil to facilitate compaction. If water must be added to dry soil, it should be uniformly applied and thoroughly mixed into the soil by disking or scarifying prior to compaction. Each lift of engineered fill should be tested for conformance to the project density requirements prior to placement of subsequent lifts. Care should be taken to apply adequate compaction effort throughout the detention pond embankment fill, including at the toe of slopes. A sheep's foot roller is recommended for compaction of cohesive soils.

PSI recommends that vegetation be established within the upper portion of all basin side slopes above the normal pool elevation immediately following placement, compaction and shaping. To provide additional erosion control until the vegetation's' root systems can be established, PSI recommends that an erosion control blanket, mat, jute or netting product also be placed over the slope. The blanket or netting should be placed and securely fastened or stapled to the subgrade soils per the manufactures recommendations.

PSI's recommends that more substantial erosion and slope protection be provided for all basin side slopes below the normal pool elevation. Erosion/stabilization alternatives include rip-rap, cellular confinement systems or concrete mats. Plain or heavy rip-rap may be placed from the bottom of the basin to the recommended top elevation. The rip-rap should be a minimum of 8 inches thick and should conform to the requirements of Section 916 of the "2012 MDOT Standard Specifications" or local government specifications. At a minimum, PSI recommends that rip-rap be placed around all the inlet and outlet structures. In addition, rip-rap should be provided below drainage channels extending from the inlet pipes to the bottom of the basin. Cellular confinement systems consist of approximately 2 to 8 inch diameter honey-combed shaped cells which are placed in rolls or mats from the top to bottom of the slope and backfilled with sand or gravel. The cells may also be backfilled with topsoil materials where it is desired to establish heavy vegetation. A third alternative are concrete mats, which consist of 'blankets' of open or closed cell concrete blocks inter-connected with cables that are laid out over the basin slope. Open celled blocks should be used if it is desired to promote light vegetation within the blankets.

Each of the erosion/slope stabilization products above are typically placed over a geotextile filter fabric. The final choice of erosion/stabilization product(s) to be used within the lower portion of the basin side slopes below the normal pool elevation should be based on the relative economic, engineering and construction advantages of each as well as the associated maintenance requirements following construction of each product alternative. PSI recommends that individual product manufactures be consulted to determine the appropriate product type and installation guidelines.

4.0 CONSTRUCTION CONSIDERATIONS

4.1 Drainage, Groundwater and Related Considerations

Relatively shallow groundwater or perched water was encountered during drilling at depths ranging from approximately 1.4 to 2 feet below the existing ground surface at the locations of Borings B-7 and B-11 and a depth of approximately 8 feet at the location of Boring B-9. Groundwater or perched water was not encountered during drilling or following completion of drilling at the remaining boring locations performed. Therefore, difficulty with groundwater seepage is generally not anticipated during excavation associated with shallow foundation construction. However, difficulty with groundwater seepage and subgrade instability should be anticipated during earthwork operations associated with the removal of the existing deleterious old fill and buried native soil with organics (i.e. peat and marl). PSI recommends that the Contractor verify the actual groundwater and seepage conditions at the time of the construction activities and propose the groundwater control methods for the Engineer's approval, including the disposal of discharge water.

Every effort should be made to keep the excavations and any other prepared subgrades dry if water is encountered or if rainfall or snowmelt occurs during construction. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. In addition, soils that become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. It will, therefore, be advantageous to perform earthwork and foundation construction activities during dry weather. Positive site surface drainage should be provided to reduce infiltration of surface water. The grades should be sloped away from the proposed building structure and surface drainage should be collected and discharged. Water accumulation should be removed from excavations by pumping from sump pits placed around the perimeter of the excavation.

4.2 Excavation Safety Considerations

Typically, soils penetrated by augers can be removed with conventional earthmoving equipment (backhoe and/or trencher). However, subsurface excavation equipment varies, and field refusal conditions may vary as well. The Contractor should come to the site prepared to excavate hard sandy clay soils and buried obstructions within the old fill as necessary.

Excavation near any existing structure or utility must be performed with the utmost of care and under the supervision of the geotechnical engineer's representative. Locations of all underground utilities within the proposed site must be verified by the Contractor prior to excavation.

In Federal Register, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". This document was issued to better insure the safety of workmen entering trenches or excavations. It is mandated by this federal regulation that excavations, whether they be utility trenches, basement excavation or footing excavations, be constructed in accordance with OSHA guidelines. It is our understanding that these regulations are being strictly enforced and if they are not closely followed, the Owner and the Contractor could be liable for substantial penalties. The Contractor is solely responsible for designing and constructing stable, safe, temporary excavations and should shore, slope or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The Contractor's "responsible person", as defined in 29 CFR Part 1926, must evaluate the soil exposed in the excavations as part of the Contractor's safety procedures.

The angle of the excavation side slopes must strictly be decided based on the soil type and unconfined compressive strength of the excavated soil per OSHA requirements. For Type A soils, such as clay above water table having unconfined compressive strength values equal to or more than 1½ ton per square foot (tsf), the maximum allowable slope for excavations up to 20 feet deep is ¾ (Horizontal) :1 (Vertical). For Type B soils, such as clay above water table having unconfined compressive strength values between ½ to 1½ ton per square foot (tsf), or angular gravel, the maximum allowable slope for excavations up to 20 feet deep is 1 (Horizontal) :1 (Vertical). For Type C soils, such as clay above water table having unconfined compressive strength values less than ½ ton per square foot (tsf), or granular soils such as gravel and sand, and all submerged soils, the maximum allowable slope for excavations up to 20 feet deep is 1½ (Horizontal) :1 (Vertical). The Contractor should be aware that slope height, slope inclination, and excavation depth should not exceed the specified local, state, and federal regulations.

Earthwork, subgrade preparation, and foundation construction operations must be conducted in strict accordance with the project specifications and under the supervision of the geotechnical engineer or his representative. PSI is providing this information solely as a service to our client. PSI does not assume responsibility for construction site safety or the contractor's or other parties' compliance with local, state, and federal safety or other regulation

5.0 REPORT LIMITATIONS

The recommendations submitted in this report are based on the available subsurface information obtained by PSI and the project information furnished by Huron Consultants. If there are any revisions to the plans for this project, or if deviations from the subsurface conditions noted in this report are encountered during construction, PSI should be notified immediately to determine if changes in the earthwork, subgrade preparation and foundation design parameter recommendations are required. If PSI is not notified of such changes, PSI will not be responsible for the impact of those changes on the project.

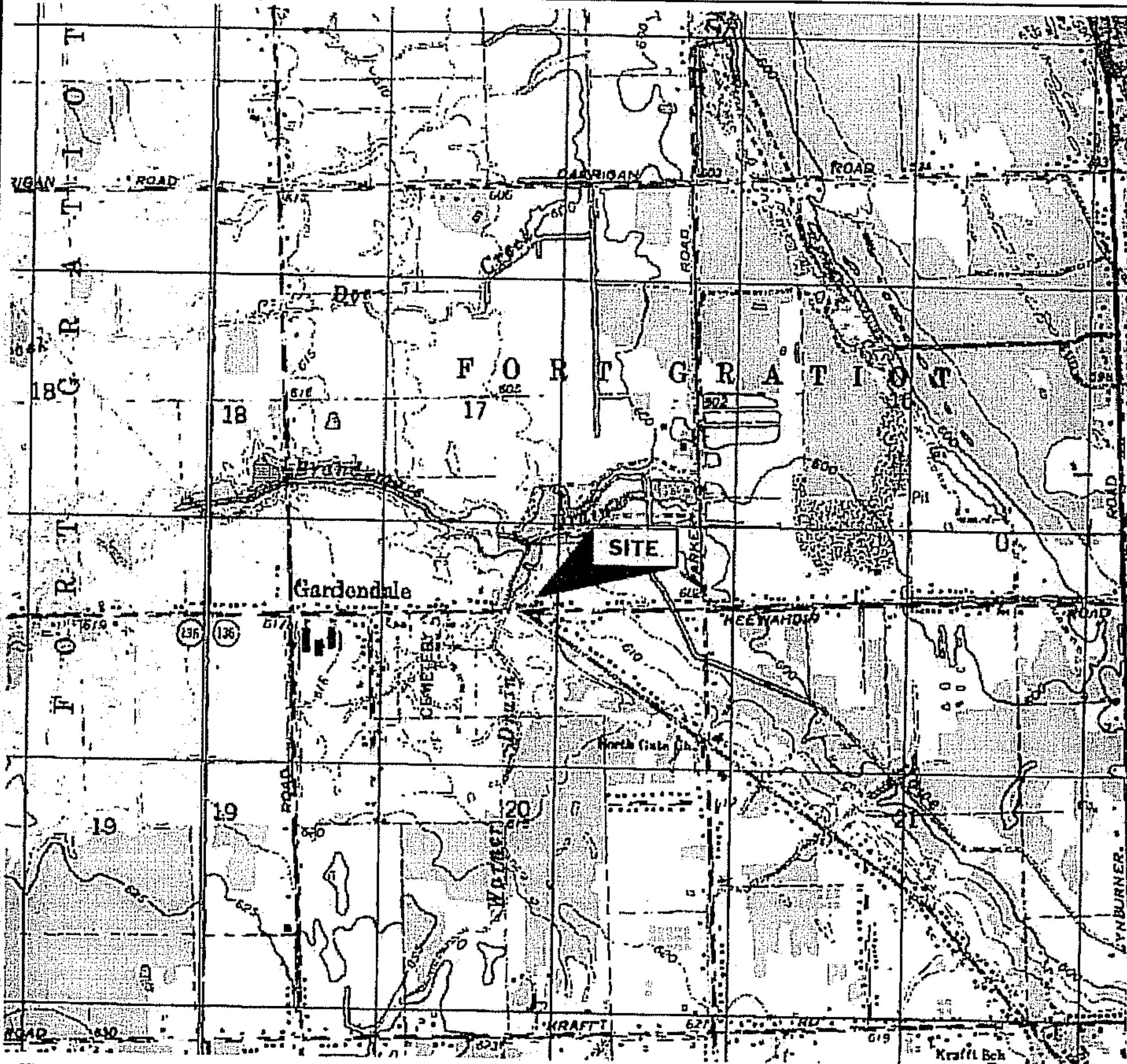
The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional engineering practices in the local area. No other warranties are implied or expressed.

This report has been prepared for the exclusive use of Huron Consultants and their authorized representatives. This report is intended for the specific application to the proposed Fort Gratiot Municipal Center to be constructed at 3720 Keewahdin Road in Fort Gratiot Township, St. Clair County, Michigan.

APPENDIX

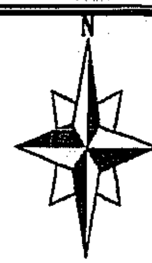
PROPOSED MUNICIPAL CENTER
3720 KEEWAHDIN ROAD
FORT GRATIOT TOWNSHIP, ST. CLAIR COUNTY, MICHIGAN

Figure 1
Site Vicinity Map



SCALE 1:24,000

1 ½ 0 MILES 1



PSI Project No.: 0381704

psi Information To Build On
Engineering • Consulting • Testing

Base Map:
Lakeport and Ruby, MI
Quadrangle 7.5 Minute Series
Topographic Maps

Peak Acceleration (%g) with 10% Probability of Exceedance in 50 Years
USGS Map, Oct. 2002

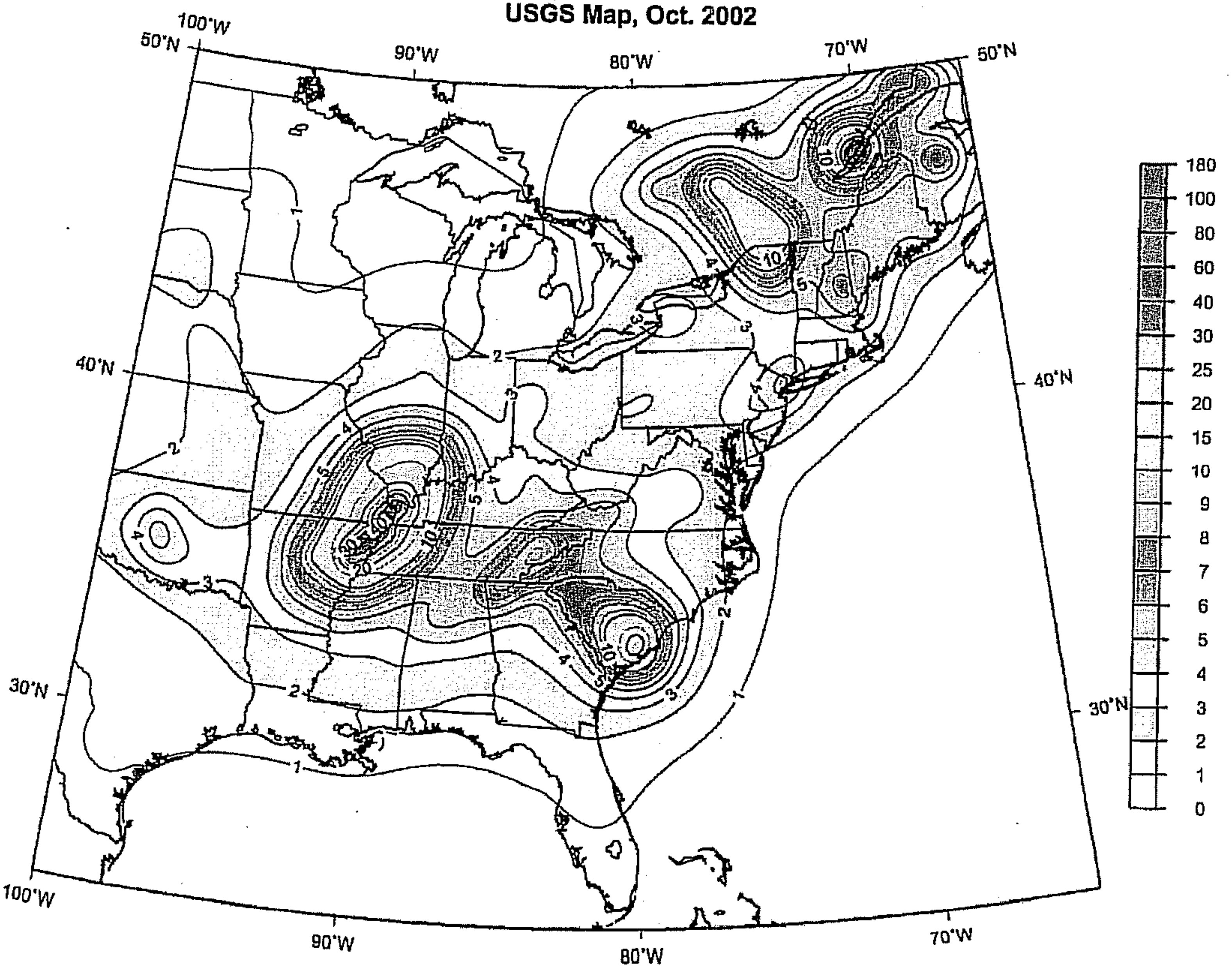
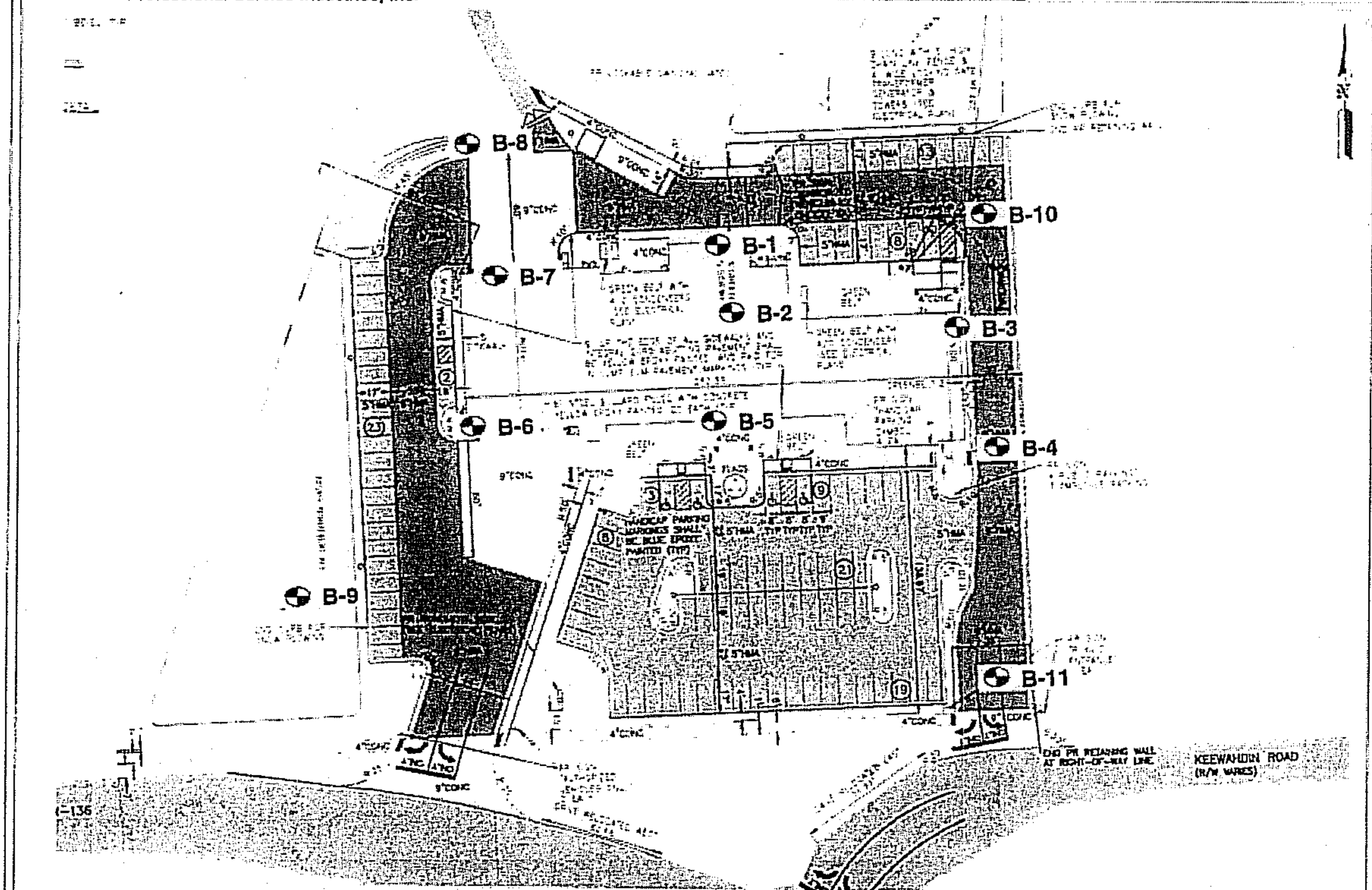


FIGURE NO. 2

Earthquake Hazard Risk Map

Source: http://earthquake.usgs.gov/hazmaps/

Professional Service Industries, Inc.



PROJECT NAME:	BORING LOCATION PLAN	PROJECT NUMBER:	FIG. NO.
PROPOSED MUNICIPAL CENTER 3720 KEEWAHDIN ROAD FORT GRATIOT TOWNSHIP, ST. CLAIR COUNTY, MICHIGAN	*BASED ON THE "TOPOGRAPHICAL SURVEY & DEMOLITION PLAN" DATED DECEMBER 5, 2013 PREPARED BY HURON CONSULTANTS AND PROVIDED TO PSI FOR USE IN THE GEOTECHNICAL EXPLORATION AND ENGINEERING REPORT*	0381704	3
		DATE: January 23, 2014 Scale:	

BORING B-1

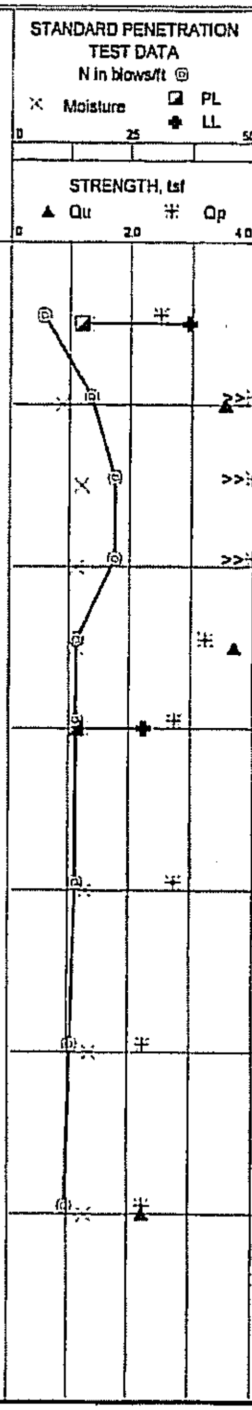
DATE STARTED:	1/15/14	DRILL COMPANY:	PSI, Inc.
DATE COMPLETED:	1/15/14	DRILLER: J. Arsenault	LOGGED BY: J. Hestwood
COMPLETION DEPTH	30.5 ft	DRILL RIG:	CME 45
BENCHMARK:	N/A	DRILLING METHOD:	3.25" HSA
ELEVATION:	606.82 ft	SAMPLING METHOD:	2" SS
LATITUDE:		HAMMER TYPE:	Automatic
LONGITUDE:		EFFICIENCY	76%
STATION: N/A	OFFSET: N/A	REVIEWED BY:	A. Cekic

REMARKS: Borehole backfilled with auger cuttings upon completion

Water: While Drilling None feet; Upon Completion None feet; Cave-In @ 28.25 feet

BORING LOCATION: See Boring Location Plan

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			10" SILTY TOPSOIL				
605		1	12	SILTY CLAY, with sand, trace gravel, mottled orange brown, light reddish brown and gray, moist, very stiff	CL	1,3,4 N=7	16	LL = 37 PL = 15 Qp = 2.5 tsf
	5	2	18	SANDY CLAY, trace gravel, mottled brown and gray, moist, very stiff to hard	CL	5,7,10 N=17	11	DD = 132 pcf Q_u = 3.6 tsf Qp = 4.5+ tsf
600		3	18			6,9,13 N=22	15	Qp = 4.5+ tsf
	10	4	16	SANDY CLAY, trace gravel, dark brown to grayish brown, moist, hard	CL	7,10,12 N=22	14	Qp = 4.5+ tsf
595		5	12	SANDY CLAY, trace gravel, gray, moist, very stiff	CL	5,6,8 N=14	14	DD = 119 pcf Q_u = 3.7 tsf Qp = 3.25 tsf
	15	6	18			3,6,8 N=14	15	LL = 28 PL = 14 Qp = 2.75 tsf
590	20	7	10			4,6,8 N=14	16	Qp = 2.75 tsf
585	25	8	16			3,5,8 N=13	17	Qp = 2.25 tsf
580	30	9	18			3,5,7 N=12	16	DD = 118 pcf Q_u = 2.2 tsf Qp = 2.25 tsf
				End of Boring				



Professional Service Industries, Inc.
45749 Helm Street
Plymouth, MI 48170
Telephone: (734) 453-7900

PROJECT NO.: 0381704
PROJECT: Proposed Municipal Center
LOCATION: 3720 Keewahdin Road, Fort Gratiot Township, St. Clair County, Michigan

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED:	1/15/14	DRILL COMPANY:	PSI, Inc.
DATE COMPLETED:	1/15/14	DRILLER: J. Arsenault	LOGGED BY: J. Hestwood
COMPLETION DEPTH	25.5 ft	DRILL RIG:	CME 45
BENCHMARK:	N/A	DRILLING METHOD:	3.25" HSA
ELEVATION:	607.24 ft	SAMPLING METHOD:	2" SS
LATITUDE:		HAMMER TYPE:	Automatic
LONGITUDE:		EFFICIENCY	76%
STATION: N/A	OFFSET: N/A	REVIEWED BY:	A. Cekic

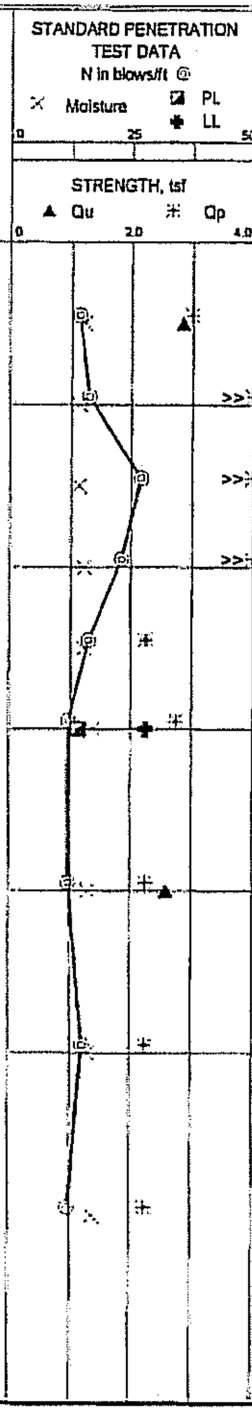
REMARKS: Borehole backfilled with auger cuttings upon completion

BORING B-2

Water		
While Drilling		None feet
Upon Completion		None feet
	Cave-In @ 28 feet	

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			11" SILTY TOPSOIL				
				SILTY SAND, fine, trace gravel, light brown, moist	SM			
605		1	18	SILTY CLAY, with sand, trace gravel, mottled orange brown, light reddish brown and gray, moist, very stiff	CL	2,6,8 N=14	15	DD = 118 pcf Q_u = 2.9 tsf Qp = 3.0 tsf
	5	2	18	SANDY CLAY, trace gravel, mottled brown and gray, moist, hard	CL	4,6,10 N=16	14	Qp = 4.5+ tsf
600		3	18	SANDY CLAY, trace gravel, brown to grayish brown, moist, hard	CL	6,9,18 N=27	14	Qp = 4.5+ tsf
	10	4	18			6,10,13 N=23	15	Qp = 4.5+ tsf
595		5	18	SANDY CLAY, trace gravel, gray, moist, very stiff	CL	3,7,9 N=16	15	Qp = 2.25 tsf
	15	6	18			3,5,7 N=12	17	LL = 28 PL = 14 Qp = 2.75 tsf
590								
	20	7	18			3,5,7 N=12	16	DD = 118 pcf Q_u = 2.6 tsf Qp = 2.25 tsf
585								
	25	8	18			4,7,8 N=15	16	Qp = 2.25 tsf
		9	18			4,5,7 N=12	17	Qp = 2.25 tsf
				End of Boring				



Professional Service Industries, Inc.
45749 Helm Street
Plymouth, MI 48170
Telephone: (734) 453-7900

PROJECT NO.: 0381704
PROJECT: Proposed Municipal Center
LOCATION: 3720 Keewahdin Road, Fort Gratiot Township, St. Clair County, Michigan

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-3

DATE STARTED:	1/15/14	DRILL COMPANY:	PSI, Inc.
DATE COMPLETED:	1/15/14	DRILLER: J. Arsenault	LOGGED BY: J. Hestwood
COMPLETION DEPTH	20.5 ft	DRILL RIG:	CME 45
BENCHMARK:	N/A	DRILLING METHOD:	3.25" HSA
ELEVATION:	606.70 ft	SAMPLING METHOD:	2" SS
LATITUDE:		HAMMER TYPE:	Automatic
LONGITUDE:		EFFICIENCY	76%
STATION: N/A	OFFSET: N/A	REVIEWED BY:	A. Cekic

REMARKS: Borehole backfilled with auger cuttings upon completion

Water:
- While Drilling: None feet
- Upon Completion: None feet
- Cave-in @ 18.2 feet

BORING LOCATION: See Boring Location Plan

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			13" SILTY TOPSOIL				
605				SILTY SAND, fine, trace gravel, light brown, moist	SM			
		1	18	SILTY CLAY, with sand, trace gravel, mottled orange brown, light reddish brown and gray, moist, very stiff to hard	CL	2,4,8 N=12	18	Qp = 4.5+ tsf
	5	2	18	SANDY CLAY, trace gravel, mottled brown and gray, moist, hard	CL	6,8,12 N=20	14	Qp = 4.5+ tsf
600		3	18	SANDY CLAY, trace gravel, brown to grayish brown, moist, hard	CL	7,11,13 N=24	14	DD = 121 pcf Q_u = 6.5 tsf Qp = 4.5+ tsf
	10	4	18	SANDY CLAY, trace gravel, gray, moist, hard		6,9,12 N=21	14	Qp = 3.75 tsf
595		5	18			3,5,10 N=15	15	LL = 28 PL = 14 Qp = 3.0 tsf
	15	6	18		CL	3,6,7 N=13	15	Qp = 2.75 tsf
590								
	20	7	18			3,5,8 N=13	16	Qp = 2.75 tsf
				End of Boring				

STANDARD PENETRATION TEST DATA: N in blows/ft ⊚; × Moisture; PL; LL; 0 – 25 – 50. STRENGTH, tsf: ▲ Qu; ✳ Qp; 0 – 2.0 – 4.0

Professional Service Industries, Inc.
45749 Helm Street
Plymouth, MI 48170
Telephone: (734) 453-7900

PROJECT NO.: 0381704
PROJECT: Proposed Municipal Center
LOCATION: 3720 Keewahdin Road, Fort Gratiot Township, St. Clair County, Michigan

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-4

DATE STARTED:	1/15/14	DRILL COMPANY:	PSI, Inc.
DATE COMPLETED:	1/15/14	DRILLER: J. Arsenault	LOGGED BY: J. Hestwood
COMPLETION DEPTH	20.5 ft	DRILL RIG:	CME 45
BENCHMARK:	N/A	DRILLING METHOD:	3.25" HSA
ELEVATION:	608.96 ft	SAMPLING METHOD:	2" SS
LATITUDE:		HAMMER TYPE:	Automatic
LONGITUDE:		EFFICIENCY	76%
STATION: N/A	OFFSET: N/A	REVIEWED BY:	A. Cekic

REMARKS: Borehole backfilled with auger cuttings upon completion

Water
- While Drilling: None feet
- Upon Completion: None feet
- Cave-In @ 7.8 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0				12" SILTY TOPSOIL				
		SS	1	18	SILTY SAND, fine, trace gravel, light yellowish brown, moist, medium dense	SM	2,6,9 N=15	6	
605	5	SS	2	18	SILTY CLAY, with sand, trace gravel, mottled orange brown, light reddish brown and gray, moist, very stiff to hard	CL	5,8,13 N=21	17	LL = 37 PL = 15 Qp = 4.0 tsf
		SS	3	18	SANDY CLAY, trace gravel, mottled brown and gray, moist, hard	CL	7,11,16 N=27	13	Qp = 4.5+ tsf
600	10	SS	4	18	SANDY CLAY, trace gravel, gray, moist, hard to stiff	CL	6,11,14 N=25	12	Qp = 4.5+ tsf
		SS	5	18			6,8,9 N=17	14	Qp = 3.75 tsf
595	15	SS	6	18			3,5,7 N=12	15	DD = 120 pcf Q_u = 1.8 tsf Qp = 2.25 tsf
590	20	SS	7	18			2,4,6 N=10	17	Qp = 2.0 tsf
					End of Boring				

STANDARD PENETRATION TEST DATA
N in blows/ft ◎
× Moisture ◪ PL ✚ LL
0 25 50
STRENGTH, tsf
▲ Qu ✳ Qp
0 2.0 4.0

Professional Service Industries, Inc.
45749 Helm Street
Plymouth, MI 48170
Telephone: (734) 453-7900

PROJECT NO.: 0381704
PROJECT: Proposed Municipal Center
LOCATION: 3720 Keewahdin Road
Fort Gratiot Township
St. Clair County, Michigan

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED:	1/14/14	DRILL COMPANY:	PSI, Inc.
DATE COMPLETED:	1/14/14	DRILLER: N. Wilson	LOGGED BY: J. Hestwood
COMPLETION DEPTH	20.5 ft	DRILL RIG:	CME 75
BENCHMARK:	N/A	DRILLING METHOD:	3.25" HSA
ELEVATION:	608.31 ft	SAMPLING METHOD:	2" SS
LATITUDE:		HAMMER TYPE:	Automatic
LONGITUDE:		EFFICIENCY	82%
STATION: N/A	OFFSET: N/A	REVIEWED BY:	A. Cekic

REMARKS: Borehole backfilled with auger cuttings upon completion

BORING B-5

Water		
While Drilling		None feet
Upon Completion		None feet
	Cave-In @ 18.9	feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			8" SILTY TOPSOIL				
				SILTY SAND, fine, light brown, moist	SM			
605		1	6	SILTY CLAY, with sand, trace gravel, mottled orange brown, light reddish brown and gray, very moist, stiff	CL	3,4,6 N=10	18	LL = 37 PL = 15 Qp = 1.25 tsf
	5	2	12	SANDY CLAY, trace gravel, mottled brown and gray, moist, hard	CL	6,9,11 N=20	17	
600		3	18	SANDY CLAY, trace gravel, brown to grayish brown, moist, hard	CL	7,12,14 N=26	15	Qp = 4.5+ tsf
	10	4	18			6,10,13 N=23	14	Qp = 4.5+ tsf
595		5	18	SANDY CLAY, trace gravel, gray, moist, very stiff	CL	6,7,9 N=16	15	Qp = 3.5 tsf
	15	6	18			5,7,9 N=16	15	Qp = 2.75 tsf
590								
	20	7	18	becomes very moist, stiff		4,5,5 N=10	18	Qp = 1.75 tsf
				End of Boring				

STANDARD PENETRATION TEST DATA: N in blows/ft ◎; × Moisture; PL; LL (0, 25, 50). STRENGTH, tsf: ▲ Qu; ✳ Qp (0, 2.0, 4.0)

Professional Service Industries, Inc.
45749 Helm Street
Plymouth, MI 48170
Telephone: (734) 453-7900

PROJECT NO.: 0381704
PROJECT: Proposed Municipal Center
LOCATION: 3720 Keewahdin Road
Fort Gratiot Township
St. Clair County, Michigan

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 1/14/14
DATE COMPLETED: 1/14/14
COMPLETION DEPTH 20.5 ft
BENCHMARK: N/A
ELEVATION: 608.46 ft
LATITUDE:
LONGITUDE:
STATION: N/A OFFSET: N/A
REMARKS: Borehole backfilled with auger cuttings upon completion

DRILL COMPANY: PSI, Inc.
DRILLER: N. Wilson LOGGED BY: J. Hestwood
DRILL RIG: CME 75
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: 2" SS
HAMMER TYPE: Automatic
EFFICIENCY 82%
REVIEWED BY: A. Cekic

BORING B-6

Water		
▽	While Drilling	None feet
▼	Upon Completion	18 feet
▽	Cave-In @	18.5 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL 0 25 50; STRENGTH, tsf ▲ Qu ✳ Qp 0 2.0 4.0	Additional Remarks
	0					1.8" ASPHALT PAVEMENT					
						4.5" CRUSHED LIMESTONE BASE					
605				1	12	FILL - SANDY CLAY, trace gravel, organics, glass and concrete rubble, occasional seams of fine silty sand, dark gray and dark grayish brown, moist		4,4,6 N=10	18		
	5			2	10	LOI = 7.2% (2SS)	CL	3,3,6 N=9	17		
600				3	4			3,1,1 N=2	14		
	10			4	18	SILTY CLAY, with sand, trace gravel, mottled orange brown, light reddish brown and gray, very moist, stiff	CL	2,2,2 N=4	19		DD = 111 pcf Q_u = 1.6 tsf Qp = 2.0 tsf
595				5	0	SANDY CLAY, trace gravel, gray, moist, very stiff		6,8,11 N=19			
	15			6	18			5,8,12 N=20	17		Qp = 3.75 tsf
590							CL				
	20			7	18			5,7,9 N=16	18		Qp = 2.25 tsf
						End of Boring					

Professional Service Industries, Inc.
45749 Helm Street
Plymouth, MI 48170
Telephone: (734) 453-7900

PROJECT NO.: 0381704
PROJECT: Proposed Municipal Center
LOCATION: 3720 Keewahdin Road
Fort Gratiot Township
St. Clair County, Michigan

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-7

DATE STARTED:	1/15/14	DRILL COMPANY:	PSI, Inc.
DATE COMPLETED:	1/15/14	DRILLER: J. Arsenault	LOGGED BY: J. Hestwood
COMPLETION DEPTH	25.5 ft	DRILL RIG:	CME 45
BENCHMARK:	N/A	DRILLING METHOD:	3.25" HSA
ELEVATION:	605.92 ft	SAMPLING METHOD:	2" SS
LATITUDE:		HAMMER TYPE:	Automatic
LONGITUDE:		EFFICIENCY	76%
STATION: N/A	OFFSET: N/A	REVIEWED BY:	A. Cekic

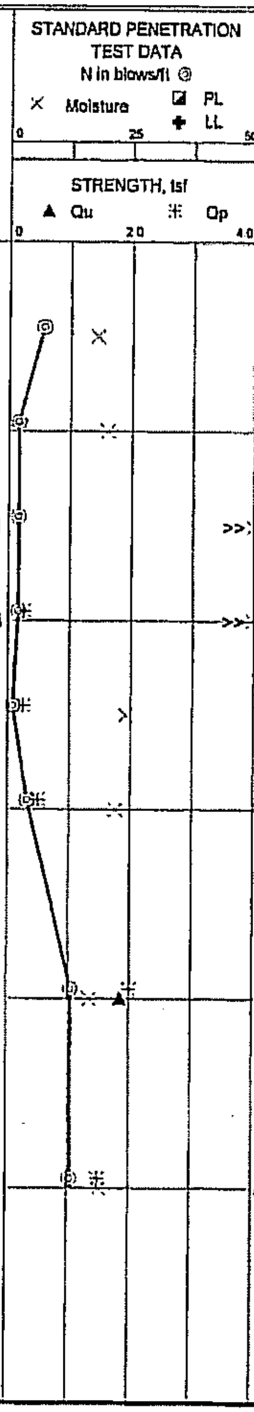
REMARKS: Borehole backfilled with auger cuttings upon completion

Water

While Drilling	1.4 feet
Upon Completion	1.4 feet
Cave-In @	1.4 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			18" SILTY GRAVEL				
605		1	18	FILL - SILTY SAND, fine to medium, trace gravel, organics and glass, dark gray to black, trace reddish brown slag and foundry brick, very moist to wet	SM	4,4,3 N=7	18	
600	5	2	6	LOI = 5.5% (2SS)		1,1,1 N=2	20	
		3	6	AMORPHOUS PEAT, trace wood, dark gray, very soft	PT	HW,1,1 N=2	111	
595	10	4	18	ORGANIC SILT (MARL) - trace wood, brown, very soft LOI = 24.7%	ML	1,1,1 N=2	178	Qp = 0.25 tsf
		5	18	CLAYEY SAND, light gray, wet, very loose	SC	HW,HW,1 N=1	24	Qp = <0.25 tsf
590	15	6	12	SILTY CLAY, with sand, mottled light gray and light bluish gray, wet, soft	CL	1,1,3 N=4	22	Qp = 0.5 tsf
585	20	7	18	SANDY CLAY, trace gravel, mottled gray and olive to gray, very moist, stiff	CL	4,6,7 N=13	17	DD = 114 pcf Q_u = 1.9 tsf Qp = 2.0 tsf
	25	8	8			4,6,7 N=13	19	Qp = 1.5 tsf
				End of Boring				



Professional Service Industries, Inc.
45749 Helm Street
Plymouth, MI 48170
Telephone: (734) 453-7900

PROJECT NO.: 0381704
PROJECT: Proposed Municipal Center
LOCATION: 3720 Keewahdin Road
Fort Gratiot Township
St. Clair County, Michigan

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED:	1/15/14	DRILL COMPANY:	PSI, Inc.
DATE COMPLETED:	1/15/14	DRILLER: J. Arsenault	LOGGED BY: J. Hestwood
COMPLETION DEPTH	15.5 ft	DRILL RIG:	CME 45
BENCHMARK:	N/A	DRILLING METHOD:	3.25" HSA
ELEVATION:	604.91 ft	SAMPLING METHOD:	2" SS
LATITUDE:		HAMMER TYPE:	Automatic
LONGITUDE:		EFFICIENCY	76%
STATION: N/A	OFFSET: N/A	REVIEWED BY:	A. Cekic

REMARKS: Borehole backfilled with auger cuttings upon completion

BORING B-8

Water		
▽	While Drilling	None feet
▼	Upon Completion	None feet
▽		feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL 0 25 50 / STRENGTH, tsf ▲ Qu ✳ Qp 0 2.0 4.0	Additional Remarks
	0					11" SILTY TOPSOIL					
				1	18	FILL - SILTY CLAYEY SAND, trace gravel, organics, glass, concrete rubble and sandy clay, gray, dark gray and black, moist		4,7,7 N=14	15		
600	5			2	4		SC-SM	50/4"	15	>>	
				3	0			20,8,5 N=13			
595	10			4	18	AMORPHOUS PEAT, trace wood, dark gray, soft LOI = 24.1%	PT	1,2,2 N=4	149	>>	
590	15			5	18	SILTY CLAY, with sand, trace gravel, mottled gray and olive, moist, very stiff	CL	3,5,6 N=11	18		Qp = 3.0 tsf
						End of Boring					

Professional Service Industries, Inc.
45749 Helm Street
Plymouth, MI 48170
Telephone: (734) 453-7900

PROJECT NO.: 0381704
PROJECT: Proposed Municipal Center
LOCATION: 3720 Keewahdin Road
Fort Gratiot Township
St. Clair County, Michigan

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 1/3/14
DATE COMPLETED: 1/3/14
COMPLETION DEPTH 15.5 ft
BENCHMARK: N/A
ELEVATION: 607.76 ft
LATITUDE:
LONGITUDE:
STATION: N/A OFFSET: N/A
REMARKS: Borehole backfilled with auger cuttings upon completion

DRILL COMPANY: PSI, Inc.
DRILLER: N. Wilson LOGGED BY: J. Hestwood
DRILL RIG: CME 75
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: 2" SS
HAMMER TYPE: Automatic
EFFICIENCY 82%
REVIEWED BY: A. Cekic

BORING B-9

Water		
▽ While Drilling		14 feet
▼ Upon Completion		8 feet
▽	Cave-In @	12 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			3.0" ASPHALT PAVEMENT				
				7.75" CRUSHED ASPHALT BASE				
				5.25" CRUSHED LIMESTONE BASE				
605		1	3	FILL - SILTY CLAYEY SAND, trace gravel, organics, glass, wood, dark gray, with reddish brown slag and foundry brick, moist to wet		3,3,3 N=6	24	
	5	2	10		SC-SM	2,3,3 N=6	32	
600		3	6			1,1,1 N=2	74	
	10	4	12	AMORPHOUS PEAT, trace wood, dark brown, soft LOI = 45.9%	PT	2,3,3 N=6	234	
595		5	12	SILTY CLAY, with sand, trace gravel, mottled light gray and bluish gray to olive and grayish brown, very moist to wet, medium stiff to stiff	CL	HW,2,3 N=5	22	Qp = 0.75 tsf
	15	6	12			2,2,2 N=4	21	Qp = 1.75 tsf
				End of Boring				

STANDARD PENETRATION TEST DATA
N in blows/ft ⊚
✕ Moisture ◪ PL ✚ LL
0 25 50
STRENGTH, tsf
▲ Qu ✳ Qp
0 2.0 4.0

Professional Service Industries, Inc.
45749 Helm Street
Plymouth, MI 48170
Telephone: (734) 453-7900

PROJECT NO.: 0381704
PROJECT: Proposed Municipal Center
LOCATION: 3720 Keewahdin Road
Fort Gratiot Township
St. Clair County, Michigan

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED:	1/15/14	DRILL COMPANY:	PSI, Inc.		**BORING B-10**
DATE COMPLETED:	1/15/14	DRILLER: J. Arsenault	LOGGED BY: J. Hestwood		
COMPLETION DEPTH	10.5 ft	DRILL RIG:	CME 45	Water	While Drilling None feet
BENCHMARK:	N/A	DRILLING METHOD:	3.25" HSA		Upon Completion None feet
ELEVATION:	606.31 ft	SAMPLING METHOD:	2" SS		Cave-In @ 9.5 feet
LATITUDE:		HAMMER TYPE:	Automatic	BORING LOCATION:	
LONGITUDE:		EFFICIENCY	76%	See Boring Location Plan	
STATION: N/A	OFFSET: N/A	REVIEWED BY:	A. Cekic		

REMARKS: Borehole backfilled with auger cuttings upon completion

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA (N in blows/ft; Moisture; PL; LL; 0 25 50) STRENGTH, tsf (Qu; Qp; 0 2.0 4.0)	Additional Remarks
	0					12" SILTY TOPSOIL					
605						SILTY CLAY, with sand, trace gravel, mottled orange brown and light grayish white to light reddish brown and gray, moist, very stiff					
				1	18		CL	2,3,6 N=9	17		Qp = 2.75 tsf
	5			2	18			3,5,10 N=15	16		Qp = 3.0 tsf
600						SANDY CLAY, trace gravel, brown to grayish brown, moist, hard					
				3	18		CL	5,11,14 N=25	15	>>	Qp = 4.5+ tsf
	10			4	18			5,8,15 N=23	14	>>	Qp = 4.5+ tsf
						End of Boring					

Professional Service Industries, Inc.
45749 Helm Street
Plymouth, MI 48170
Telephone: (734) 453-7900

PROJECT NO.: 0381704
PROJECT: Proposed Municipal Center
LOCATION: 3720 Keewahdin Road
Fort Gratiot Township
St. Clair County, Michigan

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 1/15/14	DRILL COMPANY: PSI, Inc.		**BORING B-11**
DATE COMPLETED: 1/15/14	DRILLER: J. Arsenault LOGGED BY: J. Hestwood	Water	While Drilling 2 feet
COMPLETION DEPTH 10.5 ft	DRILL RIG: CME 45		Upon Completion 5 feet
BENCHMARK: N/A	DRILLING METHOD: 3.25" HSA		Cave-In @ 5 feet
ELEVATION: 609.71 ft	SAMPLING METHOD: 2" SS		
LATITUDE:	HAMMER TYPE: Automatic		BORING LOCATION:
LONGITUDE:	EFFICIENCY 76%		See Boring Location Plan
STATION: N/A OFFSET: N/A	REVIEWED BY: A. Cekic		

REMARKS: Borehole backfilled with auger cuttings upon completion

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			24" SILTY TOPSOIL				
		1	18	SILTY SAND, fine, yellowish brown to light brown, wet, medium dense	SM	2,4,7 N=11	19	
605	5	2	18	SILTY CLAY, with sand, trace gravel, mottled orange brown and brownish gray, very moist to wet, stiff	CL	4,5,6 N=11	18	Qp = 1.5 tsf
		3	18	SANDY CLAY, trace gravel, gray, moist, hard	CL	4,6,9 N=15	14	Qp = 4.5+ tsf
600	10	4	18			4,7,11 N=18	14	Qp = 4.5+ tsf
				End of Boring				

STANDARD PENETRATION TEST DATA
N in blows/ft
Moisture PL LL
0 25 50
STRENGTH, tsf
Qu Qp
0 2.0 4.0

Professional Service Industries, Inc.
45749 Helm Street
Plymouth, MI 48170
Telephone: (734) 453-7900

PROJECT NO.: 0381704
PROJECT: Proposed Municipal Center
LOCATION: 3720 Keewahdin Road, Fort Gratiot Township, St. Clair County, Michigan

The stratification lines represent approximate boundaries. The transition may be gradual.

GENERAL NOTES

SAMPLE IDENTIFICATION

The Unified Soil Classification System (USCS), AASHTO 1988 and ASTM designations D2487 and D-2488 are used to identify the encountered materials unless otherwise noted. Coarse-grained soils are defined as having more than 50% of their dry weight retained on a #200 sieve (0.075mm); they are described as: boulders, cobbles, gravel or sand. Fine-grained soils have less than 50% of their dry weight retained on a #200 sieve; they are defined as silts or clay depending on their Atterberg Limit attributes. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size.

DRILLING AND SAMPLING SYMBOLS

SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.
HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry
R.C.: Diamond Bit Core Sampler
H.A.: Hand Auger
P.A.: Power Auger - Handheld motorized auger

SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
ST: Shelby Tube - 3" O.D., except where noted.
RC: Rock Core
TC: Texas Cone
BS: Bulk Sample
PM: Pressuremeter
CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. Split-Spoon.
N_{60}: A "N" penetration value corrected to an equivalent 60% hammer energy transfer efficiency (ETR)
Q_u: Unconfined compressive strength, TSF
Q_p: Pocket penetrometer value, unconfined compressive strength, TSF
w%: Moisture/water content, %
LL: Liquid Limit, %
PL: Plastic Limit, %
PI: Plasticity Index = (LL-PL),%
DD: Dry unit weight, pcf
$\blacktriangledown$, $\triangledown$, $\overline{\blacktriangledown}$ Apparent groundwater level at time noted

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Relative Density	N - Blows/foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	50 - 80
Extremely Dense	80+

ANGULARITY OF COARSE-GRAINED PARTICLES

Description	Criteria
Angular:	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular:	Particles are similar to angular description, but have rounded edges
Subrounded:	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded:	Particles have smoothly curved sides and no edges

GRAIN-SIZE TERMINOLOGY

Component	Size Range
Boulders:	Over 300 mm (>12 in.)
Cobbles:	75 mm to 300 mm (3 in. to 12 in.)
Coarse-Grained Gravel:	19 mm to 75 mm (¾ in. to 3 in.)
Fine-Grained Gravel:	4.75 mm to 19 mm (No.4 to ¾ in.)
Coarse-Grained Sand:	2 mm to 4.75 mm (No.10 to No.4)
Medium-Grained Sand:	0.42 mm to 2 mm (No.40 to No.10)
Fine-Grained Sand:	0.075 mm to 0.42 mm (No. 200 to No.40)
Silt:	0.005 mm to 0.075 mm
Clay:	<0.005 mm

PARTICLE SHAPE

Description	Criteria
Flat:	Particles with width/thickness ratio > 3
Elongated:	Particles with length/width ratio > 3
Flat & Elongated:	Particles meet criteria for both flat and elongated

RELATIVE PROPORTIONS OF FINES

Descriptive Term	% Dry Weight
Trace:	< 5%
With:	5% to 12%
Modifier:	>12%

GENERAL NOTES
(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

Q_u - TSF	N - Blows/foot	Consistency
0 - 0.25	0 - 2	Very Soft
0.25 - 0.50	2 - 4	Soft
0.50 - 1.00	4 - 8	Firm (Medium Stiff)
1.00 - 2.00	8 - 15	Stiff
2.00 - 4.00	15 - 30	Very Stiff
4.00 - 8.00	30 - 50	Hard
8.00+	50+	Very Hard

MOISTURE CONDITION DESCRIPTION

Description	Criteria
Dry:	Absence of moisture, dusty, dry to the touch
Moist:	Damp but no visible water
Wet:	Visible free water, usually soil is below water table

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term	% Dry Weight
Trace:	< 15%
With:	15% to 30%
Modifier:	>30%

STRUCTURE DESCRIPTION

Description	Criteria
Stratified:	Alternating layers of varying material or color with layers at least ¼-inch (6 mm) thick
Laminated:	Alternating layers of varying material or color with layers less than ¼-inch (6 mm) thick
Fissured:	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided:	Fracture planes appear polished or glossy, sometimes striated

Description	Criteria
Blocky:	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed:	Inclusion of small pockets of different soils
Layer:	Inclusion greater than 3 inches thick (75 mm)
Seam:	Inclusion 1/8-inch to 3 inches (3 to 75 mm) thick extending through the sample
Parting:	Inclusion less than 1/8-inch (3 mm) thick

SCALE OF RELATIVE ROCK HARDNESS

Q_u - TSF	Consistency
2.5 - 10	Extremely Soft
10 - 50	Very Soft
50 - 250	Soft
250 - 525	Medium Hard
525 - 1,050	Moderately Hard
1,050 - 2,600	Hard
>2,600	Very Hard

ROCK BEDDING THICKNESSES

Description	Criteria
Very Thick Bedded	Greater than 3-foot (>1.0 m)
Thick Bedded	1-foot to 3-foot (0.3 m to 1.0 m)
Medium Bedded	4-inch to 1-foot (0.1 m to 0.3 m)
Thin Bedded	1¼-inch to 4-inch (30 mm to 100 mm)
Very Thin Bedded	½-inch to 1¼-inch (10 mm to 30 mm)
Thickly Laminated	1/8-inch to ½-inch (3 mm to 10 mm)
Thinly Laminated	1/8-inch or less "paper thin" (<3 mm)

ROCK VOIDS

Voids	Void Diameter
Pit	<6 mm (<0.25 in)
Vug	6 mm to 50 mm (0.25 in to 2 in)
Cavity	50 mm to 600 mm (2 in to 24 in)
Cave	>600 mm (>24 in)

GRAIN-SIZED TERMINOLOGY
(Typically Sedimentary Rock)

Component	Size Range
Very Coarse Grained	>4.76 mm
Coarse Grained	2.0 mm - 4.76 mm
Medium Grained	0.42 mm - 2.0 mm
Fine Grained	0.075 mm - 0.42 mm
Very Fine Grained	<0.075 mm

ROCK QUALITY DESCRIPTION

Rock Mass Description	RQD Value
Excellent	90 -100
Good	75 - 90
Fair	50 - 75
Poor	25 -50
Very Poor	Less than 25

DEGREE OF WEATHERING

Slightly Weathered:	Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered:	Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.
Highly Weathered:	Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES		SM	SILTY SANDS, SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	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
				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
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

psi

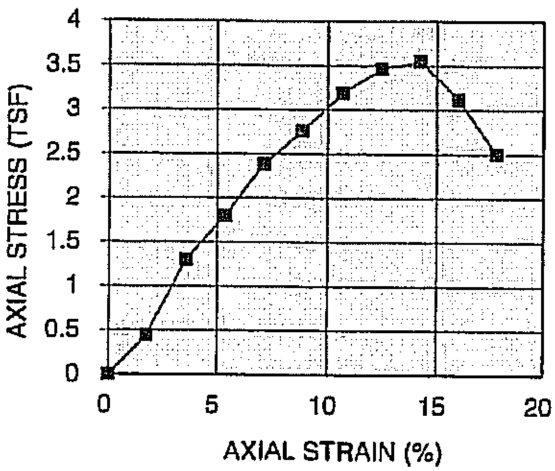
UNCONFINED COMPRESSIVE STRENGTH (ASTM D2166)

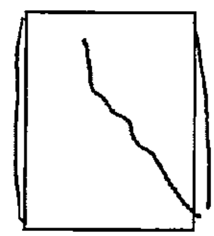
Project Name: Proposed Fort Gratiot Municipal Center
Location: Fort Gratiot Township, Michigan
Project No.: 0381704
Source: B-1; 2SS **Sample Depth:** 4.0' - 5.5'
Description: SANDY CLAY (CL) - trace gravel, mottled brown and gray
Qp (tsf): 4.5+
Wet Weight (gm): 156.96
Date Tested: 1/21/2014
Tested By: TA

Height:	2.810 inches	71.36 mm	
Diameter:	1.362 inches	34.59 mm	
Moisture Content:	11%	**Saturation (%):**	
Ht.-Diameter Ratio:	2.06	**Specific Gravity:**	
Dry Density:	132 pcf		

READING NUMBER	DEFORM. (in.)	LOAD DIAL READING	LOAD (lbs)	STRAIN (%)	CORRECTED AREA (in^2)	AXIAL STRESS (tsf)
0	0.000	0	0.0	0.00	1.457	0.00
1	0.050	29	9.2	1.78	1.483	0.45
2	0.100	87	27.2	3.56	1.511	1.30
3	0.150	123	38.4	5.34	1.539	1.80
4	0.200	167	52.0	7.12	1.569	2.39
5	0.250	197	61.4	8.90	1.599	2.76
6	0.300	232	72.2	10.68	1.631	3.19
7	0.350	257	80.0	12.46	1.664	3.46
8	0.400	269	83.7	14.24	1.699	3.55
9	0.450	241	75.0	16.02	1.735	3.11
10	0.500	198	61.7	17.80	1.772	2.51
11	0.550					
12	0.600					
13	0.650					
14	0.700					
15	0.750					
16	0.800					
17	0.850					
18	0.900					
19	0.950					
20	1.000					

Qu = 3.55 tsf 339.80 kPa, Strain 15.00%





Failure Sketch

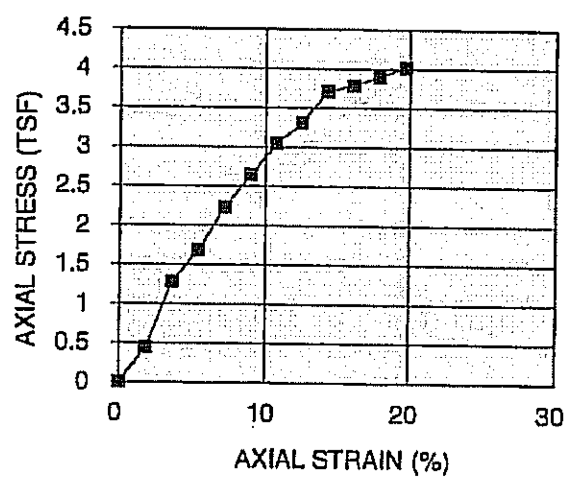
psi

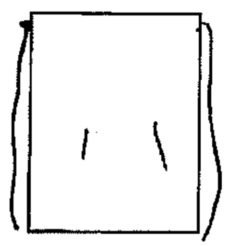
UNCONFINED COMPRESSIVE STRENGTH (ASTM D2166)

Project Name: Proposed Fort Gratiot Municipal Center
Location: Fort Gratiot Township, Michigan
Project No.: 0381704
Source: B-1; 5SS **Sample Depth:** 11.5' - 13.0'
Description: SANDY CLAY (CL) - trace gravel, gray
Qp (tsf): 3.25
Wet Weight (gm): 149.13
Date Tested: 1/21/2014
Tested By: TA

Height: 2.784 inches	70.70 mm		
Diameter: 1.384 inches	35.14 mm		
Moisture Content:	14%	**Saturation (%):**	
Ht.-Diameter Ratio:	2.01	**Specific Gravity:**	
Dry Density:	119 pcf		

READING NUMBER	DEFORM. (in.)	LOAD DIAL READING	LOAD (lbs)	STRAIN (%)	CORRECTED AREA (in^2)	AXIAL STRESS (tsf)
0	0.000	0	0.0	0.00	1.503	0.00
1	0.050	30	9.5	1.80	1.531	0.45
2	0.100	89	27.8	3.59	1.559	1.28
3	0.150	119	37.1	5.39	1.589	1.68
4	0.200	161	50.2	7.18	1.620	2.23
5	0.250	195	60.7	8.98	1.652	2.65
6	0.300	229	71.3	10.78	1.685	3.05
7	0.350	254	79.1	12.57	1.720	3.31
8	0.400	291	90.6	14.37	1.756	3.71
9	0.450	303	94.3	16.17	1.793	3.79
10	0.500	319	99.3	17.96	1.832	3.90
11	0.550	336	104.5	19.76	1.873	4.02
12	0.600					
13	0.650					
14	0.700					
15	0.750					
16	0.800					
17	0.850					
18	0.900					
19	0.950					
20	1.000					
Qu =	3.71 tsf		355.65 kPa,	Strain 15.00%		





Failure Sketch

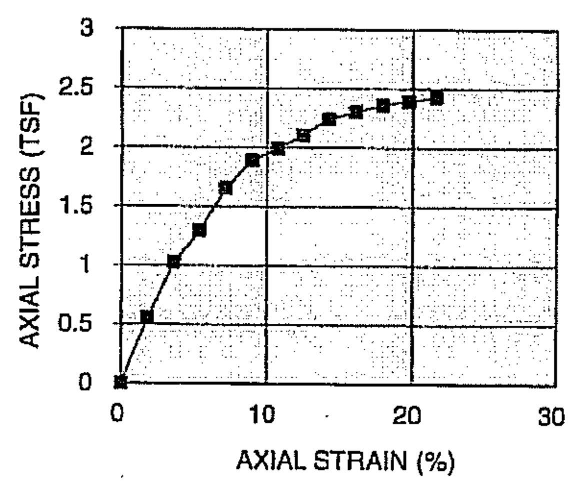
psi

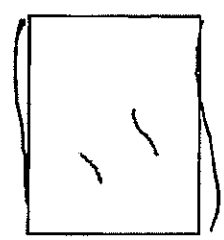
UNCONFINED COMPRESSIVE STRENGTH (ASTM D2166)

Project Name: Proposed Fort Gratiot Municipal Center
Location: Fort Gratiot Township, Michigan
Project No.: 0381704
Source: B-1; 9SS **Sample Depth:** 29.0' - 30.5'
Description: SANDY CLAY (CL) - trace gravel, gray
Qp (tsf): 2.25
Wet Weight (gm): 152.12
Date Tested: 1/21/2014
Tested By: TA

Height:	2.782 inches	70.65 mm	
Diameter:	1.394 inches	35.40 mm	
Moisture Content:	16%	Saturation (%):	
Ht.-Diameter Ratio:	2.00	Specific Gravity:	
Dry Density:	118 pcf		

READING NUMBER	DEFORM. (in.)	LOAD DIAL READING	LOAD (lbs)	STRAIN (%)	CORRECTED AREA (in^2)	AXIAL STRESS (tsf)
0	0.000	0	0.0	0.00	1.526	0.00
1	0.050	38	12.0	1.80	1.554	0.55
2	0.100	72	22.5	3.60	1.583	1.03
3	0.150	93	29.1	5.39	1.613	1.30
4	0.200	121	37.8	7.19	1.644	1.65
5	0.250	141	44.0	8.99	1.676	1.89
6	0.300	152	47.4	10.79	1.710	1.99
7	0.350	164	51.1	12.58	1.745	2.11
8	0.400	178	55.5	14.38	1.782	2.24
9	0.450	187	58.3	16.18	1.820	2.30
10	0.500	196	61.1	17.98	1.860	2.36
11	0.550	203	63.2	19.77	1.902	2.39
12	0.600	211	65.7	21.57	1.945	2.43
13	0.650					
14	0.700					
15	0.750					
16	0.800					
17	0.850					
18	0.900					
19	0.950					
20	1.000					
Qu =	2.24 tsf		214.57 kPa,	Strain 15.00%		





Failure Sketch

psi

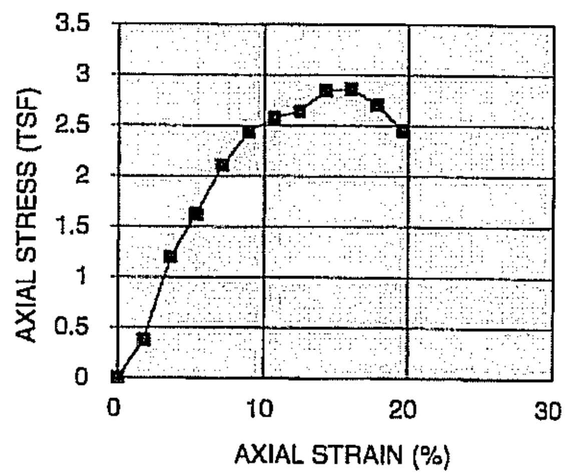
UNCONFINED COMPRESSIVE STRENGTH (ASTM D2166)

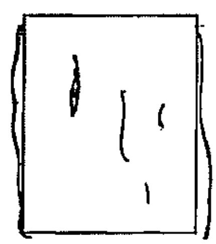
Project Name: Proposed Fort Gratiot Municipal Center
Location: Fort Gratiot Township, Michigan
Project No.: 0381704
Source: B-2; 1SS **Sample Depth:** 1.5' - 3.0'
Description: SILTY CLAY (CL) - with sand, mottled orange brown, light reddish brown, gray
Qp (tsf): 3.00
Wet Weight (gm): 148.92
Date Tested: 1/22/2014
Tested By: TA

Height:	2.802 inches		71.17 mm	
Diameter:	1.379 inches		35.01 mm	
Moisture Content:	15%	**Saturation (%):**		
Ht.-Diameter Ratio:	2.03	**Specific Gravity:**		
Dry Density:	118 pcf			

READING NUMBER	DEFORM. (in.)	LOAD DIAL READING	LOAD (lbs)	STRAIN (%)	CORRECTED AREA (in^2)	AXIAL STRESS (tsf)
0	0.000	0	0.0	0.00	1.492	0.00
1	0.050	25	7.9	1.78	1.520	0.38
2	0.100	82	25.6	3.57	1.548	1.19
3	0.150	114	35.6	5.35	1.577	1.62
4	0.200	151	47.1	7.14	1.607	2.11
5	0.250	178	55.5	8.92	1.639	2.44
6	0.300	192	59.8	10.71	1.671	2.58
7	0.350	201	62.6	12.49	1.705	2.64
8	0.400	221	68.8	14.28	1.741	2.85
9	0.450	227	70.7	16.06	1.778	2.86
10	0.500	219	68.2	17.84	1.817	2.70
11	0.550	203	63.2	19.63	1.857	2.45
12	0.600					
13	0.650					
14	0.700					
15	0.750					
16	0.800					
17	0.850					
18	0.900					
19	0.950					
20	1.000					

Qu = 2.85 tsf 272.52 kPa, Strain 15.00%





Failure Sketch

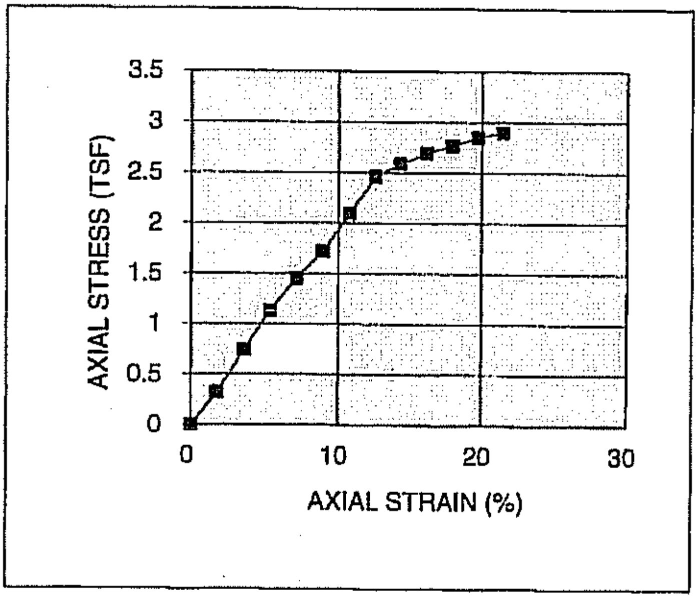
psi

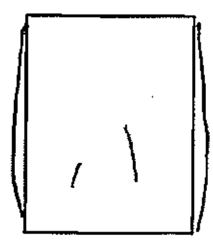
UNCONFINED COMPRESSIVE STRENGTH (ASTM D2166)

Project Name: Proposed Fort Gratiot Municipal Center
Location: Fort Gratiot Township, Michigan
Project No.: 0381704
Source: B-2; 7SS **Sample Depth:** 19.0' - 20.5'
Description: SANDY CLAY (CL) - trace gravel, gray
Qp (tsf): 2.25
Wet Weight (gm): 152.56
Date Tested: 1/21/2014
Tested By: TA

Height:	2.790	inches	70.86	mm
Diameter:	1.392	inches	35.36	mm
Moisture Content:	16%		**Saturation (%):**	
Ht.-Diameter Ratio:	2.00		**Specific Gravity:**	
Dry Density:	118	pcf		

READING NUMBER	DEFORM. (in.)	LOAD DIAL READING	LOAD (lbs)	STRAIN (%)	CORRECTED AREA (in^2)	AXIAL STRESS (tsf)
0	0.000	0	0.0	0.00	1.522	0.00
1	0.050	22	7.0	1.79	1.550	0.33
2	0.100	52	16.3	3.58	1.579	0.74
3	0.150	81	25.3	5.38	1.609	1.13
4	0.200	106	33.1	7.17	1.640	1.45
5	0.250	128	39.9	8.96	1.672	1.72
6	0.300	159	49.6	10.75	1.706	2.09
7	0.350	191	59.5	12.55	1.741	2.46
8	0.400	205	63.8	14.34	1.777	2.59
9	0.450	218	67.9	16.13	1.815	2.69
10	0.500	229	71.3	17.92	1.855	2.77
11	0.550	241	75.0	19.72	1.896	2.85
12	0.600	251	78.1	21.51	1.940	2.90
13	0.650					
14	0.700					
15	0.750					
16	0.800					
17	0.850					
18	0.900					
19	0.950					
20	1.000					
Qu =	2.59 tsf		247.67 kPa,	Strain 15.00%		





Failure Sketch

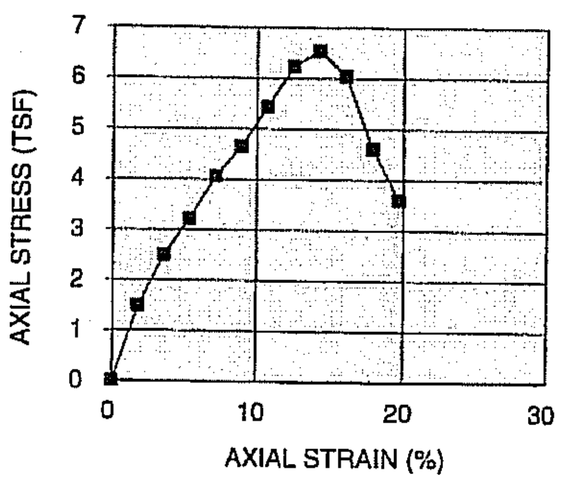
psi

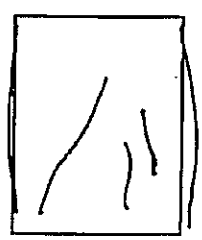
UNCONFINED COMPRESSIVE STRENGTH (ASTM D2166)

Project Name: Proposed Fort Gratiot Municipal Center
Location: Fort Gratiot Township, Michigan
Project No.: 0381704
Source: B-3; 3SS **Sample Depth:** 6.5' - 8.0'
Description: SANDY CLAY (CL) - trace gravel, brown to grayish brown
Qp (tsf): 4.5+
Wet Weight (gm): 146.93
Date Tested: 1/21/2014
Tested By: TA

Height:	2.796	inches	71.02	mm
Diameter:	1.359	inches	34.52	mm
Moisture Content:	14%		Saturation (%):	
Ht.-Diameter Ratio:	2.06		Specific Gravity:	
Dry Density:	121	pcf		

READING NUMBER	DEFORM. (in.)	LOAD DIAL READING	LOAD (lbs)	STRAIN (%)	CORRECTED AREA (in^2)	AXIAL STRESS (tsf)
0	0.000	0	0.0	0.00	1.451	0.00
1	0.050	98	30.6	1.79	1.477	1.49
2	0.100	168	52.4	3.58	1.504	2.51
3	0.150	220	68.5	5.36	1.533	3.22
4	0.200	283	88.1	7.15	1.562	4.06
5	0.250	331	103.0	8.94	1.593	4.65
6	0.300	394	122.5	10.73	1.625	5.43
7	0.350	462	143.7	12.52	1.658	6.24
8	0.400	494	153.6	14.31	1.693	6.53
9	0.450	467	145.2	16.09	1.729	6.05
10	0.500	364	113.2	17.88	1.766	4.62
11	0.550	291	90.6	19.67	1.806	3.61
12	0.600					
13	0.650					
14	0.700					
15	0.750					
16	0.800					
17	0.850					
18	0.900					
19	0.950					
20	1.000					
Qu =	6.53 tsf		625.68 kPa,	Strain 15.00%		





Failure Sketch

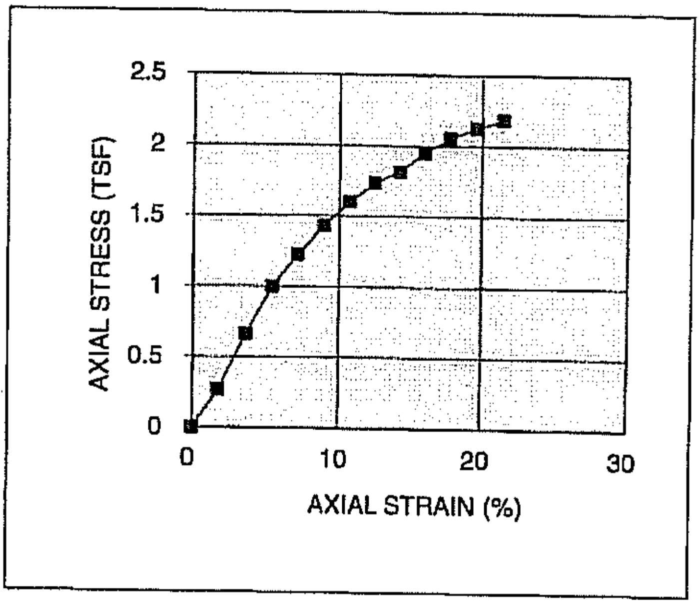
psi

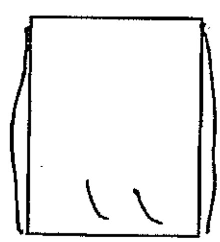
UNCONFINED COMPRESSIVE STRENGTH (ASTM D2166)

Project Name: Proposed Fort Gratiot Municipal Center
Location: Fort Gratiot Township, Michigan
Project No.: 0381704
Source: B-4; 6SS **Sample Depth:** 14.0' - 15.5'
Description: SANDY CLAY (CL) - trace gravel, gray
Qp (tsf): 2.25
Wet Weight (gm): 153.39
Date Tested: 1/21/2014
Tested By: TA

Height:	2.799	inches	71.08	mm
Diameter:	1.389	inches	35.29	mm
Moisture Content:	15%		**Saturation (%):**	
Ht.-Diameter Ratio:	2.01		**Specific Gravity:**	
Dry Density:	120 pcf			

READING NUMBER	DEFORM. (in.)	LOAD DIAL READING	LOAD (lbs)	STRAIN (%)	CORRECTED AREA (in^2)	AXIAL STRESS (tsf)
0	0.000	0	0.0	0.00	1.516	0.00
1	0.050	18	5.8	1.79	1.544	0.27
2	0.100	46	14.5	3.57	1.572	0.66
3	0.150	71	22.2	5.36	1.602	1.00
4	0.200	89	27.8	7.15	1.633	1.23
5	0.250	106	33.1	8.93	1.665	1.43
6	0.300	121	37.8	10.72	1.698	1.60
7	0.350	134	41.8	12.51	1.733	1.74
8	0.400	143	44.6	14.29	1.769	1.82
9	0.450	157	48.9	16.08	1.806	1.95
10	0.500	169	52.7	17.87	1.846	2.05
11	0.550	179	55.8	19.65	1.887	2.13
12	0.600	188	58.6	21.44	1.930	2.19
13	0.650					
14	0.700					
15	0.750					
16	0.800					
17	0.850					
18	0.900					
19	0.950					
20	1.000					
Qu =	1.82 tsf		173.81 kPa,	Strain 15.00%		





Failure Sketch

psi

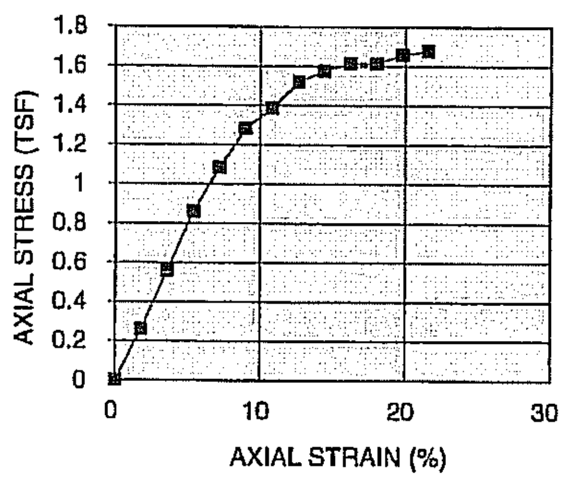
UNCONFINED COMPRESSIVE STRENGTH (ASTM D2166)

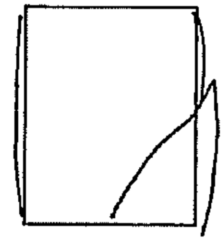
Project Name: Proposed Fort Gratiot Municipal Center
Location: Fort Gratiot Township, Michigan
Project No.: 0381704
Source: B-6; 4SS **Sample Depth:** 9.0' - 10.5'
Description: SILTY CLAY (CL) - with sand, mottled orange brown, light reddish brown, gray
Qp (tsf): 2.0
Wet Weight (gm): 150.57
Date Tested: 1/22/2014
Tested By: TA

Height:	2.773 inches		70.44 mm	
Diameter:	1.410 inches		35.81 mm	
Moisture Content:	19%	Saturation (%):		
Ht.-Diameter Ratio:	1.97	Specific Gravity:		
Dry Density:	111 pcf			

READING NUMBER	DEFORM. (in.)	LOAD DIAL READING	LOAD (lbs)	STRAIN (%)	CORRECTED AREA (in^2)	AXIAL STRESS (tsf)
0	0.000	0	0.0	0.00	1.561	0.00
1	0.050	18	5.8	1.80	1.590	0.26
2	0.100	40	12.6	3.61	1.620	0.56
3	0.150	63	19.7	5.41	1.651	0.86
4	0.200	81	25.3	7.21	1.683	1.08
5	0.250	98	30.6	9.01	1.716	1.28
6	0.300	108	33.7	10.82	1.751	1.39
7	0.350	121	37.8	12.62	1.787	1.52
8	0.400	128	39.9	14.42	1.825	1.58
9	0.450	134	41.8	16.23	1.864	1.61
10	0.500	137	42.7	18.03	1.905	1.61
11	0.550	144	44.9	19.83	1.948	1.66
12	0.600	149	46.5	21.63	1.993	1.68
13	0.650					
14	0.700					
15	0.750					
16	0.800					
17	0.850					
18	0.900					
19	0.950					
20	1.000					

Qu = 1.58 tsf 150.88 kPa, Strain 15.00%





Failure Sketch

psi

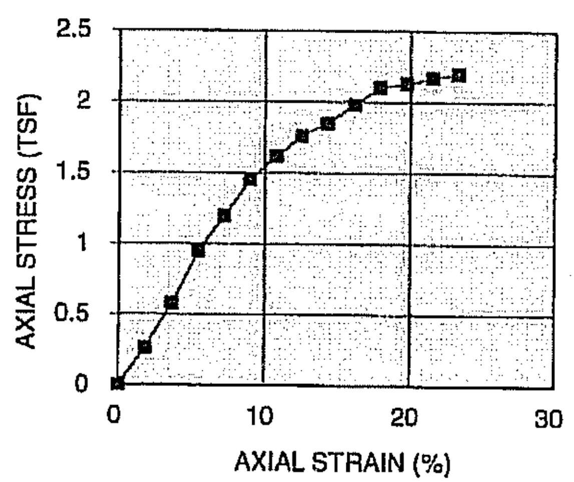
UNCONFINED COMPRESSIVE STRENGTH (ASTM D2166)

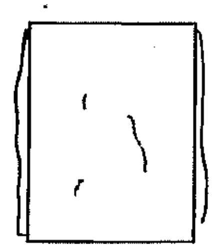
Project Name: Proposed Fort Gratiot Municipal Center
Location: Fort Gratiot Township, Michigan
Project No.: 0381704
Source: B-7; 7SS **Sample Depth:** 19.0' - 20.5'
Description: SANDY CLAY (CL) - trace gravel, gray
Qp (tsf): 2.00
Wet Weight (gm): 151.75
Date Tested: 1/22/2014
Tested By: TA

Height:	2.786	inches	70.77	mm
Diameter:	1.405	inches	35.68	mm
Moisture Content:	17%		Saturation (%):	
Ht.-Diameter Ratio:	1.98		Specific Gravity:	
Dry Density:	114	pcf		

READING NUMBER	DEFORM. (in.)	LOAD DIAL READING	LOAD (lbs)	STRAIN (%)	CORRECTED AREA (in^2)	AXIAL STRESS (tsf)
0	0.000	0	0.0	0.00	1.550	0.00
1	0.050	18	5.8	1.79	1.578	0.26
2	0.100	41	12.9	3.59	1.607	0.58
3	0.150	69	21.6	5.38	1.638	0.95
4	0.200	89	27.8	7.18	1.669	1.20
5	0.250	110	34.3	8.97	1.702	1.45
6	0.300	125	39.0	10.77	1.736	1.62
7	0.350	139	43.3	12.56	1.772	1.76
8	0.400	149	46.5	14.36	1.809	1.85
9	0.450	163	50.8	16.15	1.848	1.98
10	0.500	177	55.1	17.95	1.888	2.10
11	0.550	183	57.0	19.74	1.931	2.13
12	0.600	191	59.5	21.54	1.975	2.17
13	0.650	198	61.7	23.33	2.021	2.20
14	0.700					
15	0.750					
16	0.800					
17	0.850					
18	0.900					
19	0.950					
20	1.000					

Qu = 1.85 tsf 177.02 kPa, Strain 15.00%





Failure Sketch

psi

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

PSI
45749 Helm St.
Plymouth, Michigan
USA

Flexible Structural Design Module

Standard Duty Flexible Pavement Design
Fort Gratiot Municipal Center
Fort Gratiot Township, Michigan

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	50,000
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	90 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	3,500 psi
Stage Construction	1
Calculated Design Structural Number	2.81 in

Layered Thickness Design

Thickness precision: Actual

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Spec Thickness (Di)(in)	Min Thickness (Di)(in)	Elastic Modulus (psi)	Width (ft)	Calculated Thickness (in)	Calculated SN (in)
1	HMA Surface Course	0.42	1	2.5	1.5	350,000	-	2.50	1.05
2	HMA Leveling Course	0.42	1	2.5	-	350,000	-	2.50	1.05
3	MDOT 21AA Aggreg...	0.14	0.75	-	-	30,000	-	6.76	0.71
Total	-	-	-	-	-	-	-	11.76	2.81

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

PSI
45749 Helm St.
Plymouth, Michigan
USA

Flexible Structural Design Module

Heavy Duty Flexible Pavement Design
Fort Gratiot Municipal Center
Fort Gratiot Township, Michigan

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	250,000
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	3,500 psi
Stage Construction	1
Calculated Design Structural Number	3.88 in

Layered Thickness Design

Thickness precision   Actual

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Spec Thickness (Di)(in)	Min Thickness (Di)(in)	Elastic Modulus (psi)	Width (ft)	Calculated Thickness (in)	Calculated SN (in)
1	HMA Surface Course	0.42	1	2.5	2	350,000	-	2.50	1.05
2	HMA Leveling Course	0.42	1	4.5	-	350,000	-	4.50	1.89
3	HMA Base Course	0.36	1	2	-	275,000	-	2.00	0.72
4	MDOT 21AA Base C...	0.14	0.75	-	-	30,000	-	2.10	0.22
Total	-	-	-	-	-	-	-	11.10	3.88

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

PSI
45749 Helm St.
Plymouth, Michigan
USA

Rigid Structural Design Module

Rigid Pavement Design
Fort Gratiot Municipal Center
Fort Gratiot Township, Michigan

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	250,000
Initial Serviceability	4.5
Terminal Serviceability	2.5
28-day Mean PCC Modulus of Rupture	670 psi
28-day Mean Elastic Modulus of Slab	4,200,000 psi
Mean Effective k-value	70 psi/in
Reliability Level	95 %
Overall Standard Deviation	0.39
Load Transfer Coefficient, J	3.2
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	5.97 in

Effective Modulus of Subgrade Reaction

Period	Description	Roadbed Soil Resilient Modulus (psi)	Base Elastic Modulus (psi)
1	-	3,500	30,000

Base Type	MDOT 21AA
Base Thickness	4 in
Depth to Bedrock	100 ft
Projected Slab Thickness	9 in
Loss of Support Category	1
Effective Modulus of Subgrade Reaction	70 psi/in

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	8
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	100 %

Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	100 %
Average Initial Truck Factor (ESALs/truck)	4
Annual Truck Factor Growth Rate	0 %
Annual Truck Volume Growth Rate	0 %
Growth	Simple
Total Calculated Cumulative ESALs	233,760

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	8
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	100 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
Total	-	-	-	-	-

Growth	Simple
Total Calculated Cumulative ESALs	-*

*Note: This value is not represented by the inputs or an error occurred in calculation.