SUBSURFACE EXPLORATION AND GEOTECHNICAL REPORT NORTH ELM PLACE EXTENSION TO EAST 51ST STREET BROKEN ARROW, OKLAHOMA

December 28, 2005
Project No. 64122

KLEINFELDER 10926 E. 55th Place, Tulsa, OK 74146 (918) 627-6161 (918) 627-6262 fax

KLEINFELDER
An employee owned company

December 28, 2005

Garver Engineering
Attn: Ms. Shannon N. Hanks, P.E.
10015 East 51st Street
Tulsa, OK 74146

Subject: **Subsurface Exploration and Geotechnical Report**
North Elm Place Extension to E 51st Street
Broken Arrow, Oklahoma
Project No.: 64122

Dear Ms. Hanks:

Kleinfelder has completed the authorized subsurface exploration and geotechnical engineering evaluation for the above-referenced project in general accordance with our proposal (Proposal No. TUD05303) dated November 30, 2005. The fieldwork was completed on December 7, 2005. The purpose of the geotechnical study was to explore and evaluate the subsurface conditions at various locations within the roadway, and to provide specific pavement subgrade preparation recommendations and alternate pavement sections. The attached Kleinfelder report contains a description of the findings of our field exploration and laboratory testing program, our engineering interpretation of the results with respect to the project characteristics, and our design recommendations as well as construction guidelines for the planned project.

Recommendations provided herein are contingent on the provisions outlined in ADDITIONAL SERVICES and LIMITATIONS sections of this report. The project Owner should become familiar with these provisions in order to assess further involvement by Kleinfelder and other potential impacts to the proposed project.

We appreciate the opportunity to be of service to you on this project and are prepared to provide the recommended additional services. Please call us if you have any questions concerning this report.

Sincerely,
KLEINFELDER
Certificate of Authorization #3036, Expires 6/30/06

Dale L. Kelley II for

Scott A. Randle, P.E. (Kansas)
Geotechnical Engineer

Brian K. Marick, P.E.
Oklahoma: 21240

REGISTERED PROFESSIONAL ENGINEER
BRIAN K. MARICK
21240
12/29/05
OKLAHOMA

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Attachments:

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SUBSURFACE EXPLORATION AND GEOTECHNICAL REPORT NORTH ELM PLACE EXTENSION TO EAST 51ST STREET BROKEN ARROW, OKLAHOMA

1. INTRODUCTION

1.1 GENERAL

Kleinfelder has completed the authorized subsurface exploration and geotechnical engineering evaluation for the North Elm Place extension to East 51st Street South in Broken Arrow, Oklahoma. The services provided were in general accordance with our proposal (No. TUD05303) dated November 30, 2005.

This report includes our recommendations related to the geotechnical aspects of the project design and construction. Conclusions and recommendations presented in the report are based on the subsurface information encountered at the location of our exploration and the provision and requirements outlined in the ADDITIONAL SERVICES and LIMITATIONS sections of this report. In addition, an article prepared by The Association of Engineering Firms Practicing in the Geosciences (ASFE), *Important Information About Your Geotechnical Engineering Report*, has been included in APPENDIX C. We recommend that all individuals read the report limitations along with the included ASFE document.

1.2 PROPOSED CONSTRUCTION

We understand that North Elm Street will be extended north to East 51st Street South for approximately 2/3 of a mile. The project extends from Station 10+00 to Station 43+74 as indicated on drawings provided by the client. Cuts ranging from less than 5 feet to in excess of 30 feet and fills ranging from less than 5 feet to approximately 20 feet will be required to achieve design grades. The conceptual plans provided to us indicate preliminary cut slopes of 3 horizontal (H) to 1 vertical (V), and fill slopes of 4(H) to 1(V). Pavement thickness recommendations will be based upon the City of Broken Arrow standards.

The scope of the exploration and engineering evaluation for this study, as well as the conclusions and recommendations in this report, were based on our understanding of the project as described above. If pertinent details of the project have changed or otherwise differ from our descriptions, we must be notified and engaged to review the changes and modify our recommendations, if needed.

1.3 PURPOSE AND SCOPE OF SERVICES

The primary purposes of this geotechnical study were to explore and evaluate the subsurface conditions along the roadway, and based on this information, to develop recommendations relating to the geotechnical aspects of the project design and construction. The scope of services to achieve these purposes was outlined in our proposal and included the following:

- Reviewing available soil and geologic information.
- Drilling and logging eleven borings to explore the subsurface conditions at the site and to obtain samples for laboratory testing.
- Performing field and laboratory tests on select samples to evaluate the geotechnical engineering properties of the materials.
- Reviewing and analyzing field and laboratory data to assess subsurface conditions and to develop geotechnical engineering recommendations.
- Preparing an engineering report summarizing our findings and recommendations.

2. SITE CONDITIONS

2.1 SITE DESCRIPTION

The project site is a proposed extension of North Elm Place north to East 51st Street South in Broken Arrow, Oklahoma. The proposed project will have an overall length of approximately 2/3 of a mile. The approximate site location is indicated on Figure 1, included in APPENDIX A. The first 1,250 feet (Station 10+00 to Station 22+50) of the extension is through a hill with a drainage feature on the north side. The elevation differential between the crest of the hill and the bottom of the drainage in this portion of the proposed roadway is about 60 feet. The remaining portion of the roadway (Station 22+50 to Station 43+74.94) is undulating with an elevation differential of about 20 feet. Total elevation differential across the proposed roadway alignment is about 90 feet. Trees are located throughout the proposed roadway alignment.

2.2 SUBSURFACE CONDITIONS

Kleinfelder explored the subsurface conditions at the site by drilling and sampling 11 borings on December 6, 7, and 9, 2005. The field exploration and laboratory testing programs are presented in APPENDIX A and APPENDIX B of this report.

The following presents a general summary of the major strata encountered during our subsurface exploration and includes a discussion of the results of field and laboratory tests conducted. Specific subsurface conditions encountered at the boring locations are presented on the respective boring logs in APPENDIX A. The stratification lines shown on the logs represent the approximate boundaries between material types; in-situ, the transitions may vary or be gradual.

A 2 to 5-inch thick layer of topsoil was encountered at the ground surface in all of the borings except Borings R-01 and R-04. Existing fill material was encountered at the ground surface in Boring R-01 and continued to the bottom of the boring at an approximate depth of 8.0 feet.

The existing fill consisted of clayey sand, lean clay, and sandy clay with varying amounts of sandstone and shale fragments, and was red, brown, yellow, and gray in color.

Lean clay, lean to fat clay, and fat clay soils were encountered below topsoil in all the borings except Borings R-01, R-02, R-04, R-10, and R-11. The clay soils continued to depths ranging from 4.2 to 10 feet. The clay soils were brown to dark brown, mottled red, brown, yellow, and gray in color and exhibited stiff to very stiff consistencies.

Weathered shale bedrock was encountered below the clay soils in Borings R-07 through R-09, and continued to the bottom of the borings at an approximate depth of 10 feet. The weathered shale bedrock rock was very soft to soft, and was various combinations of brown, tan, olive, and gray in color.

Borings R-02, R-03, R-10, and R-11 were drilled within cut areas. The borings encountered weathered limestone, interbedded weathered limestone and shale, and weathered shale below the surfical soils. The weathered bedrock material continued to depths ranging from 2.8 to 10.2 feet below the ground surface. The weathered limestone was moderately hard to hard and was generally tan, brown and gray in color. The weathered bedrock was underlain by unweathered bedrock consisting of limestone and shale. The limestone bedrock continued to depths ranging from 10.7 to 13.1 feet below the ground surface. The limestone bedrock was hard and generally gray in color.

Sandy shale bedrock was encountered below the limestone bedrock at depths ranging from 10.2 to 13.1 feet. The sandy shale contained sandstone stringers/seams, was hard, and gray in color. Borings R-02, R-03, R-10, and R-11 were terminated in the sandy shale bedrock at depths ranging from 20 to 35 feet below the ground surface.

Atterberg limits tests performed on selected samples indicated liquid limit (LL) values ranging from 40 to 78, plastic limit (PL) values ranging from 20 to 27, and plasticity index (PI) values ranging from 19 to 51. The moisture content of the samples ranged from approximately 4 to 25 percent.

2.3 GROUNDWATER OBSERVATIONS

Groundwater observations were made both during and after completion of drilling operations. The borings remained dry and no groundwater seepage was observed. The materials encountered in the test borings have low to moderate permeabilities and observations over an extended period of time through use of piezometers or cased borings would be required to better define groundwater conditions.

Fluctuations of groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 GENERAL

Based on the results of our evaluation, it is our professional opinion that the proposed project site can be developed for the proposed roadway using conventional grading techniques. The primary geotechnical concerns for this project are the variable material types encountered at/or near the pavement subgrade elevations. Recommendations addressing the primary geotechnical concerns, as well as, general recommendations regarding geotechnical aspects of the project design and construction are presented below.

The soils encountered at the proposed pavement subgrade have variable plasticities. Due to the wide variation of the Plasticity Index (PI) values of the soils encountered at the site and the City of Broken Arrow requirements to reduce the PI of the subgrade soils to less than 10, we recommend that the subgrade soils be modified with hydrated lime.

The recommendations submitted herein are based, in part, upon data obtained from our subsurface exploration. The nature and extent of subsurface variations that may exist at the proposed project site will not become evident until construction. If variations appear evident, then the recommendations presented in this report should be evaluated. In the event that any changes in the nature, design, or location of the proposed project are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed and our recommendations modified in writing.

3.2 SITE DEVELOPMENT

3.2.1 Stripping and Tree Removal

Any topsoil within the proposed roadway alignment should be stripped. A minimum stripping depth of approximately 2 to 5 inches should be anticipated. Stripping depths required will likely vary and should be adjusted to remove all vegetation and root systems. More extensive stripping and undercutting may be required throughout the alignment. A representative of Kleinfelder should monitor the stripping operations to observe that all unsuitable materials have been removed. Soils removed during site stripping operations could be used for final site grading outside the proposed pavement areas. Care should be exercised to separate these materials to avoid incorporation of the organic matter in structural fill sections.

Tree removal should also be accomplished at this time. Care should be taken to thoroughly remove all root systems from the construction areas. Materials disturbed during removal of stumps should be undercut and replaced with structural fill. A zone of desiccated soils may exist in the vicinity of the trees. The desiccated soils have a higher swell potential and should also be undercut and replaced with structural fill.

3.2.2 Utility Trench Backfill Evaluation

Initial site preparation should also include an evaluation of the existing utility trench backfill within proposed construction areas. The number and depth of lines and the lateral extent of the backfill is currently unknown. If the lines are to be left in place, thorough evaluation of the backfill will be required. Evaluation should consist of excavating test pits into the fill to determine the condition and composition of this material. If unsuitable material is encountered, it should be undercut and replaced with controlled structural fill. Excavations created by removal of the existing lines or unsuitable trench backfill should be cut wide enough to allow for the use of heavy construction equipment to recompact the fill. In addition, the base of the excavations should be thoroughly evaluated by a geotechnical engineer or engineering technician prior to placement of fill. All fill should be placed in accordance with the recommendations presented in the STRUCTURAL FILL section of this report.

3.2.3 Moisture Conditioning, Compaction, and Undercutting,

Following stripping, evaluation of utility backfill, and tree removal, the moisture content of the exposed soils should be evaluated in all areas where fill is required. Depending on the in-situ moisture content of the exposed soils, moisture conditioning of the exposed grade may be required. The moisture content of the exposed grade in the fill areas should be adjusted to within the range recommended for structural fill and the material should be compacted to a minimum of 95 percent of the material's maximum dry density, as determined by the standard Proctor compaction procedure. Extremely wet or unstable areas that hamper compaction of the subgrade may require undercutting and replacement with structural fill or other stabilization techniques. Extensive undercutting may be required in the area of the drainage feature located near Station 16+00.

It is anticipated that intact shale may be encountered at proposed pavement subgrade within some cut areas of this site. Where highly weathered to weathered shale is encountered at pavement subgrade elevation in cut areas, the subgrade should be scarified to a depth of 8 inches. Support of pavements directly on relatively unweathered, shale bedrock is not recommended. Where the less weathered bedrock is encountered, the subgrade should be undercut to a minimum depth of 8 inches and brought up to grade with controlled structural fill in accordance with the recommendations presented in this report.

3.2.4 Proofrolling

Following any required moisture conditioning and prior to placement of structural fill, it is recommended that the exposed grade be proofrolled. Proofrolling of the subgrade aids in identifying soft or disturbed areas. Unsuitable areas identified by the proofrolling operation should be undercut and replaced with structural fill. Proofrolling can be accomplished through use of a fully loaded, tandem-axle dump truck or similar equipment providing an equivalent subgrade loading. If extensive soft or unstable conditions are encountered during proofrolling operations, replacement of the materials or other stabilization methods are recommended.

3.3 CLIMATIC CONDITIONS

Weather conditions will influence the site preparation required. In spring and late fall, following periods of rainfall, the moisture content of the near surface soils may be significantly above the optimum moisture content. The surficial materials generally appeared to have higher permeabilities than the underlying lean to fat and fat clay soils and could allow significant infiltration of surface water. The underlying fat clay would impede the downward percolation of the water that would result in the surficial materials being in a saturated, unstable condition. Perched ground water may also develop above dense cemented soils or impervious bedrock units (such as shale) saturating near surface materials. These conditions could seriously impede grading by causing an unstable subgrade condition. Typical remedial measures include aerating the wet subgrade, removal of the wet materials and replacing them with dry materials, or treating the material with lime or fly ash.

If site grading commences during summer months, moisture contents may be low and lean to fat and fat clay soils could have a high swell potential. Typically discing and moisture conditioning of the subgrade materials to the moisture content criteria outlined in the STRUCTURAL FILL section will reduce this swell potential of the dry materials. As an alternative, the dry materials could be undercut and replaced with low plasticity structural fill.

3.4 TEMPORARY EXCAVATIONS

3.4.1 General

It is anticipated that excavations for the proposed pavement and utilities will be in natural soils, existing fill, shale, limestone, or controlled structural fill. Although not anticipated, temporary dewatering techniques should be sufficient to remove any water seepage that may be encountered in the excavations.

3.4.2 Excavations and Slopes

Excavations should be cut to a stable slope or be temporarily braced, depending on the excavation depths and the subsurface conditions encountered. ***Temporary construction slopes should be designed in strict compliance with the most recent governing regulations.*** Construction slopes should be closely observed for signs of mass movement: tension cracks at the crest, bulging at the toe, etc. If potential stability problems are observed, a geotechnical engineer should be contacted immediately. ***The responsibility for excavation safety and stability of temporary construction slopes lie solely with the contractor.***

3.4.3 Construction Considerations

Stockpiles should be placed well away from the edge of the excavation and their height should be controlled so they do not surcharge the sides of the excavation. Surface drainage should be carefully controlled to prevent flow of water into the excavations.

3.5 STRUCTURAL FILL

3.5.1 Materials

All structural fill required to achieve design grades should consist of approved materials, free of organic matter and debris. All fill placed within 8 inches of the pavement subgrade should consist of a lower plasticity, lean clay, clayey sand, or a sandy lean clay type of soil with a Plasticity Index less than 10 percent, as determined by the Atterberg Limits test ASTM D 4318, wet preparation procedure. The onsite soils or similar imported materials could be utilized within the upper 8 inches of the pavement subgrade as structural fill in the pavement areas provided they are modified with lime prior to construction of the pavements. Higher PI soils could be utilized for fill placed 8 inches or more below finish subgrade level.

Broken shale and limestone excavated during mass grading along the roadway alignment will likely be suitable fill material for construction of the roadway. If used as fill within the upper 24 inches of final grade, the rock fragment size should be limited to a maximum size of 3 inches in any dimension to limit the occurrence of voids within the fill material caused by nesting of the rock fragments. Additional testing at the time of construction would be required to determine the suitability of these materials for reuse as structural fill.

Consideration could be given to the use of broken limestone within the lower portion of deep fill sections (24 inches or more below final subgrade) of the pavement areas. Use of this material within the slopes is not recommended. Limestone fragments should be less than 2 feet in maximum overall dimension. The rock fill should contain a sufficient amount of clay and smaller aggregate sizes to fill voids between fragments. The fill should be placed in a manner that will allow compaction of clay around and between the limestone fragments. Normally, multiple passes of heavy, construction equipment, such as a D-8 tracked bulldozer, or equivalent, provides adequate compaction of mixed rock and soil fills. Placement and compaction should be closely monitored by an experienced engineering technician, since normal compaction control testing is not possible with rock fills. Incorporation of broken limestone in structural fill sections should not be considered in areas where utility trenches are to be excavated.

3.5.2 Compaction Criteria

Fill should be placed in lifts having a maximum loose lift thickness of 9 inches. All fill should be compacted to a minimum of 95 percent of the material's maximum dry density as determined by ASTM D 698 (standard Proctor compaction). The moisture content of any fill materials at time of compaction should be within a range of 2 percent below to 2 percent above the optimum moisture content. Moisture contents should be maintained within these ranges until the paving operations are completed.

3.5.3 Construction Considerations

Compaction of soil fill on any bedrock exposed in the undercut areas will require the use of rubber tread equipment to achieve proper compaction. The use of pad foot or sheep's foot type of compaction equipment in depressions in the rock surface is not recommended as the compactors will span between high points on the rock surface. Where fill is placed on the rock surface, it is recommended that the loose lift thickness be limited to 6 inches and that the initial lifts be compacted by tracking with loaded scrapers or dump trucks.

3.6 PERMANENT SLOPES

3.6.1 General

Permanent cut or fill slopes in soil and weathered shale should be no steeper than 3(H) to 1(V) to maintain long-term stability and to provide ease of maintenance. Steeper slopes in soil and weathered shale are susceptible to erosion, will be difficult to maintain, and could experience problems with instability. Where limestone bedrock is encountered in the excavations, cut slopes can be increased to vertical or near vertical. Where weathered limestone is encountered, cut slopes can be increased to vertical or near vertical. However; a bench equivalent to the height of the weathered limestone should be provided at the base of the weathered limestone (or limestone if continuous) to provide an area to catch spalling limestone. Where shale is encountered in the excavations, cut or fill slopes may be increased to 1(H) to 1(V). The crest or toe of cut or fill slopes should be no closer than 10 feet from any foundation and no closer than 5 feet from the edge of any pavement.

3.6.2 Erosion Control

It is recommended that permanent slopes be vegetated, as soon as practical, in order to minimize the potential for erosion.

3.7 PAVEMENTS

3.7.1 General

Based on the types of soils encountered within the borings and previous experience with CBR testing on similar soils, we have assumed a California Bearing Ratio (CBR) of 3. Based on this CBR value, an effective design Resilient Modulus (M_R) of 3,600 pounds per square inch (psi) was used for the flexible pavement design.

We understand that the roadway will be designed in accordance with the "Land Subdivision Code" of the City of Broken Arrow (1998). We anticipate that the roadway will be designated as a collector street and should have a minimum Structural Number of 4.4. If the roadway is to be designed as an arterial roadway, we should be provided the anticipated traffic.

3.7.2 Pavement Subgrade Preparation

Pavement subgrades should be prepared in accordance with the recommendations presented in the SITE DEVELOPMENT and STRUCTURAL FILL sections of this report. The City of Broken Arrow specifications require that all pavement subgrade materials with a Plasticity Index (PI) greater than 10 be modified with an appropriate material to reduce the PI to less than 10. Based on the laboratory test results on the samples collected at the site, modification of the upper 8 inches of the pavement subgrade with hydrated lime will be required. A hydrated lime content of 5 to 7 percent on a dry weight basis is generally sufficient to achieve the desired reduction in PI. Laboratory tests will be necessary to determine the actual amount required. The lime should be placed, mixed, and compacted in accordance with ODOT "Standard Specifications for Highway Construction, Section 307." Specifications for lime modification should be included in the project specifications.

Unstable areas encountered within the pavement subgrade following lime modification should be undercut and replaced with low plasticity structural fill (PI less than or equal to 10) or could be stabilized with Class "C" fly ash. Class "C" fly ash contents of 12 to 14 percent on a dry weight basis are generally sufficient to achieve the desired stabilization. Laboratory tests will be necessary to determine the actual amount required to determine the optimum moisture content to achieve maximum potential strength. In addition to reducing the swell potential of the soils, Class "C" fly ash stabilization of the subgrade will provide a more stable subgrade, less subject to disturbance during construction. Class "C" fly ash should be placed, mixed, and compacted in accordance with ODOT "Standard Specifications for Highway Construction, Section 317." Specifications for Class "C" fly ash stabilization should be included in the project specifications.

Construction scheduling typically involves paving and grading by separate contractors and can often involve a time lapse between the end of grading operations and commencement of paving. Disturbance, desiccation, and/or wetting of the subgrade between grading and paving can result in deterioration of the previously completed subgrade. A non-uniform subgrade can result in poor pavement performance and local failures relatively soon after pavements are constructed. We recommend that the pavement subgrades be proofrolled and the moisture content and density of the top 8 inches of subgrade be checked within two days prior to commencement of actual paving operations. Proofrolling should be accomplished with multiple passes of a fully loaded, tandem-axle dump truck or similar equipment providing an equivalent subgrade loading. If any significant event, such as precipitation, occurs after proofrolling, the subgrade should be reviewed by qualified geotechnical engineering personnel immediately prior to placing the pavement. The subgrade should be in its finished form at the time of the final review.

3.7.3 Recommended Pavement Sections

The pavement sections recommended for this project are presented in Table 1.

Table 1: Recommended Pavement Sections

Road Classification	Minimum Asphaltic Concrete (AC) Design Thickness, inches	Minimum Portland Cement Concrete (PCC) Design Thickness, inches
Collector	2.0 AC Surface Course[1] 6.0 AC Base Course[2] 6.0 Aggregate Base[3] 8.0 Lime Modified Subgrade[4]	8.0 PCC 4.0 Clean Gravel 8.0 Recompacted Base

1 ODOT "Standard Specifications for Highway Construction" Section 708, Type B
2 ODOT "Standard Specifications for Highway Construction" Section 708, Type A
3 ODOT "Standard Specifications for Highway Construction" Section 703.01, Type A
4 ODOT "Standard Specifications for Highway Construction" Section 307

As previously stated, the pavement sections recommended for this project are based on the previously presented design parameters. If the City of Broken Arrow has different design parameters that they would like utilized for the design, we should be provided this information to determine if a modification of our recommendations would be warranted.

All pavements should be sloped approximately 1/4 inch per foot to provide rapid surface drainage. Water allowed to pond on or adjacent to the pavement could saturate the subgrade and cause premature pavement deterioration. The edges of the pavement sections should be protected by the use of curbs and gutters or thickened edge pavement sections.

3.7.4 Pavement Construction Considerations

Proper drainage below the pavement section helps prevent softening of the subgrade and has a significant impact on pavement performance and pavement life of all pavement types. Therefore, we recommend that a granular blanket drain be constructed at all storm sewer inlets within the pavement areas. The blanket drain should consist of clean, crushed stone aggregate extending a minimum of 6 inches below pavement subgrade level. The blanket drains should extend a minimum of 15 feet away from the curb at all storm sewer inlets, and should be a minimum of 15 feet wide. The grade within the blanket drain should be sloped toward the storm sewer inlet, and weep holes should be drilled through the inlet to provide drainage of the granular section into the inlet. Placement of geotextile filter fabric across the weep holes could be considered to prevent loss of soil through the weep holes.

Construction traffic on the pavements has not been considered in the design. If construction scheduling dictates the pavements will be subject to traffic by construction equipment/vehicles, the designs should be reconsidered to include the effects of the additional traffic loading.

4. ADDITIONAL SERVICES

4.1 PLANS AND SPECIFICATIONS REVIEW

We recommend that Kleinfelder conduct a general review of the final plans and specifications to evaluate that our earthwork and foundation recommendations have been properly interpreted and implemented during design. In the event Kleinfelder is not retained to perform this recommended review, we will assume no responsibility for misinterpretation of our recommendations.

4.2 CONSTRUCTION OBSERVATION AND TESTING

We recommend that all earthwork during construction be monitored by a representative from Kleinfelder. The field observations should include site preparation, placement of all engineered fill, and construction of the roadway subgrades. The purpose of these services would be to provide Kleinfelder the opportunity to observe the soil conditions encountered during construction, evaluate the applicability of the recommendations presented in this report to the soil conditions encountered, and recommend appropriate changes in design or construction procedures if conditions differ from those described herein.

The following section outlines geotechnical engineering and construction testing services necessary to implement the recommendations presented in this report. To effectively achieve the intent of these recommendations and maintain continuity from design through construction, Kleinfelder should be retained to provide these services:

1. An experienced engineering technician should observe the subgrade throughout the proposed construction area immediately following stripping and/or undercutting to identify areas requiring additional undercutting and to evaluate the suitability of the exposed surface for fill placement.

2. An experienced engineering technician should evaluate the moisture condition of the pavement subgrade throughout the proposed construction area to determine if moisture conditioning of the subgrade would be required.

3. An experienced engineering technician should observe the moisture conditioning and proofrolling of the subgrade prior to placement of structural fill to evaluate the suitability of the exposed surface for fill placement.

4. An experienced engineering technician should monitor and test all fill placed within the pavement areas to determine whether the type of material, moisture content and degree of compaction are within recommended limits.

5. The condition of the subgrade in all pavement areas should be evaluated immediately prior to commencing paving operations. Proofrolling would aid in evaluation of the subgrade.

6. Mixing operations for the lime modified or fly ash stabilization of the subgrade should be closely monitored to determine whether mixing procedures are providing uniform distribution and thorough blending of the stabilizing agent.

5. LIMITATIONS

Recommendations contained in this report are based on our field observations and subsurface explorations, limited laboratory tests, and our present knowledge of the proposed construction. It is possible that soil conditions could vary between or beyond the points explored. If soil conditions are encountered during construction that differ from those described herein, we should be notified immediately in order that a review may be made and any supplemental recommendations provided. If the scope of the proposed construction, including the proposed loads or structural locations, changes from that described in this report, our recommendations should also be reviewed.

We have prepared this report in substantial accordance with the generally accepted geotechnical engineering practice as it exists in the site area at the time of our study. No warranty is expressed or implied. The recommendations provided in this report are based on the assumption that an adequate program of tests and observations will be conducted by Kleinfelder during the construction phase in order to evaluate compliance with our recommendations. The scope of our services did not include any environmental assessment or exploration for the presence of hazardous or toxic materials in the soil, surface water, groundwater or air, on, below or around this site.

This report may be used only by the client and only for the purposes stated, within a reasonable time from its issuance, but in no event later than three years from the date of report. Land use, site conditions (both on-site and off-site), regulations, or other factors may change over time, and additional work may be required with the passage of time. Any party other than the client who wishes to use this report shall notify Kleinfelder of such intended use. Based on the intended use of the report, Kleinfelder may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else will release Kleinfelder from any liability resulting from the use of this report by any unauthorized party and client agrees to defend, indemnify and hold harmless Kleinfelder from any claim or liability associated with such unauthorized or non-compliance.

APPENDIX A

FIELD EXPLORATION PROGRAM

KLEINFELDER 10926 E. 55th Place, Tulsa, OK 74146 (918) 627-6161 (918) 627-6262 fax

APPENDIX A
FIELD EXPLORATION PROGRAM

DRILLING & SAMPLING PROCEDURES

Kleinfelder conducted the fieldwork for this study on December 6, 7, and 9, 2005. The exploration consisted of a total of 11 borings. Borings ranged in depth from 7.5 to 35 feet below the existing ground surface.

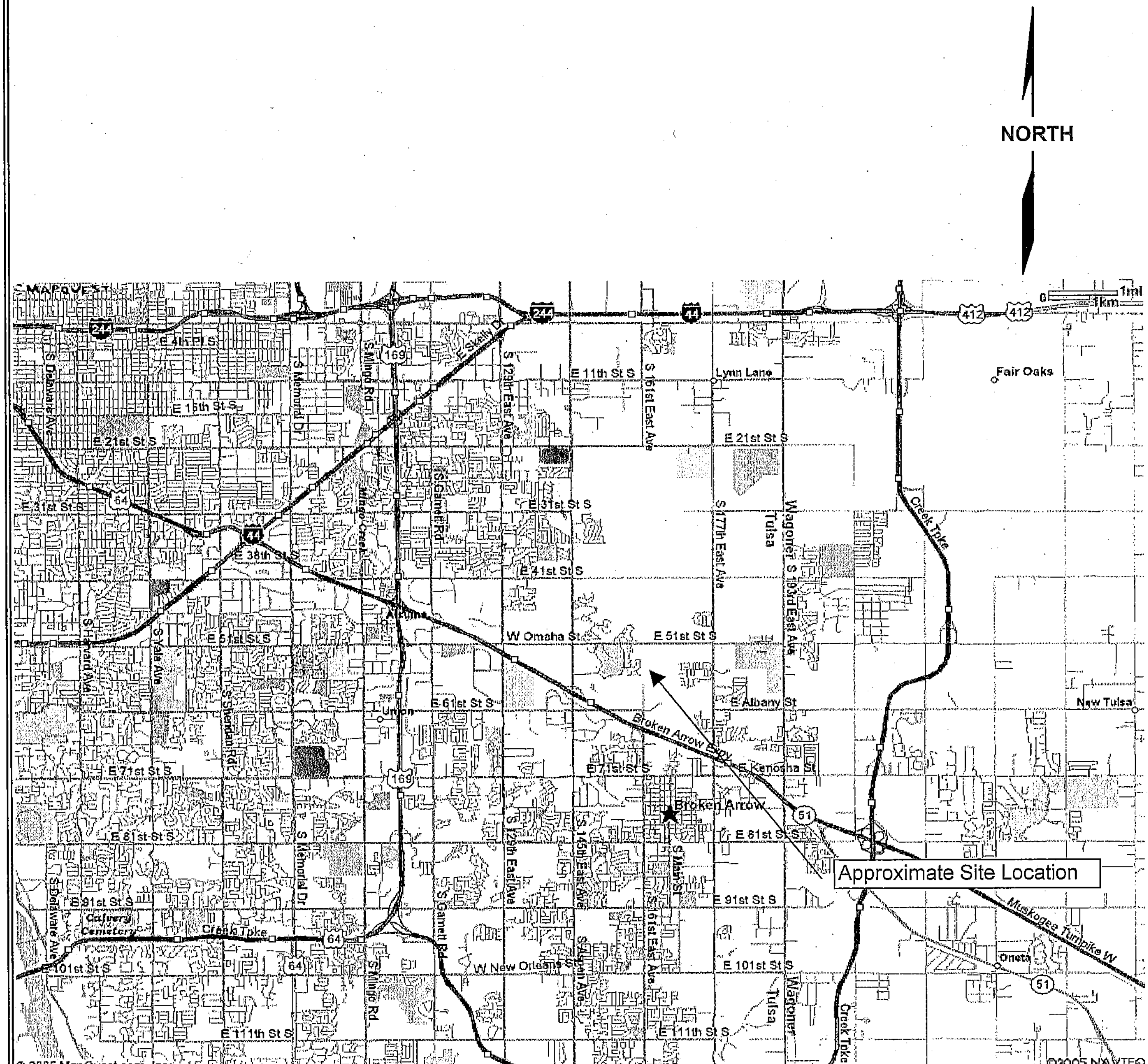
Representatives of Garver Engineers established the boring locations in the field. With the exception of Boring R-08, the borings were drilled within 15 feet of the staked locations. Boring R-08 was offset approximately 300 feet east of staked location due to dense tree growth.

Approximate Boring Locations and Elevations		
Boring Number	Station (approximate)	Offset
R-1	10 + 50	
R-2	11 + 80	
R-3	13 + 00	
R-4	19 + 50	
R-5	23 + 50	40 Feet Lt
R-6	28 + 50	
R-7	33 + 00	
R-8	39 + 00	300 Feet Rt
R-9	43 + 00	
R-10	12 + 00	80 Feet Rt
R-11	41 + 00	90 Feet Rt

The borings were drilled with a truck-mounted CME 55 rotary drill rig using solid stem augers to advance the boreholes. Samples of the subsurface materials were obtained by performing a standard penetration test (SPT) using a 2-inch O.D. split-barrel sampler. A CME automatic SPT hammer was used to advance the split-barrel sampler. The SPT and split-barrel sampling were conducted in general accordance with ASTM D1586 (ASTM D 1586, *Standard*

Test Method for Penetration and Split-Barrel Sampling of Soils). The split-barrel sampler is driven into the bottom of the boring over an 18-inch sampling interval by a 140-pound hammer that is dropped a distance of 30 inches. The SPT N-value, recorded on the boring logs, is the number of blows required to drive the split-barrel sampler the final 12 inches of the 18-inch sampling interval. The samples were sealed and returned to our laboratory for further examination, classification and testing.

Boring logs included in this APPENDIX, present such data as soil and bedrock descriptions, depths, sampling intervals and observed groundwater conditions. Conditions encountered in each of the borings were monitored and recorded by the drill crew. Field logs included visual classification of the materials encountered during drilling, as well as drilling characteristics. Our final boring logs represent the engineer's interpretation of the field logs combined with laboratory observation and testing of the samples. Stratification boundaries indicated on the boring logs were based on observations during our fieldwork, an extrapolation of information obtained by examining samples from the borings and comparisons of soils with similar engineering characteristics. Locations of these boundaries are approximate, and the transitions between material types may be gradual rather than clearly defined.

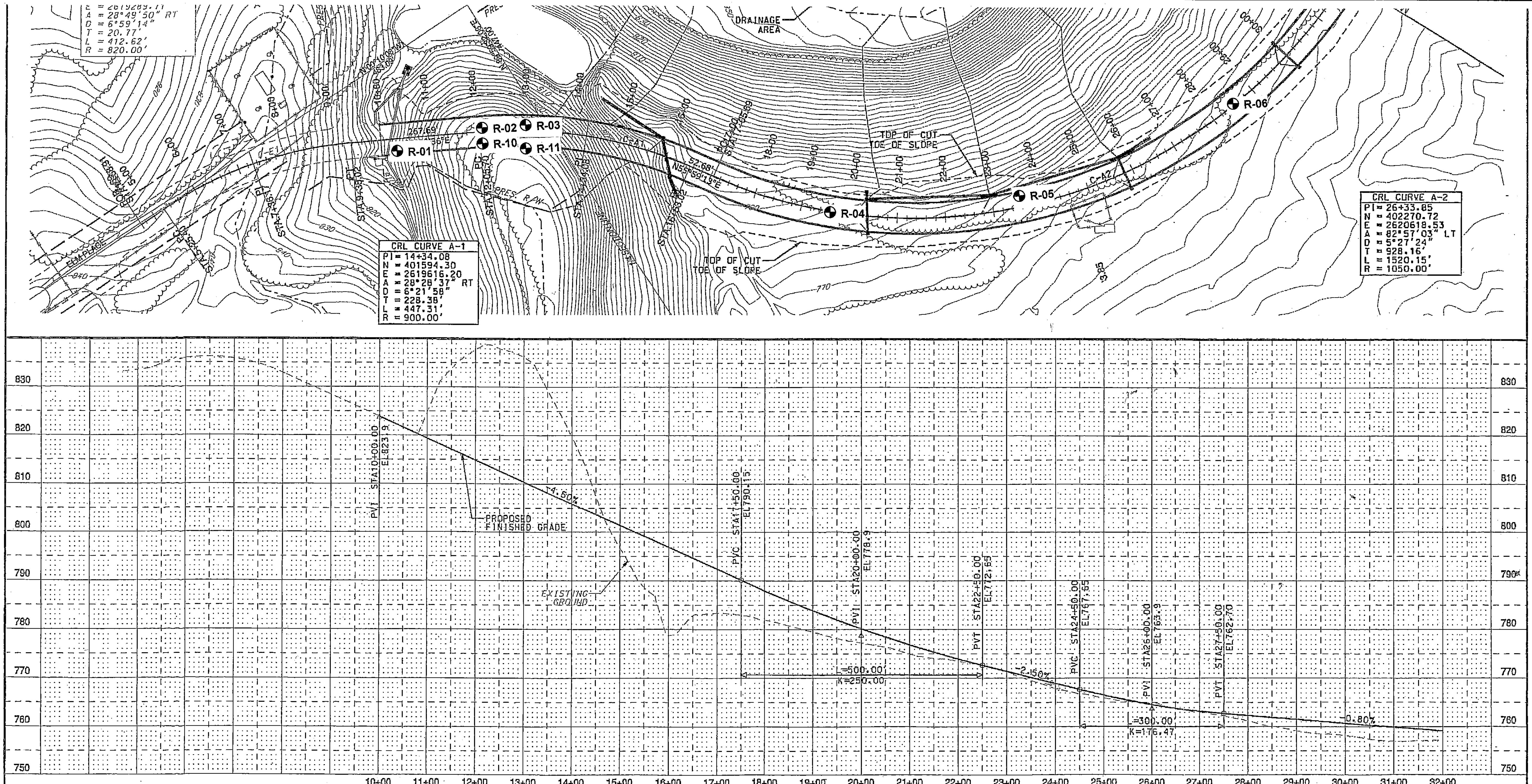


Site Location Diagram | **Not to Scale** | **Figure 1**

North Elm Place Extension
North Elm Place & E. 51st St. S.
Broken Arrow, Oklahoma

KLEINFELDER

Approved By: BKM	**Project No. 64122**



DATE	REVISIONS

CITY OF BROKEN ARROW, OKLAHOMA
ENGINEERING SERVICES

GARVER | ENGINEERS
10016 EAST 51 ST STREET
TULSA, OKLAHOMA 74148
(918) 250-5922 VOICE (918) 250-6529 FAX

ELM PLACE EXTENSION
PLAN & PROFILE

SCALE:
HORZ. 1" = 100'
VERT. 1" = 10'

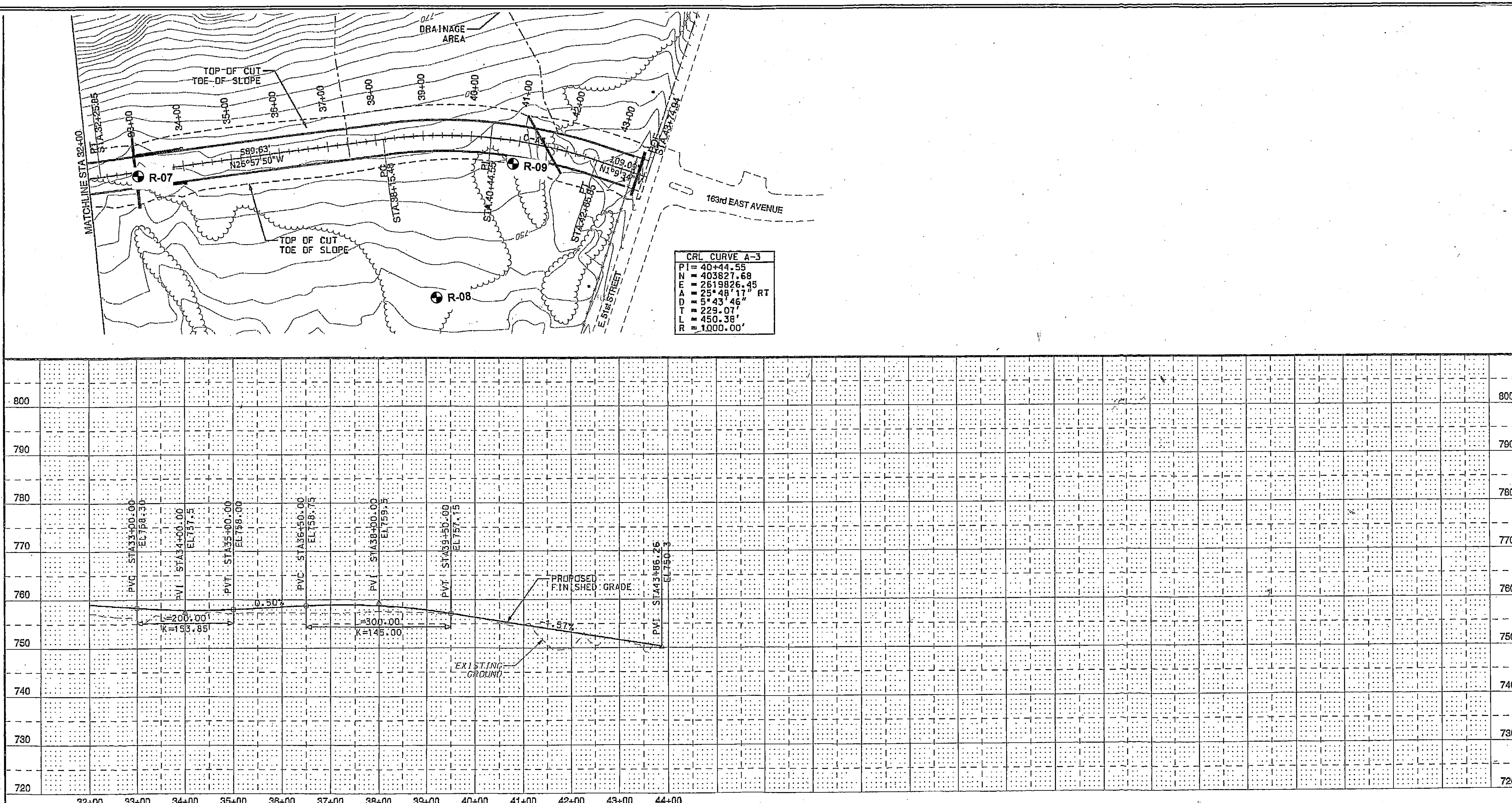
DESIGN	DATE	DRAWN	DATE
DDD	10/6/05	RMC	10/6/05
CHK'D BY	DATE	APPROVED	DATE
DDD	10/6/05		
SHEET OF ??		PROJECT NO. 05950430	

Boring Location Diagram | Project No. 64122 | **Figure 2**

North Elm Place Extention
North Elm Place & E. 51st St, S,
Broken Arrow, Oklahoma

KLEINFELDER

Scale: Not To Scale | **Approved By:** BKM



DATE	REVISIONS

CITY OF BROKEN ARROW, OKLAHOMA
ENGINEERING SERVICES

GARVER | ENGINEERS
10016 EAST 51 ST STREET
TULSA, OKLAHOMA 74146
(918) 250-5922 VOICE (918) 250-6529 FAX

ELM PLACE EXTENSION
PLAN & PROFILE

SCALE: HORZ. 1" = 100' VERT. 1" = 10'

DESIGN	DATE	DRAWN	DATE
DDD	10/6/05	RWC	10/6/05
CHK'D BY	DATE	APPROVED	DATE
DDD	10/6/05		
SHEET OF ??		PROJECT NO. 05350430	

Boring Location Diagram | Project No. 64122 | Figure 3

North Elm Place Extention
North Elm Place & E. 51st St, S,
Broken Arrow, Oklahoma

KLEINFELDER

Scale: Not To Scale | Approved By: BKM

LOG OF BORING NO. R-01

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	LOCATION
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA									FILL - Clayey Sand with Gravel
1	SS	15	37			15.9				
									2.4	
	PA									FILL - Lean Clay and Sandy Clay with Sandstone and Shale Fragments, red, brown, yellow, and gray
2	SS	14	12			19.1				
									5	
	PA									
3	SS	5	4/6 50/6			16.2				
									8.0	
										BOTTOM OF BORING
										**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
⊻ Dry W.D.	BORING STARTED 12-7-05		
▼ Dry A.B.	BORING COMPLETED 12-7-05		
	DRILL RIG CME-55	DRILLER PV	
Backfilled @ Completion	APPROVED DLK	JOB NO. 3055271	

KLEINFELDER

AUTO HAMMER 3055271.GPJ GEOSYSTM.GDT 12/28/05

LOG OF BORING NO. R-02

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	LOCATION
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA									0.1 TOPSOIL
1	SS	14	32			4.1	SP			SAND with gravel and cobbles, dense, tan
										1.3 **WEATHERED INTERBEDDED LIMESTONE AND SHALE, light brown to dark brown
	PA									2.8 **INTERBEDDED LIMESTONE AND SHALE, light to dark brown
2	SS	14	31/6 37/6 50/2			14.6				
	PA								5	
										6.3 **LIMESTONE, hard, gray and brown
3	SS	4	50/4			8.3				
	PA								10	
										10.7 **SANDY SHALE, hard, brown to gray
4	SS	5	50/5			9.3				
										14.4 **SANDY SHALE with sandstone and calcarious layers, hard, gray
	PA								15	

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	BORING STARTED 12-7-05	
∇ Dry W.D.	BORING COMPLETED 12-7-05	
▼ Dry A.B.	DRILL RIG CME-55	DRILLER PV
Backfilled @ Completion	APPROVED DLK	JOB NO. 3055271

KLEINFELDER

AUTO HAMMER 3055271.GPJ GEOSYSTM.GDT 12/28/05

LOG OF BORING NO. R-02

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	LOCATION
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
5	SS	3	50/3			6.0				
	PA								20	20.7
										**VERY SANDY SHALE with sandstone stringers, moderately hard, gray
6	SS	4	50/4			5.4				
	PA								25	
7	SS	3	50/3			5.3				
	PA								30	30.0
										BOTTOM OF BORING **Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	BORING STARTED	12-7-05		
∇ Dry W.D.	BORING COMPLETED	12-7-05		
▼ Dry A.B.	DRILL RIG	CME-55	DRILLER	PV
Backfilled @ Completion	APPROVED	DLK	JOB NO.	3055271

KLEINFELDER

AUTO HAMMER 3055271.GPJ GEOSYSTM.GDT 12/28/05

LOG OF BORING NO. R-03

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	LOCATION
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	DEPTH, FT.	DESCRIPTION
	PA							0.3	TOPSOIL
1	SS	8	25			4.6	CL		SANDY LEAN CLAY with limestone fragments, hard, tan, and brown
	PA								- limestone fragments increasing in size with depth
2	SS	8	8/6 50/3			25.0	CL	4.2	**WEATHERED LIMESTONE, hard, brown, tan, and gray
	PA							5	- with sandy shale stringers below 6.7 feet
3	SS	3	50/3			6.1			
	PA							10 / 10.2	**VERY SANDY SHALE, soft to moderately hard, olive, brown, tan, and gray
4	SS	9	42/6 50/3			10.3			
	PA							15 / 16.3	**VERY SANDY SHALE with limestone stringers, hard, gray

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS				
Dry W.D.	BORING STARTED	12-7-05		
Dry A.B.	BORING COMPLETED	12-7-05		
Backfilled @ Completion	DRILL RIG	CME-55	DRILLER	PV
	APPROVED	DLK	JOB NO.	3055271

KLEINFELDER

LOG OF BORING NO. R-03

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	LOCATION
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
5	SS	4	50/4			6.6				
	PA								20	**VERY SANDY SHALE with limestone stringers, hard, gray
									21.4	**SANDSTONE with shale partings, poorly cemented, brown
6	SS	6	50/6			11.7				
	PA								25 / 25.1	**VERY SANDY SHALE with sandstone layers, moderately hard, gray to dark gray
7	SS	3	50/3			6.0				
	PA								30	
8	SS	3	50/3			6.3				
	PA								35 / 35.0	BOTTOM OF BORING

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
∇ Dry W.D.	BORING STARTED 12-7-05		
▼ Dry A.B.	BORING COMPLETED 12-7-05		
	DRILL RIG CME-55	DRILLER PV	
Backfilled @ Completion	APPROVED DLK	JOB NO. 3055271	

KLEINFELDER

LOG OF BORING NO. R-03

OWNER/CLIENT **Garver Engineers**	PROJECT NAME **Elm Place Extension**
ARCHITECT/ENGINEER **Garver Engineers**	LOCATION **Tulsa, Oklahoma**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
										**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
∇ Dry W.D.	BORING STARTED 12-7-05		
▼ Dry A.B.	BORING COMPLETED 12-7-05		
Backfilled @ Completion	DRILL RIG CME-55	DRILLER PV	
	APPROVED DLK	JOB NO. 3055271	

KLEINFELDER

AUTO HAMMER 3055271.GPJ GEOSYSTM.GDT 12/28/05

LOG OF BORING NO. R-04

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	LOCATION
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA									SANDY SILT, dense, brown
1	SS	15	16			7.8	ML			
	PA								2.4	FAT CLAY, stiff, mottled red, brown, gray, and yellow
2	SS	14	22			18.3	CH			
	PA								5	
3	SS	16	29			16.9	CH			
	PA									
4	SS	16	30			11.1	CH		10.0	
									10	BOTTOM OF BORING

ATTERBERG LIMITS

Sample 2, Depth 2.5-4 feet

LL	PL	PI
78	27	51

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
∇ Dry W.D.	BORING STARTED	12-9-05	
▼ Dry A.B.	BORING COMPLETED	12-9-05	
	DRILL RIG CME-55	DRILLER PV	
Backfilled @ Completion	APPROVED DLK	JOB NO. 3055271	

KLEINFELDER

LOG OF BORING NO. R-05

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	LOCATION
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA									0.3 TOPSOIL
1	SS	15	19			8.2	CL CH			LEAN TO FAT CLAY with sand, very stiff, brown
	PA									2.8
2	SS	14	18			16.5	CH			FAT CLAY, stiff, mottled red, brown, gray, and yellow
	PA								5	
3	SS	14	22			16.9	CH			
	PA									
4	SS	14	31			14.7	CH		10	10.0
										BOTTOM OF BORING

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	BORING STARTED 12-9-05	
∇ Dry W.D.	BORING COMPLETED 12-9-05	
▼ Dry A.B.	DRILL RIG CME-55	DRILLER PV
Backfilled @ Completion	APPROVED DLK	JOB NO. 3055271

KLEINFELDER

AUTO HAMMER 3055271.GPJ GEOSYSTM.GDT 12/28/05

LOG OF BORING NO. R-06

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	**LOCATION**
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA									0.3 TOPSOIL
1	SS	14	8			15.6	CL CH			LEAN TO FAT CLAY, stiff, dark brown
	PA									
2	SS	15	13			17.3	CH			3.8 FAT CLAY, stiff to very stiff, red, brown, gray, and tan
	PA								5	
3	SS	16	28			15.4	CH			
										8.5 BOTTOM OF BORING

ATTERBERG LIMITS

Sample 1, Depth 0.5-2 feet

LL	PL	PI
48	21	27

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
⊻ Dry W.D.	BORING STARTED 12-9-05		
▼ Dry A.B.	BORING COMPLETED 12-9-05		
	DRILL RIG CME-55	DRILLER PV	
Backfilled @ Completion	APPROVED DLK	JOB NO. 3055271	

KLEINFELDER

AUTO HAMMER 3055271.GPJ GEOSYSTM.GDT 12/28/05

LOG OF BORING NO. R-07

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	**LOCATION**
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA								0.3	TOPSOIL
1	SS	15	15			10.8	CL			LEAN CLAY with silt, stiff, brown
	PA								2.6	FAT CLAY, very stiff, gray and tan
2	SS	16	43			12.6	CH			
	PA								5	
									6.4	**WEATHERED SANDY SHALE, very soft to soft, tan and brown
3	SS	6	50/6			9.1			7.5	

BOTTOM OF BORING

ATTERBERG LIMITS

Sample 1, Depth 0.5-2 feet

LL	PL	PI
40	19	21

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
▽ Dry W.D.	BORING STARTED 12-9-05		
▼ Dry A.B.	BORING COMPLETED 12-9-05		
	DRILL RIG CME-55	DRILLER PV	
Backfilled @ Completion	APPROVED DLK	JOB NO. 3055271	

KLEINFELDER

AUTO HAMMER 3055271.GPJ GEOSYSTM.GDT 12/28/05

LOG OF BORING NO. R-08

OWNER/CLIENT **Garver Engineers**	PROJECT NAME **Elm Place Extension**
ARCHITECT/ENGINEER **Garver Engineers**	LOCATION **Tulsa, Oklahoma**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA								0.4	TOPSOIL
1	SS	14	12			9.9	CL			LEAN CLAY with sand, stiff, brown to dark brown
	PA								2.9	FAT CLAY, stiff, brown and tan, trace gray
2	SS	15	12			14.1	CH		5	
	PA								6.3	**WEATHERED SHALE, trace sand, soft, brown and olive, trace gray
3	SS	18	16/6 28/6 50/6			13.2			8.5	

BOTTOM OF BORING

ATTERBERG LIMITS

Sample 2, Depth 3.5-5 feet

LL	PL	PI
56	20	36

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
▽ Dry W.D.	BORING STARTED	12-9-05	
▼ Dry A.B.	BORING COMPLETED	12-9-05	
Backfilled @ Completion	DRILL RIG CME-55	DRILLER PV	
	APPROVED DLK	JOB NO. 3055271	

KLEINFELDER

AUTO HAMMER 3055271.GPJ GEOSYSTM.GDT 12/28/05

LOG OF BORING NO. R-09

OWNER/CLIENT **Garver Engineers**	PROJECT NAME **Elm Place Extension**
ARCHITECT/ENGINEER **Garver Engineers**	LOCATION **Tulsa, Oklahoma**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA									0.3 TOPSOIL 0.8 LEAN CLAY with silt, brown to dark brown
1	SS	13	14			12.6	CH			FAT CLAY, stiff, brown
	PA									2.7 FAT CLAY, very stiff, brown and tan, trace gray
2	SS	15	23			12.3	CH		5	
	PA									5.9 **WEATHERED SHALE, very soft to soft, brown with trace olive
3	SS	12	30/6 50/6			10.6				8.0

BOTTOM OF BORING

ATTERBERG LIMITS
Sample 1, Depth 0.5-2 feet

LL	PL	PI
62	23	39

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
▽ Dry W.D.	BORING STARTED 12-9-05		
▼ Dry A.B.	BORING COMPLETED 12-9-05		
	DRILL RIG CME-55	DRILLER PV	
Backfilled @ Completion	APPROVED DLK	JOB NO. 3055271	

KLEINFELDER

LOG OF BORING NO. R-10

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	LOCATION
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA									0.3 TOPSOIL
1	SS	13	15			15.0				**WEATHERED LIMESTONE, moderately hard to hard, brown, tan, and orange
	PA									2.7 **HIGHLY WEATHERED SHALE with limestone stringers, soft, brown, red, and tan
2	SS	12	50/6			20.1				
	PA								5	5.4 **LIMESTONE with shale partings, hard, gray
3	SS	1	50/3			5.3				
	PA								10	- with numerous shale and sandstone partings and stringers below 8.4 feet 11.6 **WEATHERED SANDY SHALE, very soft to soft, brown, orange, and tan
4	SS	14	30/6 25/6 50/2			14.1				
	PA								15	15.2 **VERY SANDY SHALE with sandstone stringers, hard, gray

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	BORING STARTED	12-7-05		
∇ Dry W.D.	BORING COMPLETED	12-7-05		
▼ Dry A.B.	DRILL RIG	CME-55	DRILLER	PV
Backfilled @ Completion	APPROVED	DLK	JOB NO.	3055271

KLEINFELDER

AUTO HAMMER 3055271.GPJ GEOSYSTM.GDT 12/28/05

LOG OF BORING NO. R-10

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	LOCATION
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
5	SS	3	50/3			4.7				
	PA								20	20.0

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
▽ Dry W.D.	BORING STARTED 12-7-05		
▼ Dry A.B.	BORING COMPLETED 12-7-05		
	DRILL RIG CME-55	DRILLER PV	
Backfilled @ Completion	APPROVED DLK	JOB NO. 3055271	

KLEINFELDER

AUTO HAMMER 3055271.GPJ GEOSYSTM.GDT 12/28/05

LOG OF BORING NO. R-11

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	LOCATION
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA									0.3 TOPSOIL
1	SS	15	20			10.8				**WEATHERED LIMESTONE with sand and lean clay, moderately hard, highly fractured, tan, gray, red, and brown
	PA									
2	SS	6	33/6 50/2			11.4				
	PA								5	
3	SS	4	50/5			6.2				
	PA									9.4 **LIMESTONE, hard, gray
									10	- with shale and sandstone partings and seams below 10.3 feet
										13.1 **WEATHERED SANDY SHALE, very soft, brown and tan, trace olive
4	SS	15	27/6 27/6 50/3			15.4				
	PA								15	
										16.8 **VERY SANDY SHALE with sandstone stringers, hard, gray

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	BORING STARTED	12-6-05		
▽ Dry W.D.	BORING COMPLETED	12-6-05		
▼ Dry A.B.	DRILL RIG	CME-55	DRILLER	PV
Backfilled @ Completion	APPROVED	DLK	JOB NO.	3055271

KLEINFELDER

AUTO HAMMER 3055271.GPJ GEOSYSTM.GDT 12/28/05

LOG OF BORING NO. R-11

OWNER/CLIENT	PROJECT NAME
Garver Engineers	Elm Place Extension
ARCHITECT/ENGINEER	LOCATION
Garver Engineers	Tulsa, Oklahoma

SAMPLE NO.	SAMPLE TYPE	RECOVERY	***STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
5	SS	3	50/3			5.9				
	PA								20	**VERY SANDY SHALE with sandstone stringers, hard, gray
6	SS	3	50/3			6.0				
	PA								25	25.0
										BOTTOM OF BORING
										**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

***CME Automatic Hammer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
∇ Dry W.D.	BORING STARTED	12-6-05	
▼ Dry A.B.	BORING COMPLETED	12-6-05	
	DRILL RIG CME-55	DRILLER PV	
Backfilled @ Completion	APPROVED DLK	JOB NO. 3055271	

KLEINFELDER

Boring Log Symbols

SURFACE MATERIALS

- Topsoil
- Fill Material
- Asphaltic Concrete
- Concrete
- Granular Base
- Rubble Fill
- Wood Fill
- Water

WEATHERED BEDROCK

- Joint or Void
- Weathered Shale
- Weathered Sandstone
- Weathered Limestone
- Weathered Dolomite

FINE-GRAINED SOILS

- Fat Clay
- Lean Fat Clay
- Lean Clay
- Clayey Silt
- Silt
- Elastic Silt
- Sandy Fat Clay
- Sandy Lean to Fat Clay
- Sandy Lean Clay
- Low Plasticity Organic
- High Plasticity Organic
- Peat

BEDROCK UNITS

- Shale
- Fissile Shale
- Sandstone
- Chalk
- Limestone
- Dolomite
- Siltstone
- Claystone
- Coal
- Gypsum
- Interbedded Limestone & Shale
- Interbedded Sandstone and Shale
- Cherty Bedrock

COARSE-GRAINED SOILS

- Cobbles and Boulders
- Well Graded Gravel
- Poorly Graded Gravel
- Silty Gravel
- Clayey Gravel
- Gravelly Sand
- Well Graded Sand
- Poorly Graded Sand
- Silty Sand
- Interbedded Sand and Silt
- Sandy Silt
- Clayey Sand

WELL SYMBOLS

- Solid Pipe with Bentonite
- Screen with Sand

GENERAL NOTES

DRILLING NOTES

WATER LEVEL MEASUREMENTS

Water levels indicated on the boring logs are levels measured in the borings at the times indicated. In permeable materials, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels is not possible with only short-term observations.

WATER LEVEL OBSERVATION DESIGNATION

W.D.	While Drilling
A.B.	After Boring
B.C.R.	Before Casing Removal
A.C.R.	After Casing Removal
24 hr.	Water level taken approximately 24 hrs. after boring completion

DRILLING AND SAMPLING SYMBOLS

AS	Auger Sample
CS	Continuous Sampler
DB	Diamond Bit -NX unless otherwise noted
HA	Hand Auger
HS	Hollow Stem Auger
PA	Power Auger
RB	Rock Bit
SS*	Split-Barrel
ST	Shelby Tube - 2" (51mm) unless otherwise noted
WB	Wash Bore

*The Standard Penetration Test is conducted in conjunction with the split-barrel sampling procedure. The "N" value corresponds to the number of blows required to drive the last 1 foot (0.3m) of an 18 in. (0.46m) long, 2 in. (51mm) O.D. split-barrel sampler with a 140 lb. (63.5 kg) hammer falling a distance of 30 in. (0.76m). The Standard Penetration Test is carried out according to ASTM D-1586. (See "N" Value below.)

SOIL PROPERTIES & DESCRIPTIONS

TEXTURE

PARTICLE	SIZE	
Clay	< 0.002 mm	(< 0.002 mm)
Silt	< #200 Sieve	(0.075 mm)
Sand	#4 to #200 Sieve	(4.75 to 0.075 mm)
Gravel	3 in. to #4 Sieve	(75 mm to 4.75 mm)
Cobbles	12 in. to 3 in.	(300 mm to 75 mm)
Boulders	> 12 in.	(300 mm)

COMPOSITION

SAND & GRAVEL

Description	% by Dry Weight
trace	< 15
with	15 - 29
modifer	> 30

FINES

Description	% by Dry Weight
trace	< 5
with	5 - 12
modifier	> 12

Soil descriptions are based on the Unified Soil Classification System (USCS) as outlined in ASTM Designations D-2487 and D-2488. The USCS group symbol shown on the boring logs correspond to the group names listed below. The description includes soil constituents, consistency, relative density, color and other appropriate descriptive terms. Geologic description of bedrock, when encountered, also is shown in the description column.

GROUP SYMBOL	GROUP NAME	GROUP SYMBOL	GROUP NAME
GW	Well Graded Gravel	CL	Lean Clay
GP	Poorly Graded Gravel	ML	Silt
GM	Silty Gravel	OL	Organic Clay or Silt
GC	Clayey Gravel	CH	Fat Clay
SW	Well Graded Sand	MH	Elastic Silt
SP	Poorly Graded Sand	OH	Organic Clay or Silt
SM	Silty Sand	PT	Peat
SC	Clayey Sand	CL-CH	Lean to Fat Clay

COHESIVE SOILS

CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (Qu) (psf)	(kPa)
Very Soft	< 500	(< 24)
Soft	500 - 1000	(24 - 48)
Medium	1001 - 2000	(48 - 96)
Stiff	2001 - 4000	(96 - 192)
Very Stiff	4001 - 8000	(192 - 383)
Hard	> 8001	(> 383)

PLASTICITY

Description	Liquid Limit (%)
Lean	< 45%
Lean to Fat	45 to 49%
Fat	≥ 50%

COHESIONLESS SOILS

RELATIVE DENSITY	"N" VALUE*
Very Loose	0 - 3
Loose	4 - 9
Medium Dense	10 - 29
Dense	30 - 49
Very Dense	≥ 50

BEDROCK PROPERTIES & DESCRIPTIONS

ROCK QUALITY DESIGNATION (RQD**)

DESCRIPTION OF ROCK QUALITY	RQD (%)
Very Poor	0 - 25
Poor	25 - 50
Fair	50 - 75
Good	75 - 90
Excellent	90 - 100

**RQD is defined as the total length of sound core pieces, 4 inches (102mm) or greater in length, expressed as a percentage of the total length cored. RQD provides an indication of the integrity of the rock mass and relative extent of seams and bedding planes.

DEGREE OF WEATHERING

Slightly Weathered	Slight decomposition of parent material in joints and seams.
Weathered	Well-developed and decomposed joints and seams.
Highly Weathered	Rock highly decomposed, may be extremely broken.

SOLUTION AND VOID CONDITIONS

Solid	Contains no voids.
Vuggy	Containing small pits or cavities < 1/2" (13mm).
Porous	Containing numerous voids which may be interconnected.
Cavernous	Containing cavities, sometimes quite large.

When classification of rock materials has been estimated from disturbed samples, core samples and petrographic analysis may reveal other rock types.

HARDNESS & DEGREE OF CEMENTATION

LIMESTONE

Hard	Difficult to scratch with knife.
Moderately Hard	Can scratch with knife but not with fingernail.
Soft	Can be scratched with fingernail.

SHALE

Hard	Can scratch with knife but not with fingernail.
Moderately Hard	Can be scratched with fingernail.
Soft	Can be molded easily with fingers.

SANDSTONE

Well Cemented	Capable of scratching a knife blade.
Cemented	Can be scratched with knife.
Poorly Cemented	Can be broken apart easily with fingers.

BEDDING CHARACTERISTICS

TERM	THICKNESS (inches)	THICKNESS (mm)
Very Thick Bedded	> 36	> 915
Thick Bedded	12 - 36	305 - 915
Medium Bedded	4 - 12	102 - 305
Thin Bedded	1 - 4	25 - 102
Very Thin Bedded	0.4 - 1	10 - 25
Laminated	0.1 - 0.4	2.5 - 10
Thinly Laminated	< 0.1	< 2.5

Bedding Planes	Planes dividing the individual layers, beds or strata of rocks.
Joint	Fracture in rock, generally more or less vertical or transverse to the bedding.
Seam	Applies to bedding plane with an unspecified degree of weathering.

APPENDIX B

LABORATORY TESTING PROGRAM

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APPENDIX B
LABORATORY TESTING PROGRAM

GENERAL

Laboratory tests were performed on select, representative samples to evaluate pertinent engineering properties of these materials. We directed our laboratory testing program primarily toward classifying the subsurface materials, as well as measuring index values of the on-site materials. Laboratory tests were performed in general accordance with applicable standards. The results of the laboratory tests are presented on the respective boring logs. The laboratory testing program consisted of the following:

- **Moisture content tests**, ASTM D 2216, Standard Test Method for Laboratory Determination of Water
- **Atterberg limits**, ASTM D 4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- **Visual classification**, ASTM D 2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

ATTERBERG LIMITS

Atterberg limits tests were conducted on samples representative of the materials encountered across the site. The tests provide information on the plasticity of the soil, which is a basis for soil classification and for estimating the potential of subgrade soils to change volume with variations in moisture content.

CLASSIFICATION

All samples were examined in our laboratory or in the field by a geotechnical engineer using visual and manual procedures. The samples were classified in accordance with the General Notes included in APPENDIX A. Estimated group symbols, in general accordance with the Unified Soil Classification System, are shown on the boring logs.

Bedrock units encountered in the borings were described in accordance with the enclosed General Notes for Bedrock in APPENDIX A based on visual classification of disturbed auger cuttings and recovered samples, as well as drilling characteristics. Core samples may reveal other rock types.

APPENDIX C

ASFE DOCUMENT

KLEINFELDER 10926 E. 55th Place, Tulsa, OK 74146 (918) 627-6161 (918) 627-6262 fax

Important Information About Your

Geotechnical Engineering Report

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

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

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

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

Read the Full Report

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

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

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

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

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

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

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

Subsurface Conditions Can Change

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

Most Geotechnical Findings Are Professional Opinions

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

A Report's Recommendations Are *Not* Final

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

A Geotechnical Engineering Report Is Subject to Misinterpretation

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

Do Not Redraw the Engineer's Logs

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

Give Contractors a Complete Report and Guidance

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

Read Responsibility Provisions Closely

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

Geoenvironmental Concerns Are Not Covered

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

Obtain Professional Assistance To Deal with Mold

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

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

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

ASFE
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