GEOTECHNICAL REPORT

PROPOSED BRANCH LIBRARY
NEW HAVEN, MISSOURI

December 2014

Gateway No. 1412111

Owner – Scenic Regional Library

Engineer – Washington Engineering and Architecture

Gateway Geotechnical, LLC

Gateway Geotechnical, LLC

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December 10, 2014

Mr. Steve Campbell
Scenic Regional Library
308 Hawthorne Drive
Union, Missouri 63084

c/o Mr. Tim Sturholdt, AIA
Washington Engineering and Architecture
1301 West 5th Street
Washington, Missouri 63090

Reference: Geotechnical Exploration
Proposed Branch Library
New Haven, Missouri
Gateway No. 1412111

Mr. Sturholdt,

Attached is our *Geotechnical Report* that was completed following your authorization. An *Executive Summary of Recommendations* highlighting geotechnical recommendations unique to this project is also attached, immediately following this letter. The entire report, including its appendices, should be reviewed and incorporated into the project's design and construction. Please do not hesitate to call should you have any questions regarding our recommendations.

We appreciate having been of service during this phase of the project and look forward to our continued work with you. We recommend that Gateway be included in appropriate meetings during the remainder of the design process and at the commencement of construction in a preconstruction meeting. As a continuation of our services, Gateway should be retained during construction to observe the encountered conditions and test the construction materials and placement.

Respectfully,
GATEWAY GEOTECHNICAL, LLC

Shari A. Cunningham, PE
Senior Geotechnical Engineer

Attachments: Executive Summary of Recommendations
Geotechnical Report

SAC/TMM/sac

Copies: Scenic Regional Library/Mr. Steve Campbell (1 printed)
Washington Engineering and Architecture/Mr. Tim Sturholdt, AIA (4 printed + electronic)

EXECUTIVE SUMMARY OF RECOMMENDATIONS

(These recommendations are not to be used without reference to the accompanying report and its appendices for additional details and information.)

Project Proposed Branch Library
Location New Haven, Missouri

Report Date December 2014
Gateway No. 1412111

Shallow Foundations

Net Allowable Bearing Pressure 2,500 pounds per square foot (psf) for continuous wall footings and 2,750 psf for isolated, square, column footings.

Subgrade Bearing Materials Natural, low plastic cohesive soil, or newly placed structural fill.

Subgrade Treatment Removal and recompaction or replacement of existing fill. Removal of high plastic clay where present within 2 feet below shallow foundation bearing levels.

Minimum Width 24 inches for strip footings, 30 inches for square pads.

Minimum Frost Depth 30 inches.

Estimated Settlement 1 inch total, ¾ inch differential.

Seismic Category (IBC 2009) Site Class "D"

Floor Slab

Coefficient of Subgrade Reaction (k) 150 pounds per square inch per inch deflection (pci).

Minimum Base 6-mil-thick polyethylene sheet over at least 4 inches of crushed rock.

Subgrade Treatment Removal and recompaction or replacement of existing fill. Remediation of high plastic soil, if present within 3 feet below the bottom of the floor slab.

Site Development

Fill Materials On-site low plastic soil or imported low plastic materials.

Minimum Compaction Criteria for Structural Fill (Standard Proctor, ASTM D 698)

Cohesive	95 percent
Granular	100 percent

Other Considerations

Existing fill should be removed completely from the new building footprint, plus a horizontal distance outside the footprint equal to the depth of fill removed.

High plastic clay will require remediation where present below shallow foundations and floor slabs. The extent of high plastic clay remediation should be determined during construction when the excavations can be observed across the project area. In addition, high plastic clay should not be used as structural fill within 2 feet below foundation bearing levels or 3 feet below the bottom of the floor slab.

TABLE OF CONTENTS

GEOTECHNICAL REPORT

PROPOSED BRANCH LIBRARY
NEW HAVEN, MISSOURI

1.0 INTRODUCTION

At the request of Mr. Tim Sturholdt, AIA with Washington Engineering and Architecture, on behalf of Scenic Regional Library, Gateway Geotechnical, LLC (Gateway) provided a geotechnical exploration for a proposed branch library at the below-referenced site. The purpose of our study was to characterize and evaluate the subsurface conditions, provide recommendations for foundations, and address other geotechnical aspects. Our services were provided in general accordance with our November 19, 2014 proposal, and authorized by Mr. Sturholdt via email on November 24, 2014.

2.0 SITE AND PROJECT DESCRIPTION

The property is located on the east side of Douglas Street, approximately 400 feet north of its intersection with Missouri Highway 100 in New Haven, Missouri. The site is currently vacant with the exception of a two-tiered retaining wall along the east side of the site. The ground surface is relatively flat and covered by grass and sparse trees. We were not provided with information regarding former uses of the property or any structures which may have been present on the property in the past.

The preliminary site plan included in the Request for Proposal depicts a 6,000-square-foot library building to be constructed along the north side of the property, with a paved parking lot to the south. A Location and Site Plan is included as Figure 1. The building will be a single-story structure with a slab-on-grade floor and no basement. Structural loads were not available at the time of this report, but are anticipated to be light to moderate. A site grading plan has not yet been prepared, however, we understand that grades along the west side of the site will remain essentially unchanged, while the east side of the site will receive some fill to produce a more level building pad and parking lot.

No other information was available, prepared by Gateway or others, that would affect the recommendations of this report.

3.0 DESIGN RECOMMENDATIONS

3.1 Existing Fill

Existing fill was encountered in four of the seven borings drilled at this site. The thickness of the existing fill was approximately 3½ feet in B-1, and 5½ to 6 feet in B-2, B-3, and B-6. The fill generally consists of high plastic clay and low plastic silty clay, both containing variable amounts of crushed rock and organics. No records of its placement were provided to us. It would be prudent to anticipate that fills of varying material types, depths, and lateral extent could be present in other areas of the property, as well.

It is our opinion, based on the field and laboratory test data in our borings, that the fill is not compacted to the degree that would be typically recommended for support of a building. Insufficiently compacted soil fill tends to consolidate under its own weight with time. The application of additional loads, such as placement of additional fill or construction of a new building, results in further consolidation of the fill.

The most positive solution for support of the new building would be to completely remove and recompact or replace the existing fill prior to the placement of additional building pad fill and construction of the new building. Existing fill should be removed entirely within the new building footprint, plus a horizontal distance outside the footprint equal to the depth of fill removed. Removal should include any below-grade utilities (if present) and associated backfill. The base of the excavation should be relatively flat, and should expose natural undisturbed cohesive soil. The excavation should then be backfilled with structural fill as required to re-establish the design subgrade elevation. The existing fill, if verified during construction to be suitable, could be re-used as structural fill. On-site or imported fill material should meet the requirements of structural fill described in Appendix C. Because of its tendency to shrink and swell with changes in moisture content, high plastic clay should not be used as fill within 2 feet below foundation bearing levels or 3 feet below the bottom of the floor slab.

Outside of the building pad, existing fill can be left in place below proposed flexible pavement areas provided the upper 8 to 10 inches are scarified, moisture adjusted as needed, and recompacted; any soft or otherwise objectionable areas should be identified and removed during construction. Any existing below-grade elements that are encountered may be left in place in these areas provided slabs are sufficiently broken to allow drainage, it can be verified that large pieces are not nested together, and the elements left in place are at least 3 feet below proposed subgrade. Leaving existing fill or below-grade elements in place carries a higher risk of cracking and/or deflection in pavements, sidewalks, and other site features than if the fill and below-grade elements were completely removed.

3.2 High Plastic Clay

The potential for volume change in soil increases with higher values of liquid limit and plasticity index. This volume change occurs with corresponding changes in moisture content, and is normally evidenced by the heaving and cracking of floor slabs and cracking of footings and foundation walls. The borings encountered high plastic clay in the existing fill as well as the near-surface natural soil.

Because of its volume change potential with changes in moisture, we recommend that high plastic clay not be present within 2 feet below shallow foundations or 3 feet below floor slab bearing levels. High plastic clay should not be re-used or placed as fill within these restricted zones. Where natural high plastic clay is present within these restricted zones, remediation is usually accomplished by overexcavating the high plastic clay below the footings and slabs. The overexcavations should extend horizontally at least 2 feet beyond the outside edge of the footings and building footprint to facilitate uniform compaction of the replacement materials. The overexcavations may be backfilled with properly compacted low plastic soil, limestone screenings, or 1-inch-minus crushed limestone. Lean concrete can be used as backfill beneath shallow footings; in this event, the overexcavation need not extend beyond the edges of the footing. The footings and floor slab would then be constructed on the newly placed structural fill.

Chemical admixtures such as hydrated lime or Code-L, in combination with a recompaction operation, can be used to reduce the plasticity of soil, and could be considered as an alternative to overexcavation and replacement, particularly during cold or wet weather.

The above-described methods of treatment are based on generally accepted standards in the local engineering community; however, swell pressures and volume change potential greater than can be mitigated by these methods may exist. Consequently, the owner should recognize that there remains a reduced risk that foundation and floor slab damage may occur, even after remedial treatment of the subgrade soil.

3.3 Shallow Foundations

The proposed building can be designed with shallow foundations. Following removal and replacement of existing fill, and remediation of high plastic clay where present within 2 feet below foundation bearing levels, the foundations are expected to bear on newly placed structural fill or natural low plastic soil. Spread footing foundations can be sized for a maximum net allowable bearing pressure of 2,500 pounds per square foot (psf) for continuous wall footings and 2,750 psf for individual, square, column pads.

Continuous wall footings should have a minimum width of 24 inches and column pads a minimum dimension of 30 inches. Exterior footings and foundations in unheated areas should be provided with at least 30 inches of soil cover for frost protection. Interior footings in heated areas may bear at a nominal depth below the floor slab.

For footings designed and constructed as recommended in this report, we estimate generally acceptable settlements of less than 1 inch total, and less than ¾ inch differential between adjacent footings.

3.4 Floor Slab

Following removal and replacement of existing fill, and remediation of high plastic clay where present within 3 feet below the floor slab bearing level, the floor slab is expected to be supported on newly placed structural fill or natural low plastic soil. We recommend that the floor slab be designed using a modulus of subgrade reaction (k) of 150 pounds per square inch per inch of deflection (pci). The floor slab should be supported on a minimum 4-inch-thick layer of crushed rock to help distribute concentrated loads and equalize moisture conditions beneath the slab. We recommend that 6-mil-thick polyethylene sheeting be placed immediately beneath the floor slab and above the crushed rock to slow the transfer of capillary moisture to the slab.

It is generally preferable to maintain structural separation between the floor slab and the foundation walls and column pads, using isolation joints. We also suggest that joints be placed in the floor slab on no more than 15-foot intervals in any direction. Such joints permit movement of the independent elements and help reduce random cracking that might otherwise be caused by restraint of shrinkage, slight rotations, heave, or settlement.

3.5 Seismic Considerations

The 2009 International Building Code (IBC) requires the design of buildings and their structural components to withstand seismic forces. Site coefficients, which are a function of the soil or rock type and consistency, are required for the calculation of minimum earthquake design forces. Based on the consistency of the soils encountered and the observed depth to bedrock, (as per Chapter 16), Site Class “D” should be used.

The site coefficient F_a is a function of the Site Class and mapped spectral response acceleration at short periods (S_s), while the site coefficient F_v is a function of the Site Class and mapped spectral response acceleration at 1-second periods (S_1). Based on Site Class “D” and the mapped values for S_s and S_1, we calculate F_a = 1.5 and F_v = 2.3. Some vertical and horizontal movement should be expected during a major earthquake event.

3.6 Excavations and Earthwork

The soils at this site are silty and susceptible to disturbance in the presence of moisture and the traffic of construction. Care should be exercised to protect exposed subgrades from damage during

construction, particularly during cold or wet weather. Temporary ditching and sumping may be dictated by the conditions encountered during construction to collect and discharge collected water away from the work area.

The auger refusal depths in the borings are below the anticipated excavation depths for building pad preparation and shallow foundation construction; however, such excavations could encounter weathered rock, and the refusal depths in B-1 and B-4 may be only a few feet below the shallow foundation bearing level. Deeper excavations, such as for utility installation, could encounter weathered rock or intact dolomite bedrock. The depth to bedrock could change abruptly within short distances, and could vary significantly between borings due to anomalies such as pinnacles, ledges, domes, and crevasses. In addition, the high plastic clay deposits which contain chert and weathered rock may also include cobbles, boulders, and/or stringers.

Slopes which are steeper than 4H:1V should be benched prior to the placement of new fill. Benching will provide level surfaces for compaction and reduce the potential for development of inclined planes of weakness between the natural soil and newly compacted fill.

Natural moisture contents in the upper portion of the borings ranged from 19 to 30 percent. Some moisture adjustment via aeration or the addition of water should be anticipated in order to achieve suitable compaction of the on-site soils in structural fill.

4.0 RECOMMENDED CONSTRUCTION OBSERVATION AND TESTING

The following list summarizes Gateway's recommendations for a construction-phase observation and testing program. These items typically provide quality assurance in assessing design assumptions, and document related construction procedures for compliance with plans, specifications, and good engineering practice. Gateway should be retained to:

- Participate in a formal preconstruction meeting with the Owner's Representative and Contractor prior to construction.
- Observe site preparation activities, including removal of existing fill within the building pad and proofrolling existing fill in non-building areas.
- Assess potential structural fill materials, including on-site and off-site sources.
- Provide subgrade observations and compaction testing of newly placed structural fill.
- Observe foundation excavations and floor slab subgrades for adequacy and character of bearing materials.
- Provide quality assurance testing of structural concrete.
- Conduct and document routine and rain-event observations at the site, maintain and update on-site paperwork, and provide submittals required by the SWPPP and Land Disturbance Permit, unless performed by others.

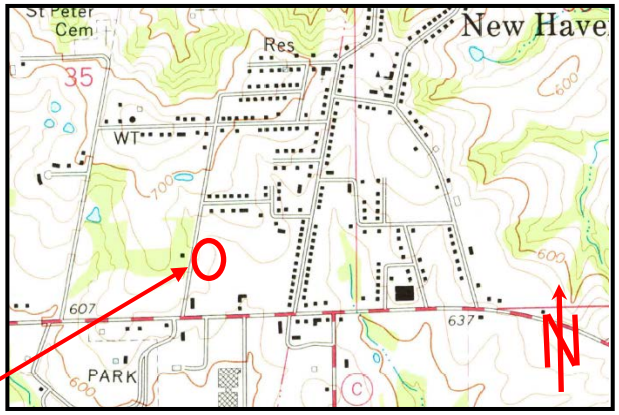
5.0 LIMITATIONS

The recommendations provided herein are for the exclusive use of our client. They are specific only to the project described, and are not meant to supersede more stringent requirements of local ordinances. They are based on subsurface information obtained at Gateway's seven specific boring locations within the project area, and our understanding of the project as presented above. No other warranty is expressed or implied. Gateway should be contacted if conditions encountered are not consistent with those described.

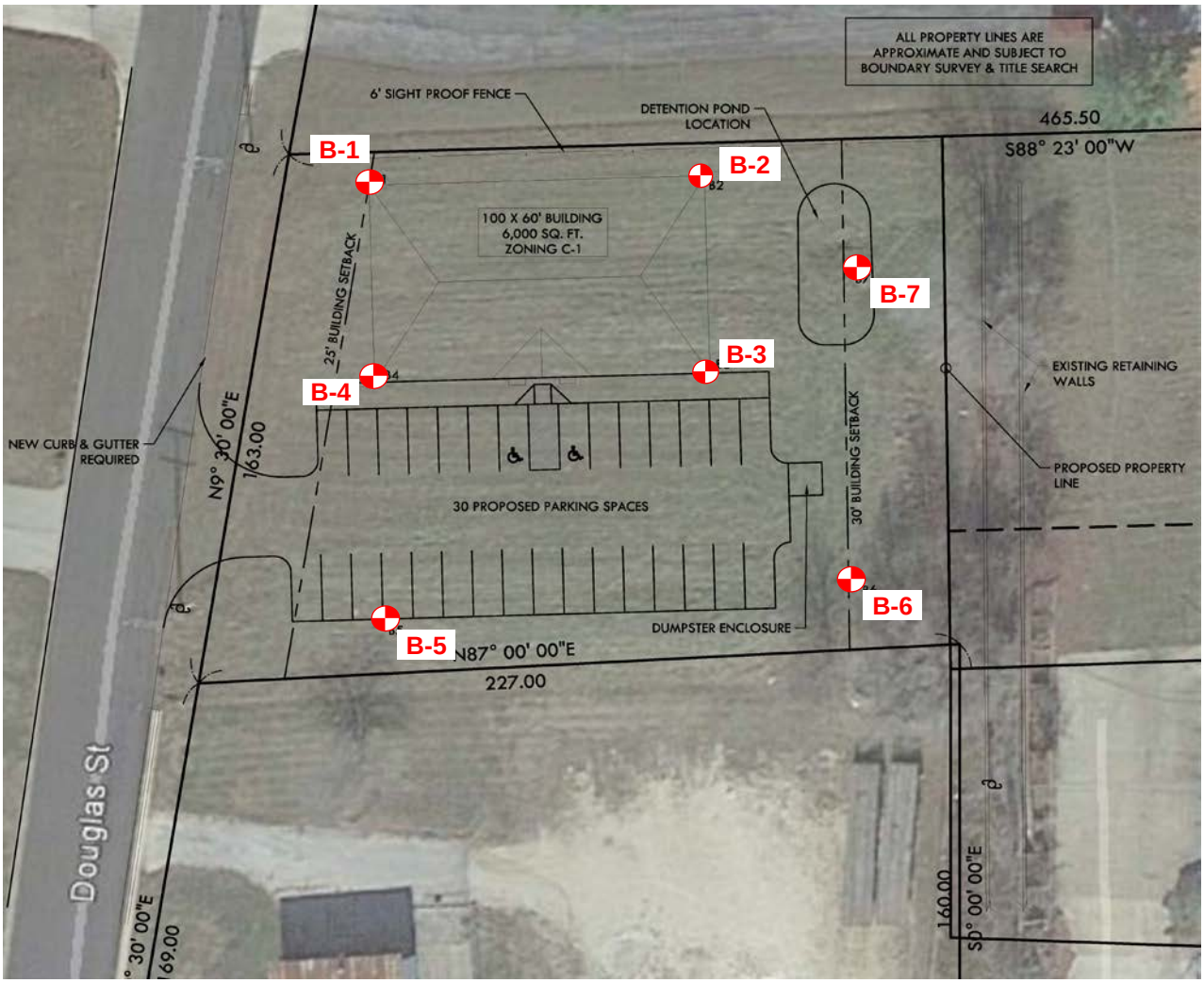
We should also be provided with a set of construction plans and specifications, when they are available, to review whether our recommendations have been understood and applied correctly. Failure to provide these documents to Gateway may nullify some or all of the recommendations provided herein. In addition, any changes in the planned project or changed site conditions may require revised or additional analyses and recommendations.

The final part of our geotechnical services should consist of direct observation during construction to observe that conditions encountered are consistent with those described in this report, and to assess the appropriateness of the analyses and recommendations contained herein. Gateway cannot assume responsibility or liability for the adequacy of its recommendations without being retained to observe construction.

* * *



Approximate Location of Site (NTS)



Notes / Legend

Approximate soil boring location

Site Plan provided by Washington Engineering & Architecture
Topographic map obtained from USGS
Aerial photo from Google Earth
Figure should not be used outside the context of this report.

N

Proposed Branch Library
New Haven, Missouri

LOCATION AND SITE PLAN

N.T.S.	Gateway No. 1412111	December 2014	Figure 1

APPENDIX A

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT

Important Information about Your

Geotechnical Engineering Report

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

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

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

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

Read the Full Report

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

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

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

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

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

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

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

Subsurface Conditions Can Change

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

Most Geotechnical Findings Are Professional Opinions

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

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual

subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

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

Do Not Redraw the Engineer's Logs

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

Give Contractors a Complete Report and Guidance

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

Read Responsibility Provisions Closely

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

Geoenvironmental Concerns Are Not Covered

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

Obtain Professional Assistance To Deal with Mold

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

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

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

ASFE THE GEOPROFESSIONAL BUSINESS ASSOCIATION

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Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@asfe.org www.asfe.org

IIGER03135.0MRP

APPENDIX B

FIELD EXPLORATION AND LABORATORY TESTING
SUBSURFACE CONDITIONS
LEGEND FOR BORING LOGS
BORING LOGS B-1 THROUGH B-7

FIELD EXPLORATION AND LABORATORY TESTING

A Utility Locate Request was submitted to Missouri One Call on November 24, 2014. Boring locations were marked in the field by Washington Engineering and Architecture. Seven borings were drilled on December 3, 2014 under subcontract to Midwest Drilling, Inc. at the approximate locations shown on the Location and Site Plan, Figure 1. The ground surface elevation at each boring location was provided by Washington Engineering and Architecture. The borings were backfilled with soil cuttings at the completion of the drilling operations.

The retained samples were manually-visually classified in our laboratory. Moisture content and pocket penetrometer values were obtained for each testable sample. Natural density and unconfined compressive strength tests were performed on the intact Shelby tube sample. Atterberg limits were determined on a selected sample to aid in classification and characterization.

SUBSURFACE CONDITIONS

Detailed information regarding the nature and thickness of the soils encountered, and the results of the field exploration and laboratory testing are shown on the Boring Logs. A Legend for Boring Logs is provided to aid with interpretation of the logs.

Existing fill was encountered at four of the seven borings. The fill extended to depths of approximately 3½ feet in B-1, and 5½ to 6 feet in B-2, B-3, and B-6. The fill generally consists of high plastic clay and low plastic silty clay, both containing variable amounts of crushed rock and organics. Moisture contents within the fill varied from 19 to 30 percent. Standard Penetration Test (SPT) values were in the range of 4 to 8 blows per foot (bpf).

The natural soil profile encountered below the ground surface at B-4, B-5, and B-7, and below the existing fill at B-1, B-2, B-3, and B-6 consists of low plastic silty clay (CL in accordance with the Unified Soil Classification System and ASTM D 2487) and high plastic clay (CH). Chert and weathered rock were observed in varying quantities within the high plastic clay. The natural, cohesive soils exhibited SPT values ranging from 5 to 22 bpf, and generally increased with the amount of chert and weathered rock. Five of the borings (B-1 through B-5) encountered 1 to 2 feet of weathered rock below the cohesive soils.

Auger refusal was encountered in B-1, B-2, B-4 and B-5 at depths of 10 to 12½ feet. Borings B-3, B-6, and B-7 terminated at 15 feet below grade without encountering auger refusal or intact bedrock, although weathered rock was observed just above the termination depth at B-3 and B-7. Auger refusal is defined as the inability to achieve further penetration with the equipment being used. It typically occurs on bedrock, but can also occur on boulders, ledges, stringers, or other obstructions.

The bedrock geologic map provided by the University of Missouri – Columbia, Center for Agricultural, Resource, and Environmental Systems (CARES) indicates the bedrock at the site likely consists of dolomite from the Jefferson City and Cotter formations. According to the *Stratigraphic*

Succession in Missouri, Thompson, 1995, the Jefferson City and Cotter formations consist of finely crystalline cherty dolomite with local sandstone beds.

Groundwater was observed in B-1 at a depth of 11 feet during drilling and at the completion of the drilling program. Groundwater was not observed in the remaining borings within the depths explored. It must be noted that the groundwater level is subject to seasonal and climatic variations and other factors, and may be present at different depths at a future date. Without extended periods of observation, accurate groundwater level measurements may not be possible, particularly in cohesive materials such as those found at this location. It is anticipated that groundwater will not significantly impact the planned construction.

*** * ***

LEGEND
FOR BORING LOGS

Depth in feet below ground surface.

Material Description indicates materials penetrated, typically soil or rock, using classification characteristics (ASTM D 2488) and the Unified Soil Classification System (ASTM D 2487). Secondary constituents are described as follows: trace for 0 to <10 percent, some for 10 to 35 percent, or by modifier to the main soil type for >35 percent.

Stratigraphic Break is indicated by a solid line where changes are observed in the field or retained samples, or a dashed line where changes are interpreted. Boundaries shown between described materials may be transitional or gradual.

Sample Type

- **SS** Disturbed sample obtained by driving a 2-inch-OD split-spoon (ASTM D 1586).
- **NX** NX-sized, nominal 2-inch-diameter rock core, obtained with a diamond coring bit (ASTM D 2113).
- **ST** Relatively undisturbed sample obtained by pushing a 3-inch-diameter, thin-walled, Shelby tube (ASTM D 1587).
- **CS** Relatively undisturbed sample obtained with the continuous sample tube system, using a split-barrel sampler in conjunction with auger advancement.
- **BS** Disturbed Bag Sample obtained from cuttings.

Recovery is the ratio of the length recovered to the total length driven, cored, or pushed, expressed as a percentage.

RQD (Rock Quality Designation) is the ratio of the total length of core segments more than 4 inches in length to the total length of core drilled (expressed as percentage). RQD is a general indicator of insitu rock quality as excellent for 90 to 100 percent, good for 75 to 90 percent, fair for 50 to 75 percent, poor for 25 to 50 percent, and very poor for 0 to 25 percent.

Blow Counts indicate the number of blows per 6 inches of split-spoon penetration when driven with a 140-pound hammer free falling 30 inches (ASTM D 1586). The total number of blows obtained for the second and third, 6-inch increments is the N value (Standard Penetration Test) in blows per foot. Practical refusal is considered to be 50 or more blows without achieving 6 inches of penetration, and is expressed as the ratio of 50 blows to actual penetration in inches. When obtained with an automatic hammer, the N value may be increased by a factor of 1.3 for analysis purposes.

Laboratory Test Results

- Pocket penetrometer value of apparently intact cohesive sample in kips per square foot (ksf).
- Unconfined compressive strength (ASTM D 2166) in kips per square foot (ksf).
- Dry density in pounds per cubic foot (pcf).
- Moisture content (ASTM D 2216) in percent.
- Liquid Limit and Plastic Index (ASTM D 4318) in percent.

Elevation in feet, corresponding to depth below ground surface.

BORING LOG B-1

PAGE 1 OF 1

Project: Proposed Branch Library
Project Number: 1412111
Location: New Haven, Missouri

Gateway Geotechnical, LLC

Ground Elevation: 661.9 ft +/-
Date Drilled: 12/3/2014
Drilling Contractor: Midwest Drilling, Inc.
Drilling Method: CME 550X w/4" CFA

Groundwater Levels (Depth, feet):
At Time Of Drilling: 11
At End Of Drilling: 11
Hours After Drilling:

Depth (ft)	Graphic	MATERIAL DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	Sample Number & Type	Recovery % (RQD)	Blow Counts (per 6 in)	Pocket Penetrometer (ksf)	Unconfined Compressive Strength (ksf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plastic Index	Elevation (ft)
0		FILL: Brown and yellowish brown high plastic clay, trace crushed rock, weathered rock, and organics	1 SS		2-3-3	2.5			29			660
		SILTY CLAY (CL): Brown and light brown	2 ST	71	--	3.5	3.1	99	25			
5			3 SS		2-4-10	2.0			21			655
		CLAY (CH): Brown and red, trace to some chert										
		yellowish brown and white, trace weathered rock	4 SS		3-5-6	4.0			38			
10		WEATHERED ROCK: Light yellowish brown										
		Auger refusal at 11.5 feet.	5 SS		50/1"--							650
15												645
20												

BORING LOG B-2

Project: Proposed Branch Library
Project Number: 1412111
Location: New Haven, Missouri

Gateway Geotechnical, LLC

Ground Elevation: 653.4 ft +/-
Date Drilled: 12/3/2014
Drilling Contractor: Midwest Drilling, Inc.
Drilling Method: CME 550X w/4" CFA

Groundwater Levels (Depth, feet):
At Time Of Drilling: None
At End Of Drilling: None
Hours After Drilling:

Depth (ft)	Graphic	MATERIAL DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	Sample Number & Type	Recovery % (RQD)	Blow Counts (per 6 in)	Pocket Penetrometer (ksf)	Unconfined Compressive Strength (ksf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plastic Index	Elevation (ft)
0		FILL: Brown high plastic clay, trace crushed rock and organics										
			1 SS		3-3-3	3.5			25			
												650
			2 SS		2-2-3	2.5			30			
5		SILTY CLAY (CL): Brown										
			3 SS		4-4-4	2.5			21			
		CLAY (CH): Brown and red, some chert										645
			4 SS		13-13-8				8			
10												
		WEATHERED ROCK: Yellowish brown										
		Auger refusal at 12.5 feet.	5 SS		50/1.5"--							
												640
15												
												635
20												

BORING LOG B-3

Project: Proposed Branch Library
Project Number: 1412111
Location: New Haven, Missouri

Gateway Geotechnical, LLC

Ground Elevation: 654.7 ft +/-
Date Drilled: 12/3/2014
Drilling Contractor: Midwest Drilling, Inc.
Drilling Method: CME 550X w/4" CFA

Groundwater Levels (Depth, feet):
At Time Of Drilling: None
At End Of Drilling: None
Hours After Drilling:

Depth (ft)	Graphic	MATERIAL DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	Sample Number & Type	Recovery % (RQD)	Blow Counts (per 6 in)	Pocket Penetrometer (ksf)	Unconfined Compressive Strength (ksf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plastic Index	Elevation (ft)
0		FILL: Brown high plastic clay, trace crushed rock and organics										
			1 SS		3-4-4	3			21			
		brown and light brown, trace organics										
			2 ST	92	--	3.5		95	19	52	25	
5												650
		SILTY CLAY (CL): Brown and light brown	3 SS		4-6-8	6.5			25			
		CLAY (CH): Brown, trace to some chert	4 SS		3-4-6	3.5			22			
10												645
		yellowish brown and brown										
			5 SS		3-4-50/1"	2.5			42			
15		WEATHERED ROCK: Yellowish brown										640
		Boring terminated at 15 feet.										
20												635

BORING LOG B-4

Project: Proposed Branch Library
Project Number: 1412111
Location: New Haven, Missouri

Gateway Geotechnical, LLC

Ground Elevation: 658.7 ft +/-
Date Drilled: 12/3/2014
Drilling Contractor: Midwest Drilling, Inc.
Drilling Method: CME 550X w/4" CFA

Groundwater Levels (Depth, feet):
At Time Of Drilling: None
At End Of Drilling: None
Hours After Drilling:

Depth (ft)	Graphic	MATERIAL DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	Sample Number & Type	Recovery % (RQD)	Blow Counts (per 6 in)	Pocket Penetrometer (ksf)	Unconfined Compressive Strength (ksf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plastic Index	Elevation (ft)
0		CLAY (CH): Brown and light brown, trace organics	1 SS		3-3-3	3.5			28			655
5		SILTY CLAY (CL): Brown and light brown	2 SS		3-4-5	5.5			21			
		CLAY (CH): Brown	3 SS		3-6-7	4.5			22			
		WEATHERED ROCK: Light yellowish brown	4 SS		50/3"--							650
10		Auger refusal at 10 feet.										
												645
15												
												640
20												

BORING LOG B-5

Project: Proposed Branch Library
Project Number: 1412111
Location: New Haven, Missouri

Gateway Geotechnical, LLC

Ground Elevation: 657.1 ft +/-
Date Drilled: 12/3/2014
Drilling Contractor: Midwest Drilling, Inc.
Drilling Method: CME 550X w/4" CFA

Groundwater Levels (Depth, feet):
At Time Of Drilling: None
At End Of Drilling: None
Hours After Drilling:

Depth (ft)	Graphic	MATERIAL DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	Sample Number & Type	Recovery % (RQD)	Blow Counts (per 6 in)	Pocket Penetrometer (ksf)	Unconfined Compressive Strength (ksf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plastic Index	Elevation (ft)
0		2 in. Topsoil										
		CLAY (CH): Brown, trace organics	1 SS		2-3-3	4.0			27			655
		SILTY CLAY (CL): Brown, trace organics	2 SS		3-4-6	4.0			27			
5			3 SS		3-3-5	2.5			23			650
		CLAY (CH): Red and brown, some chert	4 SS		8-4-5	3.5			24			
10		WEATHERED ROCK: Yellowish brown										
		Auger refusal at 11 feet.	5 SS		50/1.5"--							645
15												640
20												

BORING LOG B-6

Project: Proposed Branch Library
Project Number: 1412111
Location: New Haven, Missouri

Gateway Geotechnical, LLC

Ground Elevation: 654.2 ft +/-
Date Drilled: 12/3/2014
Drilling Contractor: Midwest Drilling, Inc.
Drilling Method: CME 550X w/4" CFA

Groundwater Levels (Depth, feet):
At Time Of Drilling: None
At End Of Drilling: None
Hours After Drilling:

Depth (ft)	Graphic	MATERIAL DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	Sample Number & Type	Recovery % (RQD)	Blow Counts (per 6 in)	Pocket Penetrometer (ksf)	Unconfined Compressive Strength (ksf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plastic Index	Elevation (ft)
0		FILL: Brown and light brown low plastic silty clay and high plastic clay, trace crushed rock and organics										
			1 SS		2-2-2	4.5			24			
		brown high plastic clay										
			2 SS		2-2-2	1.5			28			650
5												
		SILTY CLAY (CL): Brown and light brown	3 SS		2-2-3	2.0			23			
		CLAY (CH): Brown and light brown										
			4 SS		3-4-5	3.5			27			645
10												
		SILTY CLAY (CL): Brown										
			5 SS		3-4-5	2.5			24			640
15		Boring terminated at 15 feet.										
												635
20												

BORING LOG B-7

Project: Proposed Branch Library
Project Number: 1412111
Location: New Haven, Missouri

Gateway Geotechnical, LLC

Ground Elevation: 649.4 ft +/-
Date Drilled: 12/3/2014
Drilling Contractor: Midwest Drilling, Inc.
Drilling Method: CME 550X w/4" CFA

Groundwater Levels (Depth, feet):
At Time Of Drilling: None
At End Of Drilling: None
Hours After Drilling:

Depth (ft)	Graphic	MATERIAL DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	Sample Number & Type	Recovery % (RQD)	Blow Counts (per 6 in)	Pocket Penetrometer (ksf)	Unconfined Compressive Strength (ksf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plastic Index	Elevation (ft)
0		1 in. Topsoil										
		SILTY CLAY (CL): Brown, trace organics	1 SS		2-2-3	2.0			21			
		brown and light brown	2 SS		3-4-4	1.5			23			645
5			3 SS		3-3-5	4.5			22			
		CLAY (CH): Brown										
		brown and red	4 SS		3-4-14	5.0			28			640
10		some chert										
		decreased chert	5 SS		4-5-17	4.5			31			635
15		trace to some chert and weathered rock										
		Boring terminated at 15 feet.										630
20												

APPENDIX C

CONSTRUCTION RECOMMENDATIONS

The following recommendations are provided to address the construction requirements of this project; and are intended to allow easy adaptation to the client's standard specification format or, in the absence of other specifications, used directly to guide good construction practice.

Part I - General

Geotechnical Report for this project dated December 2014 was prepared by Gateway Geotechnical, LLC (Gateway). If conflicts arise between the Specifications and the Geotechnical Report, Gateway shall be contacted prior to construction.

Part II - Site clearing

1. **Site preparation**
   a. Prior to commencing work, provide erosion-control measures to reduce soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties or water bodies.
   b. Remove trees, shrubs, grass, and other vegetation to permit installation of new construction. Removal includes digging out root balls and grubbing roots.
   c. Remove existing above- and below-grade site improvements, and excavate and remove underground utilities to be abandoned, from the proposed building construction area and extending a distance of at least 5 feet beyond the limits of the proposed building footprint, or as otherwise necessary to facilitate the new construction.
   d. Refer to *Earthwork* specification for placement of fill material to bring excavations back to grade.

Part III – Earthwork

1. **Quality Control**
   a. Preconstruction meeting including Gateway shall be conducted at the project site, or other appropriate location, prior to the commencement of earthwork.
   b. Owner shall engage Gateway to perform field quality-control testing. Gateway will test compaction of soils in place according to ASTM D 6938 or ASTM D 2937, as applicable.
   c. Contractor shall allow Gateway to observe and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.
   d. Provide 25-pound samples, sealed in airtight containers, of each proposed fill material from on-site or off-site borrow sources for laboratory testing, at least 48 hours prior to planned earthwork. Gateway will perform sample classification according to ASTM D 2487, and provide compaction curve according to ASTM D 698 for each discreet sample.

2. Preparation

a. Overexcavate and remove any existing fill that may be encountered within the proposed building areas. The bottom of the excavations should extend beyond the building footprints a distance equal to the depth of existing fill removed.

b. In the parking areas and following excavation of existing fill in the building area, proofroll subgrade with heavy pneumatic-tired or other equipment approved by Gateway to identify soft pockets and areas of excess yielding. Soft areas or otherwise unacceptable materials, if encountered, should be removed and replaced with structural fill or stabilized prior to placing additional fill. Do not proofroll wet or saturated subgrades.

c. Bench steeper than 4 horizontal to 1 vertical sloped surfaces to bond newly placed fill with existing surface.

d. Scarify upper 8 to 10 inches of existing subgrade and recompact to at least 90 percent of its standard Proctor maximum dry density according to ASTM D 698.

e. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Gateway.

3. Fill

a. Fill placed under structures, building slabs, pavements, retaining walls, slopes steeper than 4 horizontal to 1 vertical, walkways, and stairs is considered to be structural fill.

b. Fill materials placed in the proposed building areas shall have a liquid limit less than 45 and a plasticity index less than 25. Acceptable non-organic fill soils include materials designated CL, ML, CL-ML, SP, SW, GP, and GW by ASTM D 2487; free of rock or gravel larger than 6 inches in any dimension, debris, waste, frozen materials, vegetation, or other deleterious matter.

c. Materials designated CH by ASTM D 2487, and otherwise meeting the requirements for acceptable fill materials indicated above, may be used as structural fill outside of building area or deeper than 2 feet and 3 feet below the base of the footings and floor slab, respectively.

d. Existing fill may be re-used in structural fill provided unsuitable materials are segregated and removed. Unsuitable materials should be disposed of legally and off site.

e. Uniformly moisten or aerate subgrade and each subsequent fill layer before compaction to within approximately -2 to +4 percent of its optimum moisture content.

f. Place and compact fill material in maximum 8-inch-thick loose layers for material compacted by heavy compaction equipment, and not more than 4 to 6 inches for material compacted by hand-operated equipment. Place and compact material to required elevations.

g. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice. These materials require removal prior to additional fill placement.

4. Compaction

a. Compact all cohesive structural fill materials to at least 95 percent of their standard Proctor maximum dry density according to ASTM D 698. Aggregate materials shall be compacted to a minimum of 100 percent of the same criterion.

b. Compact fill materials placed in landscaped areas to at least 90 percent of their standard Proctor maximum dry density according to ASTM D 698.

c. When Gateway reports that subgrades, fills, or backfills have not achieved the degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required, and recompact until specified compaction is obtained, as verified by Gateway's testing.
d. For granular material, when required thickness is 8 inches or less, place materials in a single layer. When thickness exceeds 8 inches, place materials in equal layers, with no layer more than 6 inches thick or less than 3 inches thick when compacted.

5. Grading

a. Slope grades to direct surface runoff water away from the building and to prevent ponding.

Part IV - Shallow foundations, slab-on-grade, and pavements.

1. Notify Gateway when excavations have reached required subgrade. If unsatisfactory soil is present, continue excavation and replace with structural fill, as required by Gateway.
2. Do not disturb bottom of excavations for footings and floor slab. Excavate to final grade just before placing steel reinforcement and concrete.
3. Excavations should be clean and free of loose soil or uncompacted fill; and the bearing soils maintained as near as possible to their natural, undisturbed, moisture content.
4. Prevent surface water and groundwater from entering excavations and softening subgrades, from ponding on prepared subgrades, and from flooding project site and surrounding area.
5. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.
6. Repair and re-establish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions. Scarify or remove and replace soil material to depths as directed by Gateway, reshape, and recompact.

Part V – Excavation bracing

1. Excavations

a. Excavations including utility trenches, basements, footings, and others should be excavated in accordance with the OSHA *Construction Standards for Excavations, 29 CFR, Part 1926, Subpart P*.
b. Excavations must be made under the supervision of qualified site personnel in accordance with the above referenced OSHA regulations.

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