REPORT

Geotechnical Engineering Investigation

Veterans Administration Hospital

GAI No: F091285.00

August 30, 2011

Presented To: **Astorino**

227 Fort Pitt Boulevard

Pittsburgh, Pennsylvania 15222

Presented By: **GAI Consultants, Inc**

1055 Westlakes Drive, Suite 200

Berwyn, Pennsylvania 19312

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gai consultants
transforming ideas into reality®

August 30, 2011
F091285.00

Astorino
227 Fort Pitt Boulevard
Pittsburgh, Pennsylvania 15222

Attn: Mr. John Whitmire

Re: **Veterans Administration Hospital**
Lebanon, Pennsylvania
Geotechnical Engineering Investigation

Dear Mr. Whitmire:

In accordance with your request, GAI Consultants, Inc. (GAI) performed a Geotechnical Engineering Investigation in conjunction with the proposed Laboratory Addition to Building 1 at the Lebanon VA Hospital. This investigation was performed in accordance with our Proposal of October 27, 2009, the supplemental proposal of February 3, 2011, the written acceptances and the subsequent discussions. As this investigation progressed, we coordinated with the VA facilities management and discussed the findings and preliminary evaluations with the project design team.

A preliminary report of this investigation was presented on June 3, 2011, and since then additional data pertinent to this project was obtained. The findings from this investigation and our conclusions and recommendations for the design and construction of the foundations and other geotechnical related elements of the proposed Laboratory Addition are summarized and presented in this report.

We appreciate the opportunity to perform this geotechnical investigation for the proposed Laboratory Addition to Building 1 at the Lebanon VA Hospital. If you have any questions or require additional information, please contact Richard Mabry, P.E. at 610.640.7456 ext. 2802 or r.mabry@gaiconsultants.com.

Sincerely,

GAI Consultants, Inc.

Richard E. Mabry, P.E.
Geotechnical Engineering Manager

Attachments

REM/arm

Table of Contents

SECTION 1.0 INTRODUCTION

The Geotechnical Investigation reported herein was performed by GAI for the proposed Laboratory Addition to Building 1 at the Lebanon VA. This investigation was performed in accordance with our Proposal of October 27, 2009, the supplemental proposal of February 3, 2011, and the written acceptances and subsequent discussions. As this investigation progressed, site activities were coordinated with the VA facilities management and the findings and preliminary evaluations were discussed with the project design team.

The purpose of this investigation was to explore and evaluate the geotechnical conditions of the site and to formulate conclusions and recommendations pertaining to the design and construction of the foundations and other geotechnical related elements of the proposed Laboratory Addition. This investigation included planning and performing a program of additional test borings, laboratory testing of representative soil samples, engineering analysis of the data obtained, and the preparation of this report.

This report presents the pertinent data obtained in the course of this investigation, evaluations and discussion of the geotechnical conditions and their relationship to the proposed project, and conclusions and recommendations for the design and construction of the Addition. Pertinent plans and design parameters about the proposed Laboratory Addition were provided from Astorino, the Designer for this project. Figures showing the site location plan, the geotechnical exploration plan, and the subsurface conditions are presented in Appendix A. A description of the subsurface exploration and generalized logs of the test borings that were performed for this investigation are presented in Appendix B. The results from the laboratory testing program are presented in Appendix C, together with a description of the testing program.

SECTION 2.0 PROJECT DESCRIPTION

Building 1, where the Laboratory Addition is located, is the original main building and is immediately visible as one enters the Lebanon VA Hospital campus from Lincoln Avenue, as shown on Figure 1. The Laboratory Addition will occupy the present court area on the south (project orientation) side of Building 1, and project slightly beyond the south line of the building, as shown on Figure 2.

A single story steel framed structure with a full basement is to be constructed for the proposed Laboratory Addition. This Addition will have overall footprint dimensions of about 70 by 120 feet and a finished floor at the same level as the ground floor of Building 1, Elevation 552.5 feet. The existing site topography and the finished adjacent grades are several feet above this finished floor level. Column loadings within the addition are reported to be in the range of about 50 to 190 kips.

There are two floor levels in the basement. A pipe basement and a mechanical basement are beneath the northern and southern portions, respectively, of the addition. The respective basement floor levels are seven and 14 feet below the ground floor level. An access stairway with a doorway into the mechanical basement will be constructed in the existing building immediately to the west of the addition.

SECTION 3.0 SITE AND SUBSURFACE CONDITIONS

The Laboratory Addition site located between the two wings of the former main entrance court to Building 1 is a nearly level lawn area with a few moderate to large size trees. Two drain inlets are near the ends of the wings, and it is expected that there are underground drainage pipes. There were no reports or indications of other underground utilities in the Addition area. The existing ground surface elevation ranges from about 554 feet in the southern portion of the Addition to slightly higher than 555 feet near the former building entrance area.

As previously noted, the ground floor of Building 1 is at about elevation 552.5, which is to be the finished floor of the Addition. There is an existing pipe basement beneath much of the adjacent areas of the existing building. This pipe basement has an exposed soil subgrade and about six feet of vertical clearance to the underside of the ground floor structural slab. The tops of some of the existing column footings are visible in this pipe basement. A structural drawing of the existing building shows the column footings adjacent to the Addition location bearing on rock at elevations ranging from 536 to 542 feet. These bearing elevations are slightly below to several feet above the expected subgrade excavation for the Addition mechanical basement. This drawing also indicates walls or grade beams between the footings.

Four borings were drilled for this investigation at the locations shown on Figure 2 in Appendix A. A description of the field exploration program and generalized logs of the borings is presented in Appendix B. The laboratory testing program description and the testing results are presented in Appendix C. Most of these borings encountered about two to six inches of topsoil that generally appeared as brown sandy clay with grass roots and other organic material. Beneath the topsoil, the borings encountered strata of clay and silt, weathered rock, and relatively intact rock. These strata are described below and are illustrated on Subsurface Profiles presented on Figure 3 in Appendix A.

3.1 Clay and Silt

All of the borings encountered layers of brown, and dark brown sandy clay, silty clay, and sandy silt, all with occasional pieces of limestone gravel. Overall, these materials were found by the borings extending to depths of 5.5 feet to 16.0 feet, which correspond to elevations of 539.0 to 548.6 feet and with an average elevation of about 546.3 feet. The Standard Penetration Test (SPT) N_{60}-Values of the samples taken within these soils are in the overall range of 2 to 17 blows per foot (bpf) and average about 10 bpf. Consistent with the configuration of the existing building, it is believed that some these soils may be fill materials were placed in conjunction with the construction of Building 1. These materials at the greater depths appear to be natural soils.

In three of the borings, the clay and silt soils extend to depths of 5.5 to 7.2 feet, or to elevations of 547 to 549 feet, which are above the level of the proposed pile basement. Based upon the SPT N-Values and visual observations of the samples, these soils are generally of a medium stiff to very stiff consistency. Below the pipe basement level, Boring

B-1 encountered a layer of sandy silt with SPT N-Values of about 3 bpf and a generally soft consistency.

Laboratory testing of selected representative samples shows the water content of these soils to range from 16.0 to 29.5 percent, and to average about 22 percent. The samples from above the pipe basement level were found to have water contents ranging from 16.0 to 21.2 percent and averaging about 18 percent. Determinations of the liquid and plastic limits of two of these samples indicate a classification of CL – low plastic clay. It is noted that the water contents of these soils are less than the plastic limit of about 22 percent. The tested samples from below the pipe basement level have water contents ranging from 25.2 to 29.5 percent.

3.2 Weathered Rock

Underlying the clay and silt soils, three of the borings encountered a maximum of four feet of brown and gray sand, gravel and clayey gravel. The gravel was observed to consist of limestone fragments. SPT N-Values in these soils range from 8 to greater than 50 bpf, and are generally greater than 50 bpf, indicating a generally very dense condition. Considering the overlying clay and silt soils and the underlying limestone rock, these soils appear to constitute a zone of weathered rock in a typical limestone weathering profile.

3.3 Relatively Intact Rock

At depths of 7.2 to 10.0 feet, three of the borings encountered gray limestone. These depths correspond to elevations of 545 to 547 feet. A possible pinnacled or highly irregular rock surface was encountered in one of these borings. Boring B-1 encountered the limestone at a depth of 16.5 feet, which corresponds to an elevation of 538.5. Coring of the rock was performed in all of the borings and the core recoveries range from 40 to 100 percent. Based upon the core, the rock is medium hard to hard and in a very broken to massive condition. RQD values, a modified core recovery based on naturally separated intact core pieces greater than four inches in length, range from 0 to 100 percent. These values indicate a variable rock mass condition ranging from very poor to excellent.

Published geologic mapping indicates the VA Hospital campus to be underlain by several rock formations, and some mapped formation contacts are indicated to be in the vicinity Building 1. These formations, the Richland, the Millbach and Schaefferstown, and the Snitz Creek, are typically comprised of limestone and dolomite, and are characterized as possibly containing solution openings and having a pinnacled interface with the overlying soil.

3.4 Groundwater Conditions

There was no evidence of groundwater encountered as the borings were drilled through the soil strata and drill water circulation was lost while coring the rock in several of the borings. After the borings were completed, the drill holes were generally dry. Accordingly, it is believed that the groundwater level is at an elevation below the bottoms of the borings, the deepest of which was at elevation 534 feet.

SECTION 4.0 GEOTECHNICAL EVALUATIONS

As shown on the Subsurface Profile, Figure 3, rock materials are expected to be encountered throughout most of the Addition area while excavating to the proposed basement levels. Boring B-1 encountered soft sandy silt extending down to about the level of the mechanical basement. Accordingly, the subsurface conditions of rock and possible soil materials become considerations in evaluating the site for appropriate foundations and other geotechnical related elements of the Addition, as discussed in the following sections.

4.1 Building Foundations

Based upon the test boring results and the reported column loadings, shallow foundations bearing on the rock materials appear to be appropriate for the laboratory Addition. It is noted that a similar foundation system is supporting the existing Building 1.

The foundation supporting capability of rock is more a function of the physical condition of the rock mass rather than the strength of the intact rock, and any expectations of foundation settlement. As noted, the rock cores show a broken to rock massive condition and very poor to excellent rock mass conditions. It is expected that excavating into the rock to the basement subgrades and for foundations will cause additional breakage. With these considerations, and consistent with the reported column loadings, a nominal design bearing pressure of 10,000 pounds is appropriate. Accordingly, footings in the range of about 3.0 to 4.5 feet square are anticipated.

Any settlement of these footings is expected to occur primarily as elastic compression of the rock mass and would occur almost concurrent with the loading application as the Addition is constructed. Even considering a reduction in the rock properties consistent with the variable rock condition as indicated by the cores, any such settlement is expected to be of a small magnitude, and only a portion of the total settlement is expected to occur after the architectural finishes are applied. Accordingly, footings bearing on the rock materials are considered to be appropriate for the Laboratory Addition.

As shown by Boring B-1 and the variable elevations of the existing Building 1 foundations, there is a possibility that limited zones of soil may be encountered in the course of excavating to a “usual” footing depth below the basement grades. If there are any such occurrences, it is believed that deepening the excavation to encounter the rock materials will appropriate. However, an engineering evaluation would be appropriate confirm any additional excavation.

4.2 Existing Building

The foundations and other elements of the existing building are expected to require consideration in the design and in planning the construction of the Addition. These elements may include grade beams and/or walls between the existing building foundations, a soil supported ground floor slab on grade, and the existing foundations that are bearing at elevations above the construction excavation grades for the Addition. Where these building elements are supported on soil, underpinning or other support means may be needed. However, underpinning is not expected to be feasible where existing building elements are supported on rock and different techniques to maintain the support for the existing building may be needed. There may be additional considerations depending upon the geometric relationship between the Addition basement walls and the extents of the existing footings.

Constructing the new stairway within the existing building for access from the ground level to the mechanical basement may also present several conditions for the Addition design and/or construction. Temporary support of the stairway excavation may be needed to limit the disturbance to the existing building. Also, support provisions may be needed for the doorway opening from the stairwell into the mechanical basement.

SECTION 5.0 CONCLUSIONS AND RECOMMENDATIONS

It is concluded that a shallow foundation system is appropriate for supporting the proposed Laboratory Addition. Criteria for the design and construction of foundations, related building elements, and site facilities that would be affected by the site and geotechnical conditions are presented below.

5.1 Seismic Parameters

Depending upon the governing building code for this facility, seismic considerations may be included within the structural design. As discussed above, the foundations and some of the structural elements of the Addition will be based on or within rock. The intact rocks of the formations associated with this site are generally considered to be "hard" rock, but these formations are known to be characterized with bedding, joints, fractures and other structural features. Accordingly, and following the procedures and criteria of the International Building Code (IBC), a seismic site class of B is believed to be appropriate for the design of the Addition.

5.2 Shallow Foundations

Shallow based footings bearing on the rock are recommended for supporting the columns and walls of the Addition. Criteria for the design and construction of these foundations are presented below.

5.2.1 Bearing Value

The limestone rock, as disclosed by the borings, is expected to be encountered at the basement levels throughout most of the Addition area. Considering the potential for variations in the rock and possible disturbance during excavation, footings supported on this rock should be proportioned for a net bearing pressure of 10,000 pounds per square foot. In addition, column and wall footings should be constructed to minimum widths of 3.0 and 1.5 feet, respectively, regardless of the developed bearing pressure.

With the possibility of soil zones being within the rock, Geotechnical Engineering evaluations should be made of all footing excavations to assess the specific foundation supporting conditions that are encountered. If soil materials are encountered, modifications could be developed and implemented so that appropriate foundation support is obtained.

5.2.2 Footing Depth

With the expectation that the basement spaces will not be exposed to freezing conditions, the footing bearing levels should be at least 2.0 feet below the lowest adjacent floor or finished grades. Footings that are adjacent to grade separations, such as subfloor pits or the wall between the two basement levels, should be constructed to bear at elevations below a 1:1.5 (H to V) plane projected upward from the area of lower elevation.

5.2.3 Footing Construction

All footing excavations shall be inspected prior to the placement of reinforcing steel and concrete to verify the quality and condition of the bearing materials. Any localized zones of excessively disturbed bearing materials shall be removed and replaced with concrete. Excavations shall be protected from freezing conditions and ponded water and shall be backfilled as soon as practical.

5.3 Basement and Retaining Walls

Parameters for the design of the basement and retaining walls include lateral earth pressure and lateral resistance. Also, the construction methods may also affect the design of these walls. Recommended design and construction parameters are presented below.

5.3.1 Earth Pressure

With the present building design, retaining walls are expected to be required at the stairway to the mechanical basement, around the basements and along the south side of the ground floor level. Retaining walls would also be at any subfloor sump, equipment, or elevator pits. These walls are expected to function as structurally restrained retaining walls and should be designed for the at-rest lateral pressure condition. Accordingly, the design earth pressure from ”generic” soil backfill should be determined as the hydrostatic pressure from an equivalent fluid weight of 60 pounds per cubic foot In addition, the wall pressure loading should include a uniform surcharge pressure equal to one-half of the distributed live loading on the backfill surface. The design of these walls should also consider the construction sequence relationship between backfilling the walls and the placement of the restraining structural elements.

5.3.2 Lateral Resistance

Where restraint is not provided by slabs or other structural elements, lateral resistance shall be developed through passive earth pressure and friction. Passive pressure against vertical faces of a wall footing backfilled with structural fill may be computed from an equivalent fluid weight of 300 pounds per cubic foot. Considering the possibility for structural planes of weakness in the rock, this value should also be used for footings that are poured into rock or soil excavations. Coefficients of 1/3 and 1/2 are recommended for friction between a footing bottom and supporting soil or rock, respectively. Alternately, corrosion protected reinforcing bars could be drilled and grouted for their development lengths into the rock to provide lateral resistance.

5.3.3 Construction Parameters

Prior to backfilling retaining walls, any accumulated trash, sediment, or debris should be removed. In areas of limited access, predominantly granular, readily compactable soils are recommended for backfill. All backfill should be compacted in accordance with the recommendations for structural fill.

There may be other considerations for the basement walls that relate to the rock excavation for the mechanical basement and the adjacent existing building foundations. Depending upon the excavation techniques used, some alternate designs for the basement wall support could be considered. Underpinning of adjacent footings with bearing levels on rock above the mechanical basement may not be easily accomplished, but alternate means for supporting these footings may be utilized. Otherwise, there may be additional lateral loadings onto the basement walls from these existing footings.

5.4 Floor Slabs on Grade

To preclude dampness, a gravel base course and vapor barrier shall be placed beneath the floor slabs on grade. The base course, serving as a capillary break, shall consist of at least four inches of PA DOT No. 57 or 67 coarse aggregate. The vapor barrier placed on top of the compacted base course shall be of 10 mil, minimum, polyethylene or equivalent material. Prior to placing the base course materials, the exposed subgrade shall be carefully examined for any areas that may have been disturbed by the previous construction. Any excessively loose or soft areas shall be undercut to firm materials and replaced with structural fill.

5.5 Existing Building

As described previously, the column footings of the existing building have bearing elevations ranging from 536 to 542 feet adjacent to the Addition and the stairway location. These bearing elevations are slightly below to several feet above the expected subgrade excavation for the mechanical basement. This drawing also shows walls or grade beams between the footings.

With these conditions, temporary and/or permanent stabilizing support for these footings and walls/beams may be required and should be a design consideration. However, conventional underpinning is not expected to be practical considering the rock that would be encountered. One possible alternate may be to drill and grout in reinforcing bars to stabilize the rock support for the existing building foundation elements.

Temporary excavation shoring and foundation support is usually performed by the contractors as their construction means and methods. However, some of these systems may also remain as the permanent support for the existing building. In such a case, all shoring design should be designed, reviewed, and constructed consistent with criteria for permanent building foundation and support elements. All cases such applications or systems should be designed by a Professional Engineer who is registered in Pennsylvania and is experienced with such systems.

5.6 Structural Fill and Backfill

All structural fill and backfill for the support of floor slabs on grade and pavements shall be compacted to at least 95 percent of the maximum dry density as determined in the laboratory by the modified compaction test (ASTM D 1557). Fill and backfill that is placed for site grading in non-structural landscape areas may be compacted to at least 90 percent of the D 1557 maximum dry density. These criteria should be incorporated, as appropriate, into the project drawings and specifications for utility installation and trench backfill.

It is expected that suitable on-site materials that will be excavated could be utilized in the fill construction. Materials that are used for the fill construction should be mineral soils that are free of organic, trash, or other deleterious inclusions. On-site and imported soils should have a maximum particle size of four inches, preferably a maximum plasticity index of six percent, and shall be at moisture contents that are consistent with the optimum(s) for compaction. Otherwise, wetting or drying should be performed as needed.

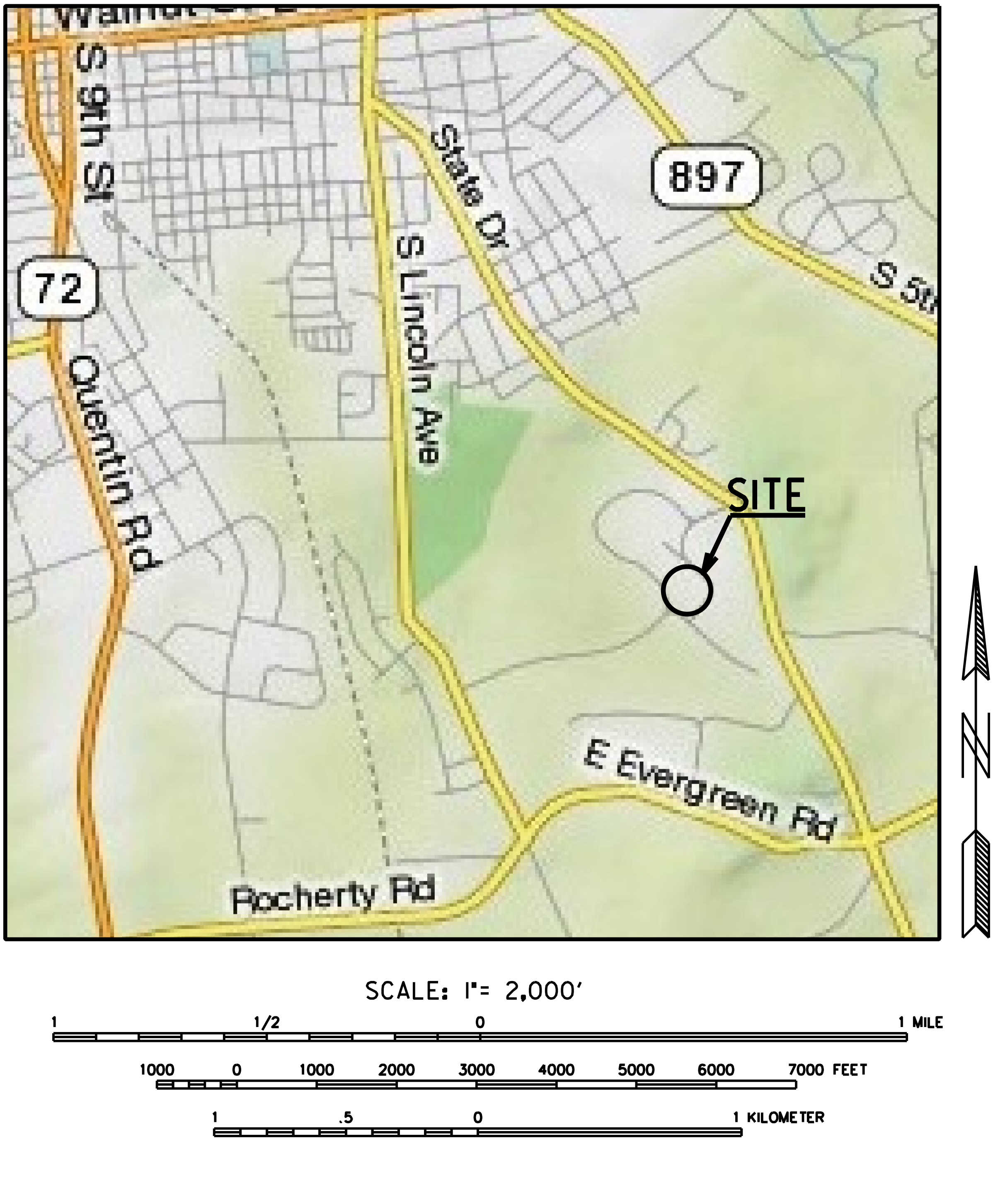
All structural fill and backfill placement and compaction shall be performed under the observation and technical supervision of a qualified Geotechnical Engineer or soil technician. Field and laboratory tests shall be performed as appropriate to document the quality of the fill materials and compaction, and to determine if the specified degree of compaction is being obtained. Experience has shown that the full time presence of a knowledgeable engineer or technician is the most effective means to assure the quality of fill construction.

SECTION 6.0 LIMITATIONS

The services described in this report were provided in accordance with reasonable and accepted engineering practice. No warranty or guarantee, expressed or implied, is intended. The conclusions and recommendations are based on the assumptions that the subsurface conditions do not deviate appreciably from those encountered in the test borings and that the loads and related project parameters are similar to these given in the project description. If the structure is moved or the loads have changed, GAI should be given the opportunity to modify the recommendations accordingly. The conclusions and recommendations are also based on competent field engineering, monitoring, and testing during construction. These conclusions and recommendations are subject to revision should the plans and specifications for this project be submitted to GAI for review before construction.

The recommendations presented in this report are solely for the use of our client for the design and construction of this particular project. Any re-use of this document by others, particularly by third parties, without the express written permission of GAI is solely at their own risk.

APPENDIX A



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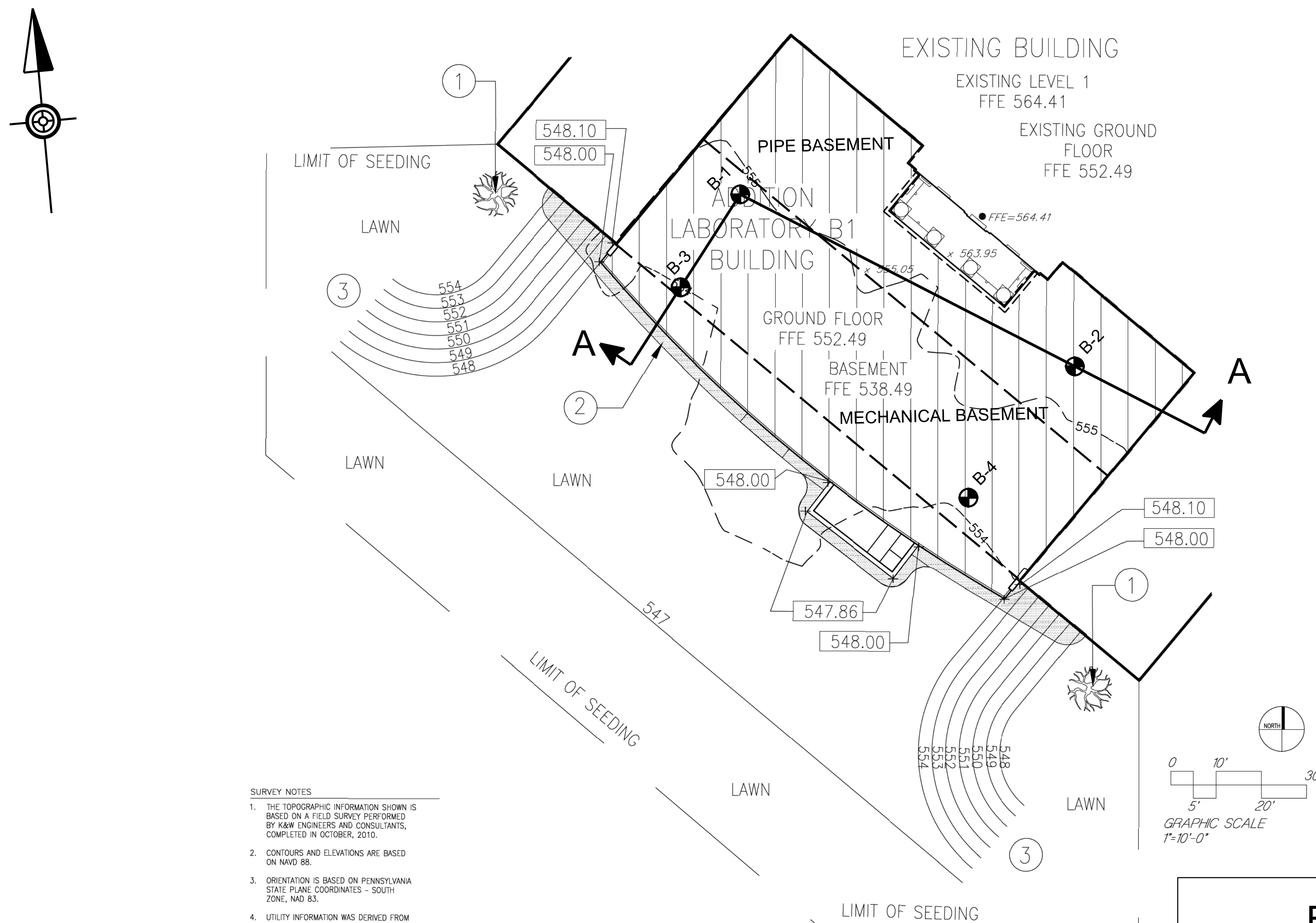
Site Location Map

Lebanon VA Hospital - Laboratory
South Lebanon Twp., Pennsylvania

FIGURE
1



SURVEY NOTES

1. THE TOPOGRAPHIC INFORMATION SHOWN IS BASED ON A FIELD SURVEY PERFORMED BY K&W ENGINEERS AND CONSULTANTS, COMPLETED IN OCTOBER, 2010.
2. CONTOURS AND ELEVATIONS ARE BASED ON NAVD 88.
3. ORIENTATION IS BASED ON PENNSYLVANIA STATE PLANE COORDINATES - SOUTH ZONE, NAD 83.
4. UTILITY INFORMATION WAS DERIVED FROM SURFACE EVIDENCE AND UTILITY PLANS PROVIDED BY THE LEBANON VA MEDICAL CENTER ENGINEERING OFFICE. NO PA ONE-CALL UTILITY MARKINGS WERE EVIDENT AT THE TIME OF THE FIELD SURVEY. PA ONE-CALL SERIAL NO. 20102840302 WAS ASSIGNED ON OCTOBER 11, 2010.

Legend

B-1 ⊗ - Test Boring Location and Designation

0' 30' 60'

FIGURE 2

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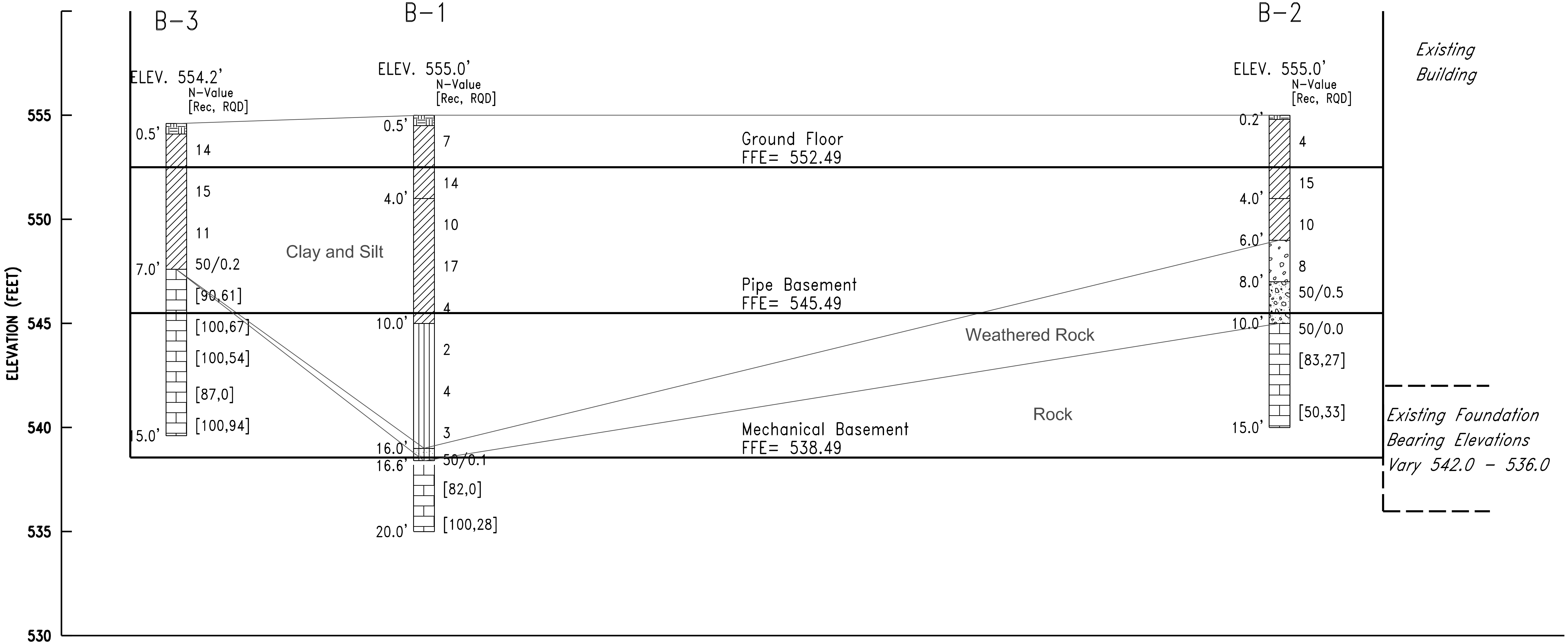
TEST BORING LOCATION PLAN

Laboratory Addition
Veterans Administration Hospital
Lebanon, PA

DWN. JWJ	CHKD. JWR	APPD. REM	DATE 8/29/11
PROJECT NO. F091285.00			SCALE: As Shown



SUBSURFACE PROFILE A-A

FIGURE 3	gai consultants

SUBSURFACE PROFILE A-A

Laboratory Addition
Veterans Administration Hospital
Lebanon, PA

DWN. JWJ	CHKD. JWR	APPD. REM	DATE 8/29/11
PROJECT NO. F091285.00			SCALE: As Shown

APPENDIX B

Subsurface Exploration

Key to Soil Symbols and Terms

Test Boring Logs (4)

Table B1. Results of Index Testing on Soil

APPENDIX B

Subsurface Exploration and Laboratory Testing

The subsurface conditions at the site for the proposed Laboratory Addition at Building 1 of the VA Hospital in Lebanon, PA were explored for this investigation through four test borings at the locations shown on Figure 2 in Appendix A. GAI personnel located the test borings on the site and provided full-time technical supervision during the field exploration. The as-drilled boring and elevations were determined by GAI with respect to reference points that are shown on the plans. Generalized logs of the test borings as well as a "Key to Soil Symbols and Terms" are presented in Appendix B.

The borings were performed by Connelly Drilling, Co. of West Chester, PA using a small track-mounted drilling rig with hollow-stem augers. Samples of the subsurface materials were taken from the test borings by means of a 2-inch O.D. split-barrel sampler driven by blows from a 140-pound hammer freely falling 30 inches (the Standard Penetration Test, ASTM D 1586). This sampling was performed using a safety hammer that was actuated by a rope being pulled over a cathead winch. The number of hammer blows required for the sampler penetration increment from 6 to 18 inches, or fraction thereof, is reported on the test boring logs for each of the samples that were taken.

Rock coring was also performed in all of the borings (B-12) using a NQ series coring barrel equipped with a diamond bit, according to ASTM D 2113. For the core runs, the percent recovery and Rock Quality Designation (RQD) were recorded and are presented on the boring logs. RQD is a modified core recovery and is defined as the percentage of the summed length of naturally separated core pieces longer than four inches divided by the length of the core run.

Laboratory tests were performed on selected samples to characterize the index and classification properties of the subsurface soils. The tests performed included determinations of the water content (ASTM D 2216) and Atterberg limits (ASTM D 4318) of selected samples. The numerical results from the index tests are summarized on Table B1 and are presented on the boring logs adjacent to the samples tested.

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (More than half of material is larger than No.. 200 sieve size)	GRAVELS (More than half of coarse fraction is larger than No. 4 sieve size)	CLEAN GRAVELS (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GRAVELS WITH FINES (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay
	SANDS (More than half of coarse fraction is larger than No. 4 sieve size)	CLEAN SANDS (little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		SANDS WITH FINES (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (More than half of material is smaller than No. 200 sieve size)	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 clay of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silty, and organic silty clays of low plasticity
	SILTS AND CLAYS (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
	HIGHLY ORGANIC SOILS		PT	Peat and other highly organic soils

N - The Standard Penetration Test value of the soil, determined in accordance with the methods of ASTM D1586. Reported in blows per ft and normalized to standard drilling equipment and an effective overburden pressure of 2 ksf., the n' value equals the number of hammer blows received by the sampler in advancing over the interval from 6 to 18 in. within a given sampling run.

PARTICLE SIZES

Boulders		->305mm
Cobbles		-76.2mm to 305mm
Gravel-	Coarse	-19.05mm to 76.2mm
	Fine	-4.75mm to 19.05mm
Sand -	Coarse	-2.00mm to 4.75mm
	Medium	-0.425mm to 2.00mm
	Fine	-0.074mm to 0.425mm
Silt		-0.005mm to 0.074mm
Clay		-<0.005mm

COHESIVE SOILS[1.]

Consistency	Unconfined Compressive Strength (psf)	Approximate Range of N
Very Soft	Below 500	0-2
Soft	500-1000	2-4
Medium Stiff	1000-2000	4-8
Stiff	2000-4000	8-15
Very Stiff	4000-8000	15-30
Hard	8000-16000	Over 30

COHESIONLESS SOILS[1.]

Density Classification	Relative Density %	Approximate Range of N
Very loose	0-15	0-4
Loose	16-35	5-10
Medium Dense	36-65	11-30
Dense	66-85	31-50
Very Dense	86-100	Over 50

1. Reference: Soil Mechanics, NA VFAC DM-7.1

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Key to Soil Symbols and Terms

TEST BORING LOG

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PROJECT NAME: Lebanon VA Hospital Laboratory Addition	BORING NO.: B-1
PROJECT NO.: F091285.00	SHEET 1 OF 1

TOWNSHIP: South Lebanon Township **COUNTY:** Lebanon **STATE:** Pennsylvania

DRILL RIG TYPE: Track **DRILLING METHOD:** HSA **DATE(S) DRILLED:** 5/24/11-5/24/11

DRILLER/COMPANY: R. Nagle / Connelly Drilling **FIELD ENGINEER:** J. Brink **CHECKED BY:** D. Mabry

GROUND ELEVATION: 555.0' **GROUNDWATER DEPTH:** Dry **FT. TIME:** 0 **HR.**

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SAMPLE NO./ CORE RUN NO.	BLOW COUNTS PER 6 IN.	REC (%)	RQD (%)	WC (%)	LL/PL (%)	USCS	qu/Pene (TSF)	STRATA SYMBOL	MATERIAL DESCRIPTION
	0											Topsoil
		SPT	S-1	2-3-4-4	80							Sandy Clay (cl), Brn., Moist, Med. Stiff to Stiff
	2	SPT	S-2	4-6-8-10	60		21.2					
	4											Clay (cl), Brn., Moist, Med. Stiff to V. Stiff
550		SPT	S-3	2-5-5-9	90							
	6	SPT	S-4	5-8-9-10	85		18.5	34/23				
	8	SPT	S-5	2-2-2-2	90		25.2					
545	10											Sandy Silt (ml), Brn., Moist, Soft [Tr. Gvl @ 12-14'] [Tr. Mica @ 14-16']
		SPT	S-6	1-1-1-1	75		25.4					
	12	SPT	S-7	1-2-2-2	75		29.4					
540	14	SPT	S-8	2-1-2-1	60		29.5					
	16	SPT	S-9	5-50/0.1	100							Micaceous Fine to Medium Sand (sm), Brn. & Gy., Moist, V. Dns [Limestone Frag. in spoon tip]
	18	ROCK CORE	R-1		82	0						Limestone, Gy & Dk. Gy., Med. Hd. to Hd., WM to WS, Ex. Cl. to Cl. Frac. V. Brok. to Sl. Brok., V. Poor to Poor [No Water Return] [Possibly broke casing @ 20.0 feet during coring]
535	20	ROCK CORE	R-2		100	28						

SAMPLE LEGEND

- SPT SAMPLE
- SHELBY TUBE
- ROCK CORE

GENERAL NOTES

GAI SELP2 BORING LOGS.GPJ 8/29/11

TEST BORING LOG

gai consultants

PROJECT NAME: Lebanon VA Hospital Laboratory Addition	BORING NO.: B-2
PROJECT NO.: F091285.00	SHEET 1 OF 1

TOWNSHIP: South Lebanon Township **COUNTY:** Lebanon **STATE:** Pennsylvania
DRILL RIG TYPE: Track **DRILLING METHOD:** HSA **DATE(S) DRILLED:** 5/23/11-5/23/11
DRILLER/COMPANY: R. Nagle / Connelly Drilling **FIELD ENGINEER:** J. Brink **CHECKED BY:** D. Mabry
GROUND ELEVATION: 555.0' **GROUNDWATER DEPTH:** Dry **FT. TIME:** 0 **HR.**

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SAMPLE NO./ CORE RUN NO.	BLOW COUNTS PER 6 IN.	REC (%)	RQD (%)	WC (%)	LL/PL (%)	USCS	qu/Pene (TSF)	STRATA SYMBOL	MATERIAL DESCRIPTION
	0											Topsoil
		SPT	S-1	2-2-2-6	75							Sandy Clay (cl), Dk. Brn., Moist, Med. Stiff to Stiff
	2	SPT	S-2	4-7-8-13	50		19.8	34/22				
550	4	SPT	S-3	4-4-6-6	85		16.4					Clay (cl), Brn., Moist, Stiff [Clay w/ Gvl. @ 5.2-6.0] [Limestone Frags.]
	6	SPT	S-4	4-4-4-8	25		15.5					Poorly Graded Gravel with Clay (gp), Dk. Gy. & Brn., Dry, Loose
	8	SPT	S-5	50/0.5	100							Well Graded Gravel (gw), Dk. Gy., Dry, V. Dns
545	10	SPT	S-6	50/0.0	0							Limestone, Gy., Hd., WS, V. Cl. to Cl. Frac. V. Brok. to Sl. Brok., V. Poor to Poor
	12	ROCK CORE	R-1		83	27						
540	14	ROCK CORE	R-2		50	33						

SAMPLE LEGEND
- SPT SAMPLE
- SHELBY TUBE
- ROCK CORE

GENERAL NOTES

(610) 640-7456 • 1055 Westlakes Drive, Suite 200, Berwyn, PA 19312 • FAX (610) 640-7459

TEST BORING LOG

gai consultants

PROJECT NAME: Lebanon VA Hospital Laboratory Addition

PROJECT NO.: F091285.00

BORING NO.: B-3

SHEET 1 OF 1

TOWNSHIP: South Lebanon Township **COUNTY:** Lebanon **STATE:** Pennsylvania

DRILL RIG TYPE: Track **DRILLING METHOD:** HSA **DATE(S) DRILLED:** 5/24/11-5/24/11

DRILLER/COMPANY: R. Nagle / Connelly Drilling **FIELD ENGINEER:** J. Brink **CHECKED BY:** D. Mabry

GROUND ELEVATION: 554.2' **GROUNDWATER DEPTH:** Dry **FT. TIME:** 0 **HR.**

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SAMPLE NO./ CORE RUN NO.	BLOW COUNTS PER 6 IN.	REC (%)	RQD (%)	WC (%)	LL/PL (%)	USCS	qu/Pene (TSF)	STRATA SYMBOL	MATERIAL DESCRIPTION
												Topsoil
			S-1	1-4-10-9	85							Sandy Clay (cl), Brn., Dry to Moist, Stiff [Tr. Gvl. @ 4-6 feet] [Auger Refusal @ 7.0']
	2											
			S-2	7-7-8-8	65		20.7					
550	4											
			S-3	2-4-7-8	85		16.0					
	6											
			S-4	6-7-8-50/0.2	45							
												Limestone, Gy. & Dk. Gy., Hd. WS, V. Close to Med. Frac., V. Brok. to Massive, V. Poor to Excellent [Dual Sample from 7-7.7']
	8		R-1		90	61						
545			R-2		100	67						
	10											
			R-3		100	54						
	12											
			R-4		87	0						
540	14		R-5		100	94						

SAMPLE LEGEND

- SPT SAMPLE
- SHELBY TUBE
- ROCK CORE

GENERAL NOTES

GAI SELP2 BORING LOGS.GPJ 8/29/11

TEST BORING LOG

gai consultants

PROJECT NAME: Lebanon VA Hospital Laboratory Addition	BORING NO.: B-4
PROJECT NO.: F091285.00	SHEET 1 OF 1

TOWNSHIP: South Lebanon Township **COUNTY:** Lebanon **STATE:** Pennsylvania

DRILL RIG TYPE: Track **DRILLING METHOD:** HSA **DATE(S) DRILLED:** 5/23/11-5/23/11

DRILLER/COMPANY: R. Nagle / Connelly Drilling **FIELD ENGINEER:** J. Brink **CHECKED BY:** D. Mabry

GROUND ELEVATION: 554.1' **GROUNDWATER DEPTH:** Dry **FT. TIME:** 0 **HR.**

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SAMPLE NO./ CORE RUN NO.	BLOW COUNTS PER 6 IN.	REC (%)	RQD (%)	WC (%)	LL/PL (%)	USCS	qu/Pene (TSF)	STRATA SYMBOL	MATERIAL DESCRIPTION
												Topsoil
		SPT	S-1	3-3-6-8	85							Well Graded Gravel (gw), Dk. Gy., Moist, Med. Dns.
	2	SPT	S-2	6-6-9-10	85							Sandy Clay (cl), Brn., Dry, Stiff [Tr. Gvl. @ 2-5.5 feet] [Limestone Frags.] [Grinding @ 4.3' , Spoon Deflected and Bent @ 5.5'] [Auger Refusal @ 6.0']
550	4	SPT	S-3	25/Deflection	15							
	6	SPT	S-4	13-13-12-9	30							Well Graded Gravel (gw), Gy., Dry, Med. Dns. [Spoon deflection @ 5.5' & Auger Refusal @ 6.0'] [Possible Pinnacle @ 5.5-7.5'] [Tried to wash out by coring, but core barrel kicked off and started rubbing HSA] [Offset 1.0' NE, Towards building balcony]

GAI SELP2 BORING LOGS.GPJ 8/29/11

SAMPLE LEGEND	GENERAL NOTES
SPT SAMPLE SHELBY TUBE ROCK CORE	

TEST BORING LOG

gai consultants

PROJECT NAME: Lebanon VA Hospital Laboratory Addition	BORING NO.: B-4A
PROJECT NO.: F091285.00	SHEET 1 OF 1

TOWNSHIP: South Lebanon Township **COUNTY:** Lebanon **STATE:** Pennsylvania
DRILL RIG TYPE: Track **DRILLING METHOD:** HSA **DATE(S) DRILLED:** 5/23/11-5/24/11
DRILLER/COMPANY: R. Nagle / Connelly Drilling **FIELD ENGINEER:** J. Brink **CHECKED BY:** D. Mabry
GROUND ELEVATION: 554.1' **GROUNDWATER DEPTH:** Dry **FT. TIME:** 0 **HR.**

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SAMPLE NO./ CORE RUN NO.	BLOW COUNTS PER 6 IN.	REC (%)	RQD (%)	WC (%)	LL/PL (%)	USCS	qu/Pene (TSF)	STRATA SYMBOL	MATERIAL DESCRIPTION
	0-4											Augered down to 4.0'. See boring log B-4 for soil description
550	4-6	SPT	S-1	4-7-10-13	75	33						Sandy Clay (cl), Dk. Brn., Moist to Dry, V. Stiff [Limestone Frag. in Spoon Tip]
	6-8	SPT	S-2	6-4-4-3	50	100						Poorly Graded Gravel with Clay (gp), Brn. & Dk. Gy., Moist to Dry, Loose [Limestone Frags.] [Hard Auger past 6.0'] [Spoon Bounced @ 8.0']
	8	SPT	S-3	50/0	0							
545	8-10.5	Rock Core	R-1		80	33						Limestone, Gy., Hd., WS, V. Cl. to Cl. Frac., Brok. to Massive, Poor to Good.
	10.5-11.5	Rock Core	R-2		40	100						
	11.5-13.5	Rock Core	R-3		100	42						
540	13.5-16.5	Rock Core	R-4		90	69						
	16.5-18.5	Rock Core	R-5		100	75						
535	18.5-20	Rock Core	R-6		53	52						

SAMPLE LEGEND	GENERAL NOTES
SPT SAMPLE SHELBY TUBE ROCK CORE	

GAI SELP2 BORING LOGS.GPJ 8/29/11

Table B1. Summary of Index Testing on Soil

Sample ID	Depth (ft)	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	USCS
B-1 / S-2	2.0–4.0	21.2	-	-	-	
B-1 / S-4	6.0-8.0	18.5	34	23	11	CL
B-1 / S-5	8.0–10.0	25.2	-	-	-	
B-1 / S-6	10.0–12.0	25.4	-	-	-	
B-1 / S-7	12.0-14.0	29.4	-	-	-	
B-1 / S-8	14.0-16.0	29.5	-	-	-	
B-2/ S-2	2.0–4.0	19.8	34	22	12	CL
B-2/ S-3	4.0-6.0	16.4	-	-	-	
B-2/ S-4	6.0-8.0	15.5	-	-	-	
B-3 / S-2	2.0–4.0	20.7	-	-	-	
B-3 / S-3	4.0-6.0	16.0	-	-	-	