GEO-TECHNOLOGY ASSOCIATES, INC.

GEOTECHNICAL AND
ENVIRONMENTAL CONSULTANTS

A Practicing Geoprofessional Business Association Member Firm

November 16, 2016

T and M Associates
74 West Broad Street, Suite 530
Bethlehem, PA 18018

Attn: Mark Buchvalt, P.E.

Re: Geotechnical Engineering Report
Maintenance Building Expansion
Bethlehem Township, Northampton County, Pennsylvania

Dear Mr. Buchvalt:

In accordance with our agreement, Geo-Technology Associates, Inc. (GTA) has performed a geotechnical exploration for the proposed Maintenance Building Expansion located at 3545 Orth Street in Bethlehem Township, Northampton County, Pennsylvania. The results of the exploration and geotechnical recommendations related to design and construction of the proposed site improvements are included in this report.

GTA appreciates the opportunity to be of assistance to you on this project. Please contact our office at (215) 536-8363 if you have questions concerning this report.

Sincerely,
GEO-TECHNOLOGY ASSOCIATES, INC.

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
MICHAEL W. DERR
ENGINEER
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Michael W. Derr, P.E.
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MNN/MWD/DNZ/mwd
31162142

GEOTECHNICAL ENGINEERING REPORT

MAINTENANCE BUILDING EXPANSION

Bethlehem Township, Northampton County, Pennsylvania

November 16, 2016

Prepared For:

T AND M ASSOCIATES
74 West Broad Street, Suite 530
Bethlehem, PA 18018

Attn: Mr. Mark Buchvalt, P.E.

Prepared By:

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GTA Job No: 31162142

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NOVEMBER 2016

INTRODUCTION

This report presents the results of a geotechnical exploration performed for the expansion to the Bethlehem Township Maintenance Building located in Northampton County, Pennsylvania. The scope of this study included a subsurface exploration, limited laboratory testing, geotechnical engineering analyses, and preparation of this geotechnical engineering report.

For our use in preparation of this report, GTA was provided with a *Schematic Site Plan*, prepared by T and M Associates dated July 20, 2016. The plan indicates the existing building, the location and configuration of the proposed addition, and the existing and proposed finish grade elevations. GTA was also provided with *Detention Basin Plan and Sections* plans prepared by Huth Associates, dated March 19, 1997. Conclusions and recommendations regarding the proposed construction were developed from engineering analyses of field data and preliminary information for the proposed improvements as detailed herein.

SITE CONDITIONS

The area of the proposed expansion consists of a paved parking lot north of the existing maintenance building. There is an existing retaining wall along northern and western sides of the parking lot with three storage bins and two concrete walls along the western side. Site topography is generally flat with grades sloping away from the existing Maintenance Building towards stormwater inlets along the retaining wall.

The retaining wall ranges in height from 6 to 15 feet with the highest points along the northern wall adjacent to the storm water management basin. Based on the referenced plans, the wall is a cast-in-place reinforced concrete wall with a spread footing that ranges in width from 3 to 19 feet. GTA observed the northern retaining wall has rotated out approximately 1 to 2 inches, and the backfill area behind the wall has settled about 4 to 6 inches. Based on conversations with Bethlehem Township employees, several asphalt and storm sewer repairs have been needed along the northern wall.

PROPOSED CONSTRUCTION

We understand the proposed addition will be approximately 3,500 square foot (sq. ft.), and will require the removal of the existing inlets, manholes and the asphalt in the parking lot. The proposed building expansion will likely be a pre-engineered steel framed building with cold-formed steel framed walls. No structural loading information was available at the time this report was prepared. However, based upon projects of similar size, GTA anticipates maximum column loads of up to 50 kips and wall loads of up to 5 kips per linear foot. It is also our understanding that the existing concrete retaining wall may be utilized as part of the new foundation on western side of the addition.

SITE GEOLOGY

According to *The Geologic Map of Pennsylvania* (1980), the site vicinity is located within the Great Valley Section of the Ridge and Valley Physiographic Province. This province is characterized by Cambrian Age, strongly folded and faulted, predominantly sedimentary rock and associated residual soil derived from the in-situ decomposition of the parent bedrock. Specifically, the site is indicated to be primarily underlain by the Allentown Formation. The Allentown Formation is described as medium- to dark-gray thick bedded dolomite and impure limestone; calcareous siltstone; laminated and oolitic. The Allentown Formation is susceptible to solution activity with bedrock pinnacles, subsurface cavities, and sinkholes commonly encountered.

GTA reviewed *Open File Report 87-02, Sinkholes and Karst-Related Features of Northampton County, Pennsylvania (1987).* The report identifies karst features such as sinkholes, closed depressions, caverns, past mines, and underground openings on USGS topographic quadrangle maps. According to the *Nazareth Quadrangle* map, several surface depressions and sinkholes are mapped surrounding the site. It should be noted that GTA did not observed any karst related features during our site visits.

SUBSURFACE EXPLORATION

The subsurface exploration consisted of drilling 5 Standard Penetration Test (SPT) borings within the proposed addition area. The test borings were drilled on October 27, 2016, and extended to depths ranging from approximately 15 to 17 feet below the existing ground surface (ft bgs). The test borings were field located by measuring from existing site features. The approximate test boring locations are indicated on the *Exploration Location Plan*, included in Appendix A. Test boring logs are included in Appendix B. Elevations indicated on the logs should be considered approximate and were estimated using elevations indicated on the *Schematic Site Plan*.

Standard Penetration Testing was performed in the boreholes, with soil samples obtained at approximately 2-foot intervals in the upper 10 feet and then at 5-foot intervals thereafter. Standard Penetration Testing involves driving a 2-inch O.D., 1 ⅜ -inch I.D. split-spoon sampler with a 140-pound hammer free-falling 30 inches. The SPT N-value, given as blows per foot, is defined as the total number of blows required to drive the sampler from the 6 to 18 inch interval. Samples retrieved from the borings were visually classified in the field and submitted for limited laboratory testing.

SUBSURFACE CONDITIONS

The borings encountered 12 inches of asphalt and crushed stone subbase material. Below the asphalt and stone, the test borings encountered fill and native soils overlying highly weathered rock consistent with the Allentown Formation.

Previously placed fill was encountered in all the borings to depths of approximately 4 to 15 ft bgs. In general, the fill extended down to the existing retaining wall footing or just a few feet above the rock surface. The fill consisted of variable consistency lean clay, silty sand, silty clayey sand, and clayey sand containing varying amounts of rock fragments and ash within the soil matrix.

The native soils consisted of silty and clayey gravel with sand, and lean clay. Highly weathered rock was encountered below the native soils and fill in all of the borings at approximately 13 ft bgs. Auger refusal on more competent bedrock was encountered in all of the borings at depths of approximately 15 to 17 ft bgs.

Groundwater was not encountered in any of the borings to the depths explored. Long-term (24-hour) water level readings were not measured because the borings were backfilled upon completion for safety reasons. Groundwater levels can fluctuate significantly and will most likely be perched on top of rock surface and fills the existing storm water management basin.

LABORATORY TESTING

Selected samples obtained from the recent test pits were submitted for limited laboratory testing including grain-size analysis and Atterberg Limits for classification in accordance with the Unified Soil Classification System (USCS) and natural moisture contents. Test results are provided in Appendix C and are summarized in the tables below:

SUMMARY OF CLASSIFICATION TESTING

SAMPLE	DEPTH (ft)	USCS CLASSIFICATION	LL%	PI%
B-5, S-2	2-4	SC-SM	27	6
B-5, S-3	4-6	CL-ML	28	7
B-5, S-5	13-15	SM	NP	NP

NP = non-plastic, LL = liquid limit, PI = plasticity index

SEISMIC INFORMATION

The soil conditions at this site can be categorized as Site Class C per the 2009 International Building Code. This categorization is based on the near surface test boring results, general geologic information for the region, and the information contained in the applicable code.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this study, it is GTA's opinion that construction of the proposed addition is feasible, provided that the geotechnical recommendations are followed, and that the standard level of care is maintained during construction. The primary geotechnical issues that will impact site development include the presence of existing fill, a tight working area, and use of the existing retaining wall as foundation support. Further discussions of these issues, as well as geotechnical recommendations related to design and construction of the proposed site improvements are provided in the following sections.

Removal of Existing Utilities and Structures

Due to potential conflicts with new foundations and underground utilities, we recommend that demolition include removal of existing utilities, concrete slabs, and asphalt from within the proposed building addition area. The resulting excavations should then be backfilled with compacted structural fill. Structural fill should be placed and compacted in accordance with our *Earthwork* recommendations provided below. It should be noted that soft/loose and/or wet soil may be encountered adjacent to existing foundation elements and abandoned utilities. Therefore, we recommend that the subgrade be evaluated by GTA for stability prior to backfilling. Where soft/loose materials are encountered, localized over-excavations may be required.

Existing utilities that will not be incorporated into the proposed construction should be completely removed or abandoned in-place. In-place abandonment of utilities should consist of completely filling the pipelines with grout and removing structures.

Earthwork

It is anticipated that minimal grading will be required to establish the proposed floor slab subgrade elevation. Prior to structural fill placement, the area should be stripped to remove any asphalt, loose/soft existing fill, or other unsuitable materials. After stripping, the exposed subgrade soils should be evaluated for stability by the geotechnical engineer, or their qualified representative. Soils observed to be unstable should be undercut to a stable stratum and backfilled with compacted structural fill as recommended in the field by the geotechnical engineer, or their qualified representative. Based upon the results of our subsurface exploration, it should be anticipated that the upper 2 to 3 feet may need to be undercut or stabilized in place.

The excavated on-site soils may be suitable for re-use as structural fill and backfill with some limitations. Excavated soils classifying as ML (sandy silt), CL (lean clay), SM (silty sand), SC (clayey sand), and well-graded sand (SW) are considered suitable for use in fill construction provided that the soils are free of organic matter and debris and are within an acceptable moisture content for placement as fill. Materials deemed unsuitable will need to be placed in non-structural areas or removed from the site. Off-site borrow, if required, should be approved by the geotechnical engineer prior to importing to the project site.

Structural fill should be placed on a stable, nearly level subgrade following subgrade evaluation and preparation described above. All structural fill and backfill should be constructed in maximum 8-inch thick loose lifts and be compacted to 95% of the materials maximum dry density using ASTM D-698, standard Proctor. Grading operations within structural areas, including utility and footing backfill, should be observed and tested on a full-time basis by a soils technician working under the supervision of a geotechnical engineer. All compactive effort should be verified by in-place density testing.

Subsurface Utilities

The natural soils and existing fill that is stable and free of deleterious materials are considered suitable for support of the proposed subsurface utility systems. GTA recommends 6 inches of crushed stone bedding material be placed if water seepage or rock is encountered to provide uniform support as dictated by site conditions. Further, GTA recommends placing crushed stone to 6 inches above the pipe in areas where plastic soils are present at the utility invert elevation. This will facilitate compaction, protect the pipe, and reduce the risk of trench settlement.

Water may be encountered in utility excavations, depending on the construction season and utility invert elevations. The contractor should be prepared to provide adequate earth support and dewatering systems in utility trench excavations. Utility pipe systems below pavement and other structural areas should be backfilled using controlled, compacted fill. The backfill should be placed and compacted as described in our *Earthwork* recommendations. Lift thickness should be reduced to 4 inches when compacting with lightweight equipment around structures.

Foundations

The variable consistency existing fill is not considered suitable for direct foundation support due to the potential for excessive total and differential settlement. It is our understanding that due to space limitations, timing, and cost, complete removal of the existing fill materials and replacement with compacted structural fill may not be preferable. Therefore, three foundation options are provided below including spread footings founded on lean concrete or crushed stone following removal of the existing fill below foundation elements, footings supported on compaction grouted improved soils, or small diameter micropiles. The cost and practicality of each of these options will be contractor and space dependent. GTA can assist with finding qualified contractors that can execute each of these options upon request.

Spread Footings

Shallow spread footings and strip wall footings founded on lean concrete or compacted crushed stone may be designed for a net allowable bearing pressure of 4,000 pounds per square foot (psf) if extended through the existing fill materials to suitable native soil or rock. Minimum widths for wall footings of 24 inches and column footings of 36 inches are recommended when design based on the recommended 4,000 psf bearing pressure results in a more narrow footing. Based on the design bearing pressure and assuming a maximum column load of 50 kips and wall load of 5 kips per linear foot, settlements on the order of 1-inch total and ½-inch differential can be anticipated.

Exterior footings should be founded a minimum of 36 inches below final exterior grade to provide protection from frost action, unless otherwise dictated by local code. New footings constructed adjacent to existing footings or walls should be designed to match bearing grades of the adjacent existing footings. New footings should be designed so that new foundation loads do not influence the existing concrete wall. We recommend a structural review of the as-built wall condition prior to finalizing the foundation design. Step footings at 2 horizontal to 1 vertical as required. Excavations should not extend below the bottom of adjacent existing footings, unless underpinning is provided, due to the potential for undermining of soils supporting the existing footings.

Lateral loads may be resisted by a combination of friction between the foundation bottom and the supporting subgrade and passive resistance acting against the vertical faces of the foundation. A coefficient of friction of 0.45 between the foundation and supporting subgrade may be used.

Footings should be supported on lean concrete or compacted crushed stone following removal of the existing fill to stable native soil or weathered rock. Based on the boring data, over-excavations on the order of 6 to 16 feet should be anticipated if this option is chosen. The decision to undercut footing subgrades or perform other foundation remedial measures should be made in the field by the geotechnical engineer during footing subgrade preparation.

Following review and approval of the subgrade by the geotechnical engineer, the undercut volume should be backfilled to the design bearing grade with concrete or dense-graded aggregate meeting the gradational requirements of PADOT Size No. 2A aggregate. Recycled concrete may also be used but should be approved by the geotechnical engineer prior to importing to the project site. The dense-graded aggregate should be placed in maximum 8 inch loose lifts and compacted using a vibra-plate mounted on the excavator to at least 95 percent of the materials maximum dry density per ASTM D698, Standard Proctor. Where excavations are greater than 5 feet deep, verification of compaction should be performed by a combination of moisture content testing prior to aggregate placement and visual observation of the compaction operation. We recommend that field density testing be performed on the final two to four lifts to verify that adequate compaction has been achieved. No personnel should enter excavations greater than 5 feet deep unless the excavation is sloped, benched or braced in accordance with the latest OSHA Standards.

Groundwater is not anticipated to be a significant problem during over-excavation operations. If water is encountered during foundation construction, the excavations should be dewatered through the use of sumps. Final grades should be established to provide adequate surface drainage away from the foundations.

Detailed foundation subgrade evaluations should be performed in each footing over-excavation prior to the placement of concrete. The foundation bearing surface evaluations should be performed by the geotechnical engineer or their representative using a combination of visual observations, Dynamic Cone Penetrometer (DCP) testing, and comparison with the borings.

Compaction Grouting

Given the presence of the existing fill materials and in order to reduce potential settlement and excavation depth, a compaction grouting program can be performed to improve the existing fill materials under the foundations and if required, within the slab areas. Provided the existing fill materials are stabilized as described below, the foundations may be designed for a maximum net allowable bearing pressure of 4,000 pounds per square foot (psf) when founded on stabilized soils and a 24-inch thick layer of compacted dense-graded aggregate. Minimum widths for wall footings of 24 inches and column footings of 36 inches are recommended when design based on 4,000 psf yields a more narrow footing. Total settlements on the order of 1 inch total with ½-inch differential can be anticipated based on the assumed structural loads as discussed in the *Proposed Construction* section of this report.

The grout injection pipes should be drilled 3 to 5 feet into the rock surface, which was encountered at depths ranging from approximately 15 to 17 feet below the existing ground surface. A low slump grout should be injected under pressure in 1 foot vertical stages using a bottom up injection technique from the rock surface up to the bottom of the proposed foundation elevation. Approximately 3 to 4 cubic feet of grout should be injected per foot for injection pressures between 100 and 300 psi and up to 13 cubic feet of grout may be needed for pressures below 100 psi. Where higher grout takes occur, additional grouting (secondary points) should be performed as recommended in the field by the geotechnical engineer. An injection rate of 2 cubic feet per minute or less should be used to maximize ground improvement. Number of grout injection points will be dependent on the footing dimensions.

The composition of the grout mix will be dependent upon the evaluation of the injection pipe installation and initial grout take by the geotechnical engineer. Where large voids, extreme fractures, or very soft soil is present, a stiff consistency compaction-type grout will be required to fill voids/fractures and displace soft soil which may be within the void/fracture, while limiting the lateral spreading of the grout. The consistency of the mix will likely vary from a slump of zero to about three inches. In no case should a high slump or slurry mix or a high injection rate be used to fill voids or densify the soils on this project.

Upon completion of the grouting program, the overfilled soils should be excavated 24 inches below the proposed tank pad subgrade. A 24-inch layer of dense graded aggregate shall be placed and compacted between the improved soils and foundation to help evenly distribute the loads. The dense-graded aggregate shall be placed and compacted in accordance with the *Earthwork* section of this report, up to the proposed bottom of foundation elevation.

A grouting criteria, which includes number of grout points per foundation, grout pressure, monitoring the ground surface movement, and maximum injection volumes should be established by the geotechnical engineer and grouting contractor prior to implementing the grouting program. Pressures and volumes indicated above are typical and can be used for bidding information until the criteria can be finalized between the grouting contractor and geotechnical engineer. Grouting operations should be observed and documented by the geotechnical engineer or qualified representative. Upon request, GTA can prepare a grouting program and criteria for use on this project once the final building grades, structural loads, and excavation phasing are established.

Micro-Piles

Micro-piles may be a cost-effective alternative particularly where access and obstructions may be an issue. For this project, micro-piles are similar to drilled shafts in that they would consist of a permanently cased hole that is advanced to the weathered rock/bedrock surface. Drilling is then continued into the weathered rock or competent rock strata to create a socket where these foundations gain their capacity. The casing and rock socket is then grouted. Reinforcing steel, typically a single large diameter bar or small diameter steel casing, is installed to provide reinforcement. These foundation elements are typically a foot or less in diameter and have allowable capacities similar to that of drilled shafts.

There are numerous methods of installing these piles that vary with the particular contractor. As such, the final design of micro-piles is typically performed or modified by the contractor as a design-build contract. Allowable capacities of 75 tons per pile are expected to be feasible on this site for gravity grouted micro-piles socketed 5 to 10 feet into bedrock.

Micro-piles can be designed based on an allowable grout-to-rock skin friction of 5.0 tsf. Due to the small diameter of the micro-pile element, end bearing capacity will tend to be minimal compared to the frictional resistance. A minimum of 2 piles per cap will be required where the pile is braced in only one direction and a minimum of three piles where the cap is un-braced. The group efficiency of these piles with respect to bearing capacity should be equal to at least one when assuming a pile center-to-center spacing of at least three pile diameters.

The successful use of micro-piles is often contractor and installation procedure dependent. Therefore, full time on-site observation and consultation by the geotechnical engineer are required by the building code and considered essential on this project.

Floor Slabs

Floor slabs can be designed as concrete slabs-on-grade. A design modulus of subgrade reaction (k) of 150 pounds per cubic inch (pci) is suggested for the floor slab design. The slabs may bear over footing projections, but they should be isolated and jointed so that the foundations can settle slightly without affecting the slab.

GTA recommends that the concrete floor slabs supported on grade be founded on a 4 to 6-inch crushed stone granular layer meeting the gradation of AASHTO Size No. 57 aggregate. Where slab base friction that may restrict natural expansion and contraction of the slab is a concern, the No. 57 aggregate base can be substituted with PADOT 2A dense-graded aggregate, placed and compacted in accordance with our *Earthwork* recommendations. Where moisture sensitive floor finishes are planned, a water vapor retarder should be installed above the granular layer. Floor slab subgrade soils should be evaluated by a representative of the geotechnical engineer immediately prior to stone and concrete placement. Undercutting and/or stabilization will likely be required to prepare the subgrade for stone and concrete.

ADDITIONAL SERVICES

We recommend that GTA be retained to provide the following additional design consultation and construction observation and testing services:

- Review micropile or compaction grouting design submittals to evaluate if they conform to the intent of this report.
- Review final site and structural plans to evaluate if they conform to the intent of this report.
- Provide on-site observation and testing of structural fills, including backfill following building demolition.
- Observe excavated footing subgrades and deep foundation installations for compliance with the project drawings and the intent of this geotechnical report.
- Perform observation and materials testing during concrete, masonry, and steel construction.

LIMITATIONS

This report, including all supporting test boring logs, field data, field notes, laboratory test data, calculations, estimates and other documents prepared by GTA in connection with this project have been prepared for the exclusive use of T and M Associates, pursuant to agreement between GTA and T and M Associates, and in accordance with generally accepted engineering practice. All terms and conditions set forth in the Agreement and the General Provisions attached thereto are incorporated herein by reference. No warranty, express or implied, is made herein. Use and reproduction of this report by any other person without the expressed written permission of GTA and T and M Associates is unauthorized and such use is at the sole risk of the user.

The analysis and recommendations contained in this report are based on the data obtained from limited observation and testing of the encountered materials. Test borings indicate subsurface conditions only at specific locations and times and only at the depths penetrated. They do not necessarily reflect strata or variations that may exist between or beyond the test boring locations. Consequently, the analysis and recommendations must be considered preliminary until the subsurface conditions can be verified by direct observation at the time of construction. If variations of subsurface conditions from those described in this report are noted during construction, recommendations in this report may need to be re-evaluated.

In the event that any changes in the nature, design, or location of the facilities are planned, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed and conclusions of this report are verified in writing. Geo-Technology Associates, Inc. is not responsible for any claims, damages, or liability associated with interpretation of subsurface data or reuse of the subsurface data or engineering analysis without the expressed written authorization of Geo-Technology Associates, Inc.

The scope of our services for this geotechnical exploration did not include any environmental assessment or investigation for the presence or absence of wetlands, or hazardous or toxic materials in the soil, surface water, groundwater or air, on or below or around this site. Any statements in this report or on the test boring logs regarding odors or unusual or suspicious items or conditions observed are strictly for the information of our Client.

This report and the attached logs are instruments of service. The subject matter of this report is limited to the facts and matters stated herein. Absence of a reference to any other conditions or subject matter shall not be construed by the reader to imply approval by the writer.

31162142 **GEO-TECHNOLOGY ASSOCIATES, INC**.