PARKSTONE ADDITION

DRAINAGE PLAN

POE & ASSOCIATES, INC.
CONSULTING ENGINEERS
5940 E. Central, Suite 200 ■ Wichita, KS 67208-4242
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September 2007

PARKSTONE ADDITION

DRAINAGE PLAN

TIMOTHY R. AUSTIN
LICENSED
11496
KANSAS
PROFESSIONAL ENGINEER

8/31/07

AUGUST 2007

WICHITA

Public Works, Engineering Division
Stormwater Management Subdivision Submittal Checklist

Reviewer:______________________________ Date:______________________________

Subdivision Name:______________________________ Location:______________________________

Total Land Area Of Ownership:_________ Acres

Type: ______Residential ______Commercial ______Industrial ______Recreation ______Municipal ______Other

Applicant:______________________________ Contact:______________________________ Phone #:______________

Engineer:______________________________ Contact:______________________________ Phone #______________

Please check the appropriate box: I = Included; NA = Non-Applicable; R= Required prior to development
(If "NA" is checked, an explanation must be entered)

	Applicant			Engr	
Tab 1. Project Narrative	**I**	**NA**	**Explanation / Location in Plan**	**I**	**NA**
A. Site Location Map, using USGS Map	✓				
B. Discussion of development, existing conditions, and proposed impacts on stormwater, wetland, riparian, and flood plain	✓				
C. Discussion of offsite conditions	✓				
D. Summary of runoff calculations (pre/post development) No increase in peak discharge for all storm series	✓				
E. Narrative description of the type and function of the permanent best management practices that are incorporated into the site design					
F. Copy of the plat	✓				
G. Prelim. four corner lot grading plan (The final grading plan shall be sealed, signed and dated prior to Engineering receiving the final paving and stormwater drain plans.One plan sheet and PDF shall be submitted to the Subdivision Engineer.)		✓			
H. Professional Engineer seal, signature and date on cover of report	✓				
I. CD of drainage plan in PDF format (one file) and one paper copy bound with this checklist included behind the cover	✓				

	Applicant			Engr	
Tab 2. Existing Conditions Runoff Calculations	**I**	**NA**	**Explanation / Location in Plan**	**I**	**NA**
A. Copy of applicable orthophoto showing proposed project boundaries (preferable in color)	✓				
B. Runoff Method (Rational, Hydrograph Method, or other approved methods by Engineering)	✓				
C. Existing topography (no greater than 2-foot contours, 1-foot recommend)	✓				
D. Total Site Area and Total Impervious Area (acres)	✓				
E. Benchmarks used for site control	✓				
F. Streams, creeks, and waterway labeled		✓			
G. Predominant soils from USDA soil surveys, and/or on site soil borings	✓				
H. Location and boundaries of natural features such as wetlands, lakes, and ponds with the normal water elevation noted	✓				
I. Location of existing roads, buildings, parking lots and other impervious areas	✓				

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J. Location of existing utilities (e.g., water, sewer, gas, electric) and easements	✓				
K. Location of existing conveyance systems such as storm drains, inlets, catch basins, channels, swales, and areas of overland flow	✓				
L. Flow paths	✓				
M. Location and dimensions of existing channels, bridges or culvert crossings	✓				
N. Existing conditions hydrologic analysis for runoff rates, volumes and velocities showing methodologies used and supporting calculations (2, 5, 10, 25 & 100 year, 24-hour storm events) or Critical Duration		✓			
O. Assumed pre-developed runoff curve numbers		✓			
P. Existing time of concentrations used in calculations		✓			
Q. Evaluate immediate downstream drainage capacity, not to exceed more than 0.25 miles downstream of site					
R. Existing structural elevations (e.g., invert of pipes, manholes, etc.)		✓			
S. Cross-section data for open channels		✓			
T. Ground water elevations, if applicable		✓			

	Applicant			Engr	
Tab 3. Post-Development Hydrologic Analysis	**I**	**NA**	**Explanation / Location in Plan**	**I**	**NA**
A. Proposed (post-development) conditions hydrologic and hydraulic analysis for runoff rates, volumes, HGL, and velocities showing the methodologies used and supporting calculations for all applicable design storms (2, 5, 10, 25 & 100 year, 24-hour storm events)		✓			
B. Proposed time of concentrations used in calculations		✓			
C. Assumed post-developed runoff curve numbers		✓			
D. Proposed contours for detention facilities (to equal area used in outlet rating curves)		✓			
E. Preliminary sizing calculations for stormwater controls including contributing drainage area, storage, and outlet configuration		✓			
F. Stage-storage-discharge or outlet rating curves and inflow and outflow hydrographs for storage facilities		✓			
G. Final analysis of potential upstream/downstream impact/effects of project, where necessary	✓				
H. Dam safety analysis, where necessary		✓			
I. Existing and proposed structural elevations (e.g., invert of pipes, manholes, etc.)	✓				
J. Design water surface elevations and normal pool elevation for ponds.		✓			
K. Typical detail for outlet structures, embankments, spillways, grade control structures, conveyance channels, etc. To include height, width, elevation, and/or diameter.		✓			
L. Proposed limits of clearing and grading	✓				
M. Location of existing and proposed roads, buildings, parking lots and other impervious areas.	✓				
N. Location of existing and proposed utilities (e.g., water, sewer) and easements	✓				
O. Location of existing and proposed conveyance systems such as storm drains, inlets, catch basins, channels, swales, and areas of overland flow	✓				
P. Preliminary location and dimensions of proposed channel modifications, such as bridge or culvert crossings		✓			

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Q. Preliminary selection and location of stormwater controls		✓			
R. Emergency overflow structure's flow path		✓			
S. Detention facility provides one-foot of freeboard above the HWL and emergency outfall shown (top of berm elevation shown)		✓			
T. The 100-year 24-hour HWL delineated on the plan for detention pond		✓			
U. Lowest opening elevations table on the plat for structures located adjacent to channels or ponds		✓			
V. Stormwater Management Facilities located within a Reserve		✓			
W. Maintenance of stormwater management facility specified in the platters text as the responsibility of the Homeowner or Business Association		✓			
X. Off-site drainage easements or agreements required		✓			

	Applicant			Engr	
Tab 4. Floodplain Submittal	**I**	**NA**	**Explanation / Location in Plan**	**I**	**NA**
A. Provide source of flood profile					
B. Nearest base flood elevations					
C. Delineation of pre-developed regulatory floodplain/floodway limits					
D. Delineation of post-developed regulatory floodplain and floodway limits					
E. Floodplain boundary determination per elevation (project limits shown)					
F. Provide source of floodway data table and discharges					
G. Provide all hydrologic and hydraulic study information for site-specific floodplain studies, unnumbered Zone A area elevation determinations and flood plain map revisions					
H. Provide regulatory floodway and four natural profile *models (10,50,100, and 500-yr)* for existing and future watershed conditions					
I. Location of floodplain/floodway limits and relationship of site to upstream/downstream properties (floodplain limits to be per elevation and scaled location)					
J. Flood plains and floodways located within a Reserve					

	Applicant			Engr	
Tab 5. Federal, State and Local Permits (to be provided prior to construction unless otherwise specified)	**I/R**	**NA**	**Explanation / Location in Plan**	**I/R**	**NA**
A. US Army Corps of Engineers - Regulatory program permits (404 water quality certification)					
B. Kansas Department of Agriculture - Division of Water Resources Permits (Stream Obstruction, Channel Change, Flood Plain Fill, Levee, Water Appropriations, Dam safety permit, etc.)					
C. Federal Emergency Management Agency (FEMA) Letter of Map Changes (LOMA, LOMR, LOMR-f, CLOMR, etc.) CLOMR shall be included and approved for fill placed in the regulatory floodway					
D. Kansas Department of Transportation					
E. Sedgwick County Right-of-way Permit					

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PROJECT NARRATIVE

Parkstone Addition is a 5.9-acre, in-fill project located at the intersection of Victor and Rutan in east Wichita in the College Hill neighborhood. Parkstone is a redevelopment of existing and previously existing commercial, office, and residential developments. A copy of the USGS quad map for this area is attached as Exhibit 1.

The area slopes from the east to the west on an average gradient of 2.8%. A copy of the proposed one-step final plat is attached as Exhibit 2. A 2006 aerial is attached as Exhibit 3. The overall site drains primarily to First Street on the north, Victor in the middle, and Douglas along the south. Soil types for this area are considered to be Group B. According to the geo-technical investigation for the site, the on-site soils consist of fat clays with high shrink/swell potential. A copy of the geo-technical report showing soil types is attached as Exhibit 4. A nominal area uphill from this site drains to Victor and downhill to Hillside. Future development will need to take this into consideration to assure continued conveyance of the drainage from uphill.

The proposed development consists of a mixture of multi-family residential, office, and commercial. Green spaces are being incorporated into the site for landscaping, parks and lawn areas. Design measures will be implemented to slow run-off somewhat, but the resulting effects will likely be minimal given the cross-gradient of the site. There is no apparent increase in runoff and the presence of the fat clays makes it important to keep water away from the any structure's footings and foundations. Accordingly, detention is not recommended as being required; however, to the extent that the city requires detention, than reductions in the peak flow can be achieved either through over-sizing of storm sewer within the Victor Street right-of-way or through the use of a pumped storage collection system.

EXISTING CONDITIONS ANALYSIS

The Rational Method was utilized to approximate run-off since the drainage basin and development site are small areas. The proposed site is small at 5.9 acres and is approximately 5.5% of the overall drainage basin of 105 acres. A combined run-off coefficient using City of Wichita recommended values was developed for the proposed site. Sub-basin areas under the existing conditions were also identified. As shown on the attached drainage plan, the combined run-off coefficient, c, for the site varied between 0.65 to 0.85.

There is no storm sewer that services this area. The nearest storm sewer is along Hillside to the west and is fairly small at 24". Storm water is conveyed to Hillside via curb and gutter sections within the street right of way. Collection lines at First Street, Victor and Douglas that were recently installed as part of the Hillside improvements are primarily 15" and 18" lines. Previous conversations with city construction staff concluded that extending storm sewer the re-development site was not beneficial as the system already has insufficient capacity. A quick rudimentary check of pipe capacities verifies that the system is under-designed in accordance with today's guidelines. Copies of the plans for the street improvements is attached as Exhibit 5.

The storm sewer in Hillside serves a drainage basin of approximately 105 acres. Using the Rational Method with an assumed conservative, uniform run-off coefficient of 0.45 for the entire drainage basin, a yield of an approximate Q_5 of 215 cfs for the 5-year storm and an approximate Q_{100} of 348 cfs for the 100-year storm. The net increase in Q for either storm event is approximately 1%.

Because of the small area and the desire by city staff to be assured that additional run-off was not being generated, further calculations were done to estimate the amount of pervious area for the current, existing condition and those for the redeveloped condition. Calculated values indicate that the overall amount of pervious area with the redevelopment actually increased from approximately 70,500 square feet to 73,500 square feet.

POST-DEVELOPMENT ANALYSIS

The analysis indicates that the overall increase is minimal at less than 8% for the given site and approximately 1% for the entire drainage basin. However, the overall impervious area for the development is actually increasing and therefore detention is not recommended. A higher coefficient for the proposed conditions was utilized; however, the coefficient is probably conservative given the amount of green space that is to be integrated into the site. A copy of the drainage plan showing the results is attached as Exhibit 6.

Given the lack of storm sewer availability, the site design should integrate features to lessen storm water run-off where possible. Given the minimal increase over the existing condition, no detention is recommended; however, the following recommendations should be adopted as part of the redevelopment:

1) Based upon the current site concept, this development is not intended to increase the existing run-off greater than the existing condition. This concept is based upon a total pervious area within the development and adjoining street right of way of 73,500 square feet. Should actual building plans vary from the attached concept, then the developer shall demonstrate that the planned pervious area will not reduced from the stated amount of 73,500 square feet prior to the issuance of building permits. Reductions in the gross pervious area from the planned amount of 73,500 square feet will require the detention of the increased storm water run-off subject to the approval of the city prior to the issuance of building permits.

2) As part of the building plans, pervious lawn areas shall have the sub-grade scarified and treated with lime or other suitable amendments to a depth of 12" in order to break up the existing clay soil. The top 6 inches of the lawn areas will be constructed and backfilled with topsoil.

3) "Green" areas that are located on the top of building structures will need to be designed and constructed to detain storm water run-off.

A copy of the proposed development plan is attached as Exhibit 7.

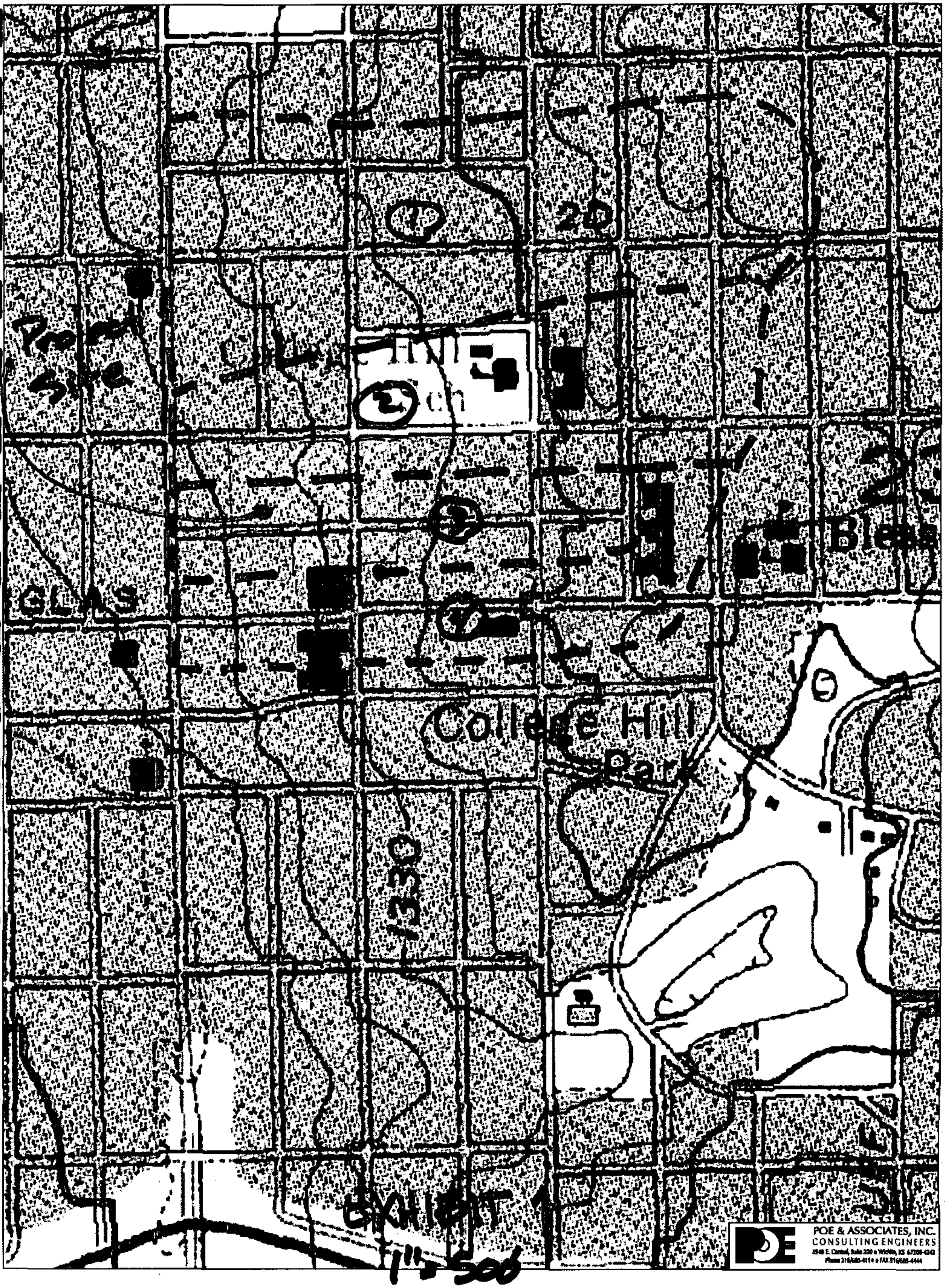

EXHIBIT 1

1" = 500'

POE & ASSOCIATES, INC.
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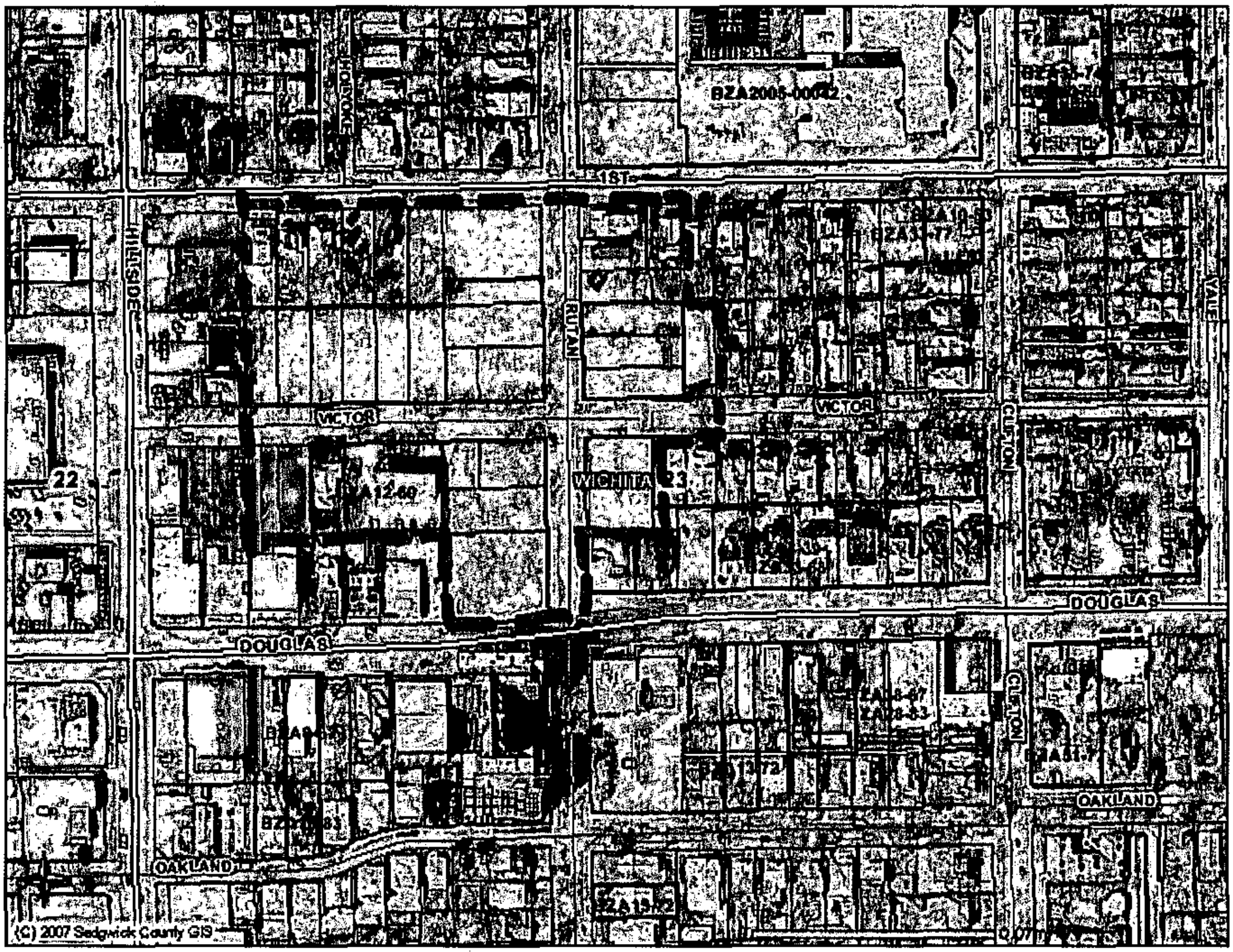
Phone 316/685-4114 • FAX 316/685-4444

Parkstone Proj Limits ▬ ▬ ▬



Legend

National Historic Site Buffers
500.0' Local Historic Site Buffers
1000' National Historic Site Buffers
Other
Historic Zoning Districts
National Historic Sites
Local Historic Sites
Roads
Highway
Highway Ramp
Major Roads
Other Roads
City Boundaries
ANDALE
BEL AIRE
BENTLEY
CHENEY
CLEARWATER
(cont)

COLWICH
DERBY
EASTBOROUGH
GARDEN PLAIN
GODDARD
HAYSVILLE
KECHI
MAIZE
MOUNT HOPE
MULVANE
PARK CITY
SEDGWICK
UNINCORPORATED
VALLEY CENTER
VIOLA
WICHITA
Other
Railroads
Rivers or Lakes
(cont)

Floodway
Rivers or Lakes
Minor Rivers
Square Mile Sections
Zoning Use Cases
Parcels
Zoning Districts
Unknown
Not Zoned
Air Force Base
B - Multi-Family 75 d.u./ac
CBD - Central Business District
GC - General Commercial
GI - General Industrial
GO - General Office
IP - Industrial Park
LC - Limited Commercial
LI - Limited Industrial
MF-18 - Multi-Family 18 d.u./ac
(cont)

MF-29 - Multi-Family 29 d.u./ac
MH - Manufactured Housing
NO - Neighborhood Office
NR - Neighborhood Retail
OW - Office Warehouse
PUD - Planned Unit Developments
RR - Rural Residential
SF-10 - Single Family: 10,000
SF-20 - Single Family: 20,000
SF-5 - Single Family: 5000
TF-3 - Two Family
U - University
Other
2006 aerial

Sedgwick County GIS
Geographic Information Services
Division of Information & Operations
www.sedgwickcounty.org/gis
525 N. Main, Suite 212, Wichita, KS 67203
Tel: 316.660.9290 Fax: 316.262.1174

GEOTECHNICAL ENGINEERING REPORT

PROPOSED PARKSTONE-PHASE 1
DOUGLAS AT HILLSIDE
WICHITA, KANSAS

Terracon Project No. 01075066
June 12, 2007

Prepared for:

LOVELAND PROPERTIES, LLC
WICHITA, KANSAS

Prepared by:

Terracon
Wichita, Kansas

Terracon

Terracon
Consulting Engineers & Scientists

1815 South Eisenhower
Wichita, Kansas 67209
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June 12, 2007

Loveland Properties, LLC.
c/o JP Weigand & Sons Inc
150 North Market
Wichita, Kansas 67202

Attention: Mr. Mike Loveland

Telephone: *316-262-6400*
Facsimile: *316-660-6815*
E-Mail: *loveland@weigand.com*

Re: Geotechnical Engineering Report
Proposed Parkstone-Phase 1
Douglas at Hillside
Wichita, Kansas
Terracon Project No. 01075066

Dear Mr. Loveland:

Terracon has completed a subsurface exploration for the proposed Parkstone-Phase 1 to be constructed at Douglas near Hillside in Wichita, Kansas.

In our opinion, it is feasible to support the proposed buildings in Phase 1 on footing foundations. Our geotechnical recommendations presented in this report should be followed to reduce foundation and floor slab movement. Recommendations regarding the geotechnical aspects of the proposed construction are presented in this report.

We appreciate the opportunity to be of service to you on this project, and we are prepared to provide the recommended construction observation and testing services. If you have any questions regarding this report, or if we may be of further service to you in other ways, please let us know.

Sincerely,

Terracon

6606

Kent J. Schwieger, P.E.
Kansas No. 6606

Michael G. Ehss, P.E.
Kansas No. 14381

Cc: Mr. Mac McKee at Gossen Livingston Architecture; Wichita, KS at mmckee@gossenlivingston.com

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GEOTECHNICAL ENGINEERING REPORT

PROPOSED PARKSTONE-PHASE 1
DOUGLAS AT HILLSIDE
WICHITA, KANSAS

Terracon Project No. 01075066
June 12, 2007

1.0 INTRODUCTION

Terracon has completed a program of subsurface exploration and geotechnical engineering analyses for the proposed Phase 1 of the Parkstone Development that you propose to construct at Douglas near Hillside in Wichita, Kansas. We performed the five borings directed by the project architect, Gossen Livingston Associates, Inc., for this phase of the Parkstone Development to obtain information on subsurface conditions. The results of these borings and a diagram showing their approximate locations are included with this report.

In this report, we describe the subsurface conditions encountered in the borings, present the laboratory data obtained, and provide geotechnical recommendations for the design and construction of foundations. We are also presenting recommendations related to subgrade preparation for the support of slabs-on-grade, pavement subgrade preparation, and typical pavement thickness values.

The recommendations contained in this report are based upon the results of field and laboratory testing, engineering analyses, our experience with similar soil conditions and structures, and our understanding of the proposed project.

2.0 PROJECT DESCRIPTION

This phase of the proposed project will involve the construction of four, 3-story, wood-framed, condominium buildings (brownstones with small basements and individual elevators) located east of Rutan, between First Street and Victor Place. Each building is to have two to five adjoining condominium units. These units will have a small centrally located activity shelter and swimming pool (with a maximum depth of about 5 feet), site improvements, and landscaping.

Building loads were not provided to us, but we anticipate maximum column loads of less than 35 kips and continuous wall loads of less than 5 kips per lineal foot. Floor loads are anticipated to be light. Paved surface parking and drives also are planned for construction at this time.

3.0 SITE EXPLORATION

3.1 Field Exploration

Terracon's drill crew used a calibrated measuring wheel to establish the boring locations in the field. We estimated the right angles for the boring location measurements. Terracon's drill crew used a surveyor's level and rod to establish the approximate ground surface elevations indicated on the boring logs. We referenced these elevations to the top of the fire hydrant at the northeast corner of Rutan Avenue and Victor Place. We assigned this temporary benchmark an arbitrary elevation of 100.0 feet. We rounded the elevations on the boring logs to the nearest one-half foot. The approximate locations and ground surface elevations of the borings should be considered accurate only to the degree implied by the methods used to make these measurements.

We drilled the borings with a truck-mounted drill rig using continuous flight augers to advance the boreholes. We obtained representative samples primarily by the split-barrel sampling procedure. In the split-barrel sampling procedure, a standard, 2-inch O.D., split-barrel sampling spoon is driven into the boring with a 140-pound hammer falling 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of an 18-inch sampling interval is recorded as the standard penetration resistance value, N.

We used a CME automatic SPT hammer to advance the split-barrel. A significantly greater efficiency is achieved with the automatic hammer compared with the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the standard penetration resistance blow count (N) values. We considered the effect of the automatic hammer's efficiency in our interpretation and analysis.

We also obtained thin-walled tube samples. In the thin-walled tube sampling procedure, a seamless steel tube with a sharpened cutting edge is pushed hydraulically into the boring to obtain a relatively undisturbed sample of cohesive or moderately cohesive material. We reported the sampling depths, penetration distances, and the standard penetration resistance values on the boring logs. We placed the soil samples obtained in the field into air-tight containers, sealed them, and returned them to our laboratory for testing and classification.

The drill crew prepared field boring logs as part of their drilling operations. These boring logs include visual classifications of the materials encountered during drilling and the driller's interpretation of the subsurface conditions between samples. The final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in the laboratory.

3.2 Laboratory Testing

We tested the samples to determine their moisture contents and estimated the unconfined compressive strengths of cohesive samples with a calibrated hand penetrometer. The thin-walled tube samples were also tested to determine the material's dry density. We performed Atterberg limits tests on representative portions of the near-surface soil to aid in classification and to evaluate the near-surface soil's shrink/swell characteristics.

As part of the testing program, an engineer/geologist examined the soil/rock samples in the laboratory. Based on the material's texture and plasticity, we described and classified the samples in accordance with the attached *General Notes* and the *Unified Soil Classification System*, respectively. We show the estimated group symbols for the *Unified Soil Classification System* in the appropriate column on the boring logs. We included a brief description of the Unified System in Appendix C. Rock descriptions are in accordance with the *General Notes for Sedimentary Rock* and have been estimated from disturbed samples. Observations of core samples and petrographic analysis may reveal other rock types.

4.0 SITE CONDITIONS

The site is in an area of former commercial/residential development. Area drainage is downward to the west. We found asphalt or concrete pavement about 5 inches thick at our boring locations. Two existing residential structures presently occupy the north portion of the Phase 1 site. Subsurface conditions encountered at the boring locations are described in greater detail below.

5.0 SUBSURFACE CONDITIONS

5.1 Geology

The project site is situated in the eastern portion of the City of Wichita near the western border of a dissected shale upland that overlooks the Arkansas River Valley to the west. The soils in this area include alluvial terrace deposits that overlie residual fat clays mantling weathered shale bedrock (the Wellington Formation of Permian geologic age). The upper portion of the shale is generally highly weathered, calcareous, and often contains gypsiferous zones and/or occasional thin limestone seams.

5.2 Soil and Rock Conditions

Below asphalt or concrete pavement generally about 5 inches thick, we logged existing fill comprised of very dark gray brown, lean clay and fat clay to a depth of about 2 or 3 feet. Below the fill in borings B-1 and C-2, we found stiff, olive-gray fat clay that extended to a depth of about 6 or 8 feet. Below the fill in boring C-3, we found stiff, dark gray-brow lean clay that extended to a depth of about 8 feet. Below these strata in borings B-1, C-2, and C-3 and below the fill in borings C-1 and D-1 we encountered olive-gray, dark olive-gray, or light gray highly and moderately weathered clay shale that continued to the bottom of our borings, depths of 10 to 20 feet.

The subsurface conditions encountered at each boring location are indicated on the boring logs. The stratification boundaries shown on the borings logs represent the approximate locations of changes in soil/rock types; in situ, the transition between material types may be gradual.

5.3 Field and Laboratory Test Results

Our field standard penetration test results (N-values) in the native clay overburden soils were 9 to 11. The N-values and calibrated hand penetrometer test results (indicated unconfined compressive strengths of 2,000 psf to 6,500 psf) in the native clays correlated with stiff consistency. The field standard penetration test results (N-values) in the existing fill soils were in the range of 2 to 10, indicating low strength, high compressibility, and substantial variability. The N-values in the underlying highly weathered clay shale were generally in the range of 9 to 33. The N-value in the moderately weathered shale was 50 blows or 5 inches penetration.

The moisture test results of the split-barrel and thin-walled tube samples in the overburden soils and weathered clay shale, typically 15% to 35%, indicate the native clay subgrade soils and weathered clay shale were in a relatively moist condition at the time of our drilling operations. The test results of the thin-walled tube samples from a depth of 3.5 to 5 feet from borings B-1 and C-1 indicate dry density values of 101 and 107 pcf, respectively.

Atterberg limits tests conducted on portions of Samples 1 and 2 from boring C-3 and Sample 1 from boring D-1 resulted in liquid limit values within the range of 31 and 55, and plasticity indices within the range of 16 and 35. These test results indicate the subgrade soil from these sample locations range from lean to fat clay that have moderate to high shrink-swell characteristics. Clays with high density, high plasticity, and low moisture content have a high potential for post-construction floor slab heave.

We show the results of our laboratory tests in Appendix B and/or on the boring logs adjacent to their respective sample locations.

5.4 Groundwater Conditions

We monitored the boreholes for water while sampling and upon completion of drilling operations. While drilling we observed water only in borings C-2 and C-3, at depths of about 3 feet and 7 feet, respectively. Upon completion of drilling activities, we observed water only in boring C-2, at a depth of 1 foot. We performed boring C-2 during a period of heavy rainfall. Our drill crew indicated the water level could have resulted from the accumulation of surface runoff entering the borehole. Boring C-3 was dry upon completion of our drilling activities indicating a perched groundwater condition affected by recent rainfall. Based on this information and the subsurface conditions encountered at the borings, in our opinion the groundwater table was located below our maximum boring depth of 15 feet at the time of our subsurface exploration, although perched groundwater conditions could form periodically at shallower depths.

We based this conclusion, in part, upon short-term observations. Fluctuations in groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, altered natural drainage paths, and other factors not evident at the time we drilled the borings. Also, perched groundwater conditions can form intermittently at shallow depths in pervious backfills. To obtain more accurate groundwater level information, longer-term observations in deeper wells or piezometers sealed from the influence of surface water would be needed .

6.0 ENGINEERING RECOMMENDATIONS

6.1 Geotechnical Considerations

Although a grading plan has not been provided for the proposed development, we assume that up to 2 feet of new fill (up to 9-feet of cut for the partial basements/pool) may be needed to develop design grade at the proposed buildings. We analyzed the foundation support conditions based on the data obtained from the field and laboratory testing programs. In our opinion, it is feasible to support the proposed structures on footing foundations bearing on suitable native soils or on new, approved engineered fill.

Note that highly plastic, native soils and expansive clay shale are present at this site. This condition necessitates some special design and construction procedures to be followed to improve foundation and slab performance because of the shrink/swell potential of the near surface soils.

Geotechnical recommendations related to foundations, building pad subgrade preparation, and other geotechnical aspects of the project are presented below.

This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and (at least minor) cracking in the structure should be anticipated. The severity of cracking and other cosmetic damage such as uneven floor slabs will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and cosmetic distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. We would be pleased to discuss other construction alternatives with you upon request.

This site contains existing fill materials. The depth and composition of the existing fill materials can vary greatly over relatively small lateral and vertical distances. Because of this variability, it may not be possible (until site grading is underway) to accurately predict the amount of fill that will need to be removed and replaced to develop suitable support for the proposed improvements. Because it is unlikely that the depth and composition of the fill observed at the discrete boring locations represents subsurface conditions across the site, exercise caution when applying this information for estimating purposes. The fill observed in our borings generally appears suitable for re-use as new controlled fill, provided it is properly moisture conditioned and compacted. However, the fill could contain unobserved materials that would render it unsuitable for re-use as new controlled fill. We encourage the owner to secure a base bid for removing and replacing a specified quantity of the existing fill. The owner should also secure unit rates for adding or deducting quantities from the base bid that include costs for exporting unsuitable materials and importing approved replacement materials, if required.

6.2 Earthwork

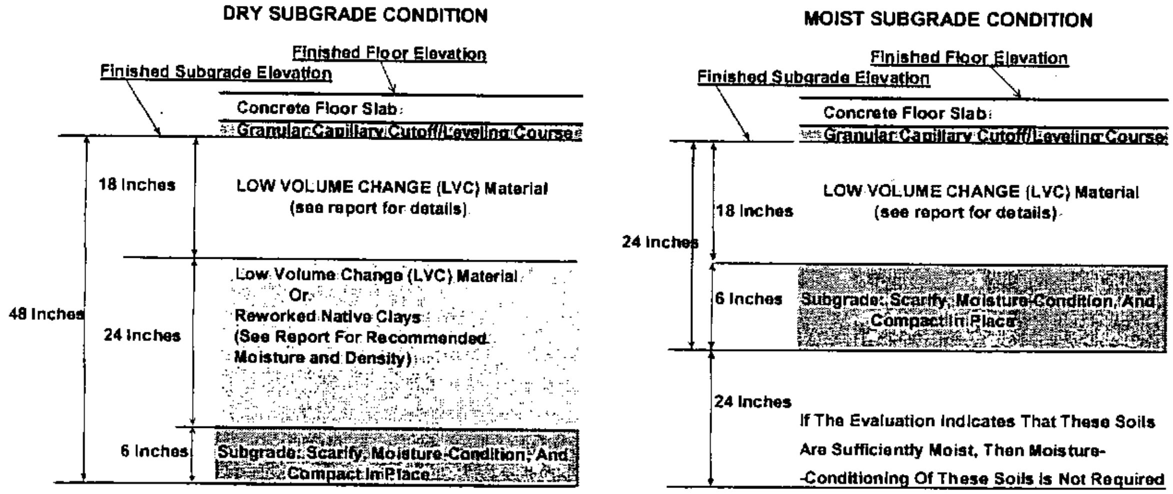
Site Preparation: We recommend all pavements, existing structures (including all slabs and foundations), trees, vegetation/organic topsoil, and existing fill be removed from within at least 5 feet beyond the proposed building locations. After completing these operations we recommend the exposed subgrade be proofrolled (under the observation of Terracon personnel) with a loaded tandem-axle dump truck, to locate any zones that are soft or unstable. The subgrade in the building areas where excessive rutting or pumping occurs during proofrolling should be removed and replaced or aerated/reworked and recompacted in place to our recommendations for engineered fill (see below for details) prior to placement of areal fill.

Subgrade Preparation for Building Pad: A factor affecting floor slab performance is the potential for the subgrade soils to swell due to variations in moisture content. Typically, some increase in the floor slab subgrade moisture content will occur as a result of gradual accumulation of capillary moisture, which would otherwise evaporate if the floor slab had not been constructed. A soil's swell potential is dependent primarily on its plasticity, and moisture content. The confining pressure provided by the weight of the floor slab and the overburden pressure (including the fill required to develop design grade) also effect swell potential. The higher the plasticity and the lower the moisture content and confining pressure, the greater the swell potential.

Some of the near surface subgrade soils are highly plastic, but were relatively moist at the time of our subsurface exploration. In our opinion, these near surface materials currently have moderate to high swell potential. To reduce swell potential we recommend that at least the upper 18 inches of subgrade soils below the floor slab be low volume change (LVC) material (see "*Low Volume Change Zone*" section for details).

Because we expect that the near-surface highly plastic lean and fat clay and weathered clay shale materials could have greater swell potential if lower moisture conditions exist at the time of construction, constructing an 18-inch thick LVC zone may not adequately reduce floor slab heave to a relatively small amount. Therefore, we recommend that the geotechnical engineer evaluate the material within 2.5 feet of the bottom of the LVC zone just prior to placement of any additional fill. As depicted in the following diagram, where the existing native materials within this depth range are drier than 3 percentage points wet of optimum moisture content (OMC), as determined by ASTM D-698, we recommend procedures be implemented to either add water and rework the dried soils or replace the dried soils with LVC material. If the on-site soils are dry and reworked, they should be uniformly increased in moisture content to at least 3 percentage points wet of OMC. If LVC soils are used to replace the dried soils, they should be placed at the moisture content values described in the following section of this report. The reworked on-site materials and LVC material should be placed in lifts not exceeding 9 inches in loose thickness and compacted to at least 95%, but not more than 100%, of the materials maximum dry density (MDD), as determined by ASTM D-698.

BUILDING SUBGRADE PREPARATION DIAGRAM (NOT TO SCALE)



Prior to placing additional area fill where moisture conditioning (as described above) is not needed, we recommend the upper 6 inches of exposed subgrade be scarified and recompacted to at least 95%, but not more than 100%, of the materials MDD at a moisture content at least 3 percentage points wet of OMC.

Any additional fill required to develop design grade below the LVC zone should be approved materials that are free of organic matter and debris. The fill should be placed in lifts not exceeding 9 inches in loose thickness and compacted to at least 95%, but not more than 100%, of the materials MDD, as determined by ASTM D-698. The zone of fill compacted to meet this criteria should extend at least 3 feet horizontally beyond the footprints of the buildings. The minimum moisture content at which the fill below the LVC zone should be placed will depend on the plasticity of the fill material as follows:

- Cohesive soils with a plasticity index (PI) greater than 25 should be placed at a moisture content of at least 3 percentage points above their OMC (ASTM D-698)
- Cohesive soils with a PI less than 25 should be placed at a moisture content above their OMC
- Granular soils should be placed at workable moisture content

Low Volume Change Zone: As stated previously, we recommend the upper 18 inches of material directly below the floor slab (excluding any granular leveling course or capillary moisture break) be LVC material. This is primarily to help protect the newly placed fill from moisture fluctuations during construction and provide a layer of soil that will not experience significant volume change as the moisture content fluctuates.

By our definition, LVC materials have a liquid limit (LL) less than 40 and a plasticity index (PI) of at least 5, but less than 15. LVC materials that meet this requirement may include granular soils (such as limestone/concrete screenings or clayey sand) or possibly silty or sandy lean clays. Laboratory testing of prospective LVC materials proposed for use by the contractor should be conducted to confirm their suitability prior to bidding/construction.

If cohesive material meeting the above criteria cannot be readily obtained, a LVC soil may be developed with the clay overburden soils by modifying them with hydrated lime or Class C fly ash, although this may result in objectionable dusting problems. Because of the potentially deleterious heave that could result if hydrated lime is used to modify shaley material that contain sulfates, such as gypsum zones or seams, we recommend that shale or existing fill that includes reworked shale **not be modified** with hydrated lime unless extensive additional laboratory and field testing is performed to determine if excessive sulfates are present and if they would react adversely with the hydrated lime. For clay materials, it has been our experience that hydrated lime contents of 4% to 6% or Class C fly ash contents of 14% to 16%, based on the dry weight of the soil, would be required to appreciably reduce the shrink/swell characteristics of clayey soils not meeting the previously described plasticity requirements for LVC materials. A more precise application rate could be developed based on additional laboratory testing. Recognized guidelines such as those specified by the City of Wichita or K.D.O.T., should be followed during the mixing and construction of the fly ash or hydrated lime modified subgrade. The modified zone should extend at least 3 feet beyond the edges of the proposed buildings. Soils mixed with Class C fly ash should be compacted within 2 hours following blending operations.

The LVC soils should be placed in lifts not exceeding 9 inches in loose thickness and compacted to at least 95%, but not more than 100%, of MDD and cohesive soils should be placed and maintained at moisture contents wet of OMC, granular soils should be placed at a workable moisture content. If hydrated lime or fly ash-modified soils are used, they should be placed and maintained at moisture contents above OMC.

Cohesive, LVC materials, including hydrated lime or fly ash-treated materials, can be swell susceptible if allowed to dry before constructing the floor slab; therefore, it is important that the recommended moisture content of the cohesive, LVC material be maintained. As a check, we recommend the moisture content be evaluated about 3 to 4 days before placing concrete. If drying of the subgrade materials has occurred at this time, measures should be taken to increase the moisture content of the subgrade soils before placing concrete which may also include recompaction. If the subgrade was previously modified with fly ash and recompaction is required additional fly ash would be needed.

We recommend constructing the upper 4 to 6 inches of the LVC zone using silty gravel similar to K.D.O.T. AB-3-Type material, crushed concrete screenings, or asphalt millings to reduce the above stated swell potential associated with cohesive LVC materials or lime/fly ash modified on-site soils that are allowed to dry excessively. This granular zone would reduce the moisture fluctuations in the bottom portion of the LVC zone and also provide a more stable working surface during construction following inclement weather.

General Drainage Recommendations: All grades must provide effective drainage away from the buildings during and after construction. Water permitted to pond next to the buildings can result in greater soil movements than those discussed in this report. These greater movements can result in unacceptable differential floor slab movements, cracked slabs and walls, and roof leaks. Estimated movements described in this report are based on effective drainage for the life of the structures and cannot be relied upon if effective drainage is not maintained.

Where utility lines enter beneath the buildings, we recommend providing plugs of concrete (with waterstops) or of compacted clay backfill, to preclude the possibility of water saturating the subgrade below the floor slabs. The clay plugs should be compacted in lifts, meet the criteria above for new areal fill, and extend at least 5 feet beyond the building perimeters.

Exposed ground should be sloped at a minimum 10 percent (5 percent where pavement will abut the buildings) away from the buildings for at least 10 feet beyond the perimeter of the buildings. After building construction and landscaping (if any), we recommend verifying final grades to document that effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted as necessary, as part of the structures' maintenance program.

6.3 Foundations

We assume that up to 3 feet of new fill/cut may be needed to develop design grade in the non-basement building areas and up to 8 to 9 feet of cut will be needed to construct the partial basements. Based on these assumptions we expect that the materials present at the base of the interior footings and perimeter footings would be new engineered fill or possibly native clay soils.

- For footings bearing within new approved, engineered fill soils we recommend using a maximum net allowable total load bearing pressure of 2,000 psf. The maximum net allowable total load bearing pressure is the pressure that can be applied at the base of the footings in excess of the minimum surrounding overburden pressure.

- Alternately, the footings could be deepened to bear within the native clay to utilize higher allowable bearing pressures. Footings bearing within undisturbed, stiff or very stiff, native clay soils could be designed for a maximum net allowable total load bearing pressure of 2,500 psf.

- Footings in the partial basement areas (likely 8 or 9 feet below present grade) are expected to bear in the highly weathered clay shale. Footings bearing within undisturbed, highly weathered clay shale could be designed for a maximum net allowable total load bearing pressure of 3,000 psf.

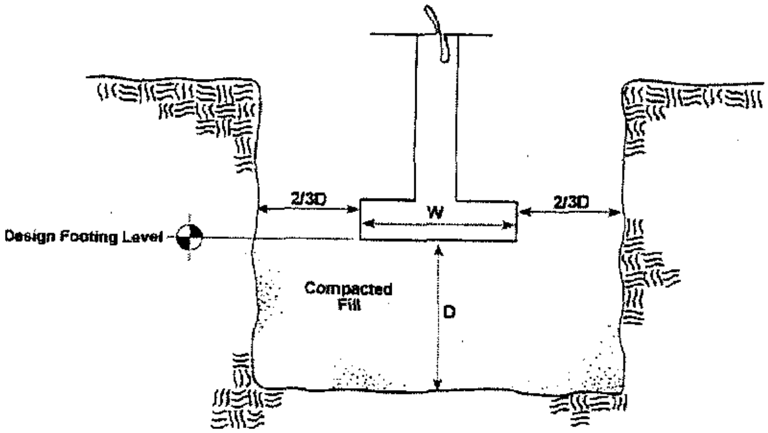
We recommend locating the base of all perimeter footings at least 3.5 feet below final outside grade to provide protection from frost heave and to reduce the magnitude of shrinking and swelling of the bearing materials that could occur due to seasonal variations in subgrade moisture content. Perimeter footing depth could be reduced to 2.5 feet below final outside grade where pavements abut the building structure.

Continuous-formed footings should have a minimum width of at least 16 inches, and isolated column footings should have a minimum width of at least 30 inches. Earth-formed trench footings also appear feasible. Trench footings should have a minimum width of at least 12 inches.

We expect long-term foundation settlement of footings bearing within approved engineered fill, stiff or very stiff native clay soils, and/or undisturbed highly weathered shale to be about 1 inch, or less. We do not expect differential settlement across the structures to exceed about one-half this value.

Regarding construction of footings, we generally anticipate that material suitable for support of the design bearing pressure will be present at the base of the footings. However, there is a possibility that isolated zones of soft, low density fill or native soils could be encountered below footing bearing level, even though field density tests are expected to be performed during fill placement operations. Therefore, we recommend the base of all footing excavations be observed and evaluated by the geotechnical engineer prior to placing reinforcing steel and concrete to determine if additional footing excavation depth is needed.

If unsuitable bearing materials are encountered at the time excavations for foundations are made, corrective procedures should be implemented. Corrective procedures could include deepening footing excavations until suitable bearing materials are encountered and filling this overexcavation with lean concrete. As an alternative, an overexcavation and backfill procedure (see the diagram below) could be utilized to support footings, wherein the overexcavation is backfilled with an approved granular material, such as silty gravel meeting K.D.O.T. AB-3 requirements.



Side walls should be sloped or braced for stability as required by OSHA. Care should be taken to prevent wetting or drying of the bearing materials during construction. Extremely wet or dry material, or any loose or disturbed material in the bottom of the footing excavations should be removed before reinforcing steel and foundation concrete is placed.

6.4 Below-Grade Pool Wall/Floor Considerations

Pool Bottom Preparation: The pool bottom and sidewall performance also depends on the swell potential of the subgrade materials. We expect that the cuts needed to develop design grade for the pool would place the bottom of the pool excavation in relatively moist, fat clay or possibly highly weathered shale. We recommend constructing an LVC zone at least 12 inches thick (including the drainage layer described below) below the proposed pool floor and adjacent to the sides of the pool to reduce the swell potential of the subgrade soils. In addition, upper 12 inches of the subgrade below the LVC layer at the pool bottom should be evaluated by the geotechnical engineer. If this subgrade is less than 3 percentage points above OMC, the subgrade should be over-excavated, moisture conditioned, and recompacted to the requirements for *"Additional Fill"* as stated in Section 6.2.

Pool-Lateral Earth Pressure and Groundwater Considerations: During construction, the sides of the pool excavations should be sloped or braced for stability to comply with OSHA criteria. The pool walls will be subjected to unbalanced lateral forces and possibly hydrostatic pressure. Hydrostatic pressures could develop on these walls during construction after periods of heavy rains. Also, hydrostatic pressures develop on the walls if leaks in utility lines were to occur during the life of the structure. Much of the time, if hydrostatic forces develop outside the pool walls, these forces will be at least partially counteracted by fluid pressure within the water-filled structure. However, some unbalanced lateral/uplift stresses could be present during maintenance and clean out operations. For these reasons, we recommend that pool walls be designed to resist the force generated by saturated materials having an equivalent fluid density of 100 pcf. An equivalent fluid density of 70 pcf could be used if a 1-foot wide zone of free-draining, granular backfill is placed next to the wall and a drain line with sump and pump are provided.

6.5 Partial Basements

Basement Lateral Earth Pressure: During construction, the sides of the excavations should be braced or sloped for stability. We recommend that basement walls be designed for earth pressure conditions as presented on the diagram in Appendix C. Please note that this is for "at rest" stress distribution conditions, based on the condition of no wall rotation. No factor of safety or hydrostatic loading of the walls are included in these load distributions. Resistance to horizontal forces can be developed by considering the friction that occurs along the bottom of the footing. We recommend a friction factor of 0.35 be used for design purposes.

Basement Groundwater Considerations: Based on the observed, short-term water level measurements, it appears that the basement excavation will be above the groundwater table. However, since fluctuations in groundwater table conditions are expected to occur, it is possible that the groundwater table could, at some time, rise above basement level. Also, surface water can collect in basement wall backfill after periods of heavy rain.

To prevent hydrostatic loading on basement walls and slabs, we recommend a perforated, rigid plastic or metal drain pipe with a minimum diameter of 4 inches be installed both inside and outside the basement walls at levels at least 1 foot below the basement floor. The drain should provide positive gravity drainage or drain to sumps equipped with pumps.

To prevent intrusion of fines, the drain line should be surrounded by a minimum of 6 inches of appropriately-sized granular filter material. As an alternative, the drains could be surrounded with at least 6 inches of free-draining granular material and the granular material encapsulated with suitable filter fabric.

The area above the perimeter drain extending at least 24 inches out from the wall should be backfilled with free-draining coarse sand containing not more than 1% material passing the #200 sieve. We recommend the upper 2 feet of backfill at the building perimeter be cohesive material, to reduce the infiltration of surface water into the perimeter drain system.

Even with perimeter drains, it is possible that the basement slab could be subjected to hydrostatic forces, if the groundwater table were to rise above basement level. Although at present the groundwater table appears to be below the typical basement level of about 8 or 9 feet, in our opinion, at some time during the life of the structure, the groundwater table (or perched groundwater) could rise above basement level. Therefore, we recommend that under-slab drains (4-inch diameter and wrapped in filter cloth) be installed in addition to perimeter drains.

Under-slab drains should extend parallel to the long dimension of the basement and be spaced on approximately 15-foot centers and drain to the sump/pump. The under-slab drain should be placed in a drainage blanket at least 6 inches thick and constructed of free-draining granular material, such as UD-1, as specified by the K.D.O.T.

Basement Floor Preparation: We expect that the cuts (8 to 9 feet) needed to develop design grade for the partial basements would place the bottom of the basement excavations in the highly weathered shale. We recommend constructing an LVC zone at least 12 inches thick (including the drainage layer described above) below the proposed basement floor to reduce the swell potential of the subgrade soils. In addition, upper 12 inches of the subgrade below the LVC zone at the basement floor should be evaluated by the geotechnical engineer. If this subgrade is less than 3 percentage points above OMC, the subgr ade should be over-excavated, moisture conditioned, and recompacted to the requirements for *"Additional Fill"* as described in Section 6.2.

6.6 Additional Design and Construction Recommendations

We recommend the sides of all excavations be sloped or braced for stability during construction to comply with applicant OSHA regulations.

The project specifications could be written to state the subgrade moisture-conditioning/recompaction activity as separate, unit-price, line items on the project bid documents as subgrade moisture conditions could change significantly before construction.

We recommend that all HVAC supply/return ducts be above floor level as air-flow and heat transfer through these ducts can cause substantial post-construction drying and shrinkage of clay subgrade and result in severe floor slab/interior wall distress.

The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer and slab contractor should refer to ACI 302 for procedures and cautions regarding the use and placement of a vapor retarder.

Fill Construction Observation and Testing: The exposed subgrade and each lift of compacted fill should be tested, evaluated, and reworked, as necessary, until approved by the geotechnical engineer's representative prior to placement of additional lifts. We recommend that each lift of fill be tested for density and moisture content at a frequency of one test for every 2,500 square feet of compacted fill in the building area and 5,000 square feet in pavement areas. We recommend one density and moisture content test for every 50 linear feet of compacted utility trench backfill.

6.7 Pavements

Pavement Subgrade Preparation: We recommend removal of vegetation and organic topsoil from the areas to be paved. The exposed subgrade should then be proofrolled as described previously in the *Site Preparation* section of this report. Following any cuts needed and proofrolling procedures, the upper 8 inches of resulting exposed subgrade prior to fill placement should be compacted to at least 95% of MDD by ASTM D-698 at moisture contents at least 2 percentage point above OMC. Any additional fill should be approved material free of organic matter and debris that is placed in lifts not to exceed 9 inches in loose thickness and compacted to at least 95% of MDD at moisture contents meeting the requirements stated previously for additional fill.

The final 8 inches of material directly below flexible pavements should be compacted to at least 98% of standard Proctor MDD. The final 18 inches of subgrade beneath rigid, Portland cement concrete pavements and exterior slabs should meet the compaction and minimum moisture recommendations stated for additional fill in this report, which may require removal and reworking or replacement.

We recommend modifying the final subgrade in pavement areas to improve subgrade support and because of the tendency for rutting in untreated wet cohesive subgrades by the paving spreader and loaded dump trucks during the paving operation. The final subgrade should be constructed of one of the following:

- Modifying the subgrade with Class C fly ash or hydrated lime
- Constructing a granular subbase of silty gravel (meeting KDOT requirements for AB-3 base)
- Constructing a crushed concrete or clean limestone subbase over a geo-grid

If used, we recommend applying Class C fly ash contents of 14% to 16% or hydrated lime contents of 4% to 6% based on the dry weight of the soil. Because of the potentially severe deleterious heave that could result if hydrated lime is used to modify shaley material that contain sulfates, such as gypsum zones or seams, we recommend that shale or existing fill that includes reworked shale **not be modified** with hydrated lime unless extensive additional laboratory and field testing is performed to determine if excessive sulfates are present and if they would react adversely with the hydrated lime. The final subgrade described above should be compacted to at least 98% of standard Proctor MDD. The moisture content of the hydrated lime or fly ash modified soils should be within 2 percentage points of OMC (ASTM D-698) beneath asphaltic concrete pavements and above OMC beneath portland cement concrete pavements. The modified zone should extend at least 2 feet beyond the edges of the pavements. Soils mixed with Class C fly ash should be compacted within 2 hours following blending operations. Recognized guidelines, such as those specified by the City of Wichita or K.D.O.T. (including minimum mixing temperatures), should be followed in the mixing and blending of hydrated lime or fly ash-modified material. If fly ash soils are disturbed or become wetted excessively after the initial set has occurred, it may be necessary for additional amounts (8% to 10%) of fly ash to be mixed into the disturbed subgrade, and then moistened and recompacted. If used, the crushed concrete or limestone subbase material should be compacted at workable moisture content.

Typical Pavement Thickness: The following table represents typical minimum thicknesses of pavements constructed on modified subgrades for similar projects. These typical pavement thicknesses assume periodic maintenance will be performed throughout the life of the pavement.

TYPICAL MINIMUM PAVEMENT SECTIONS (Inches)

	CAR PARKING & DRIVE AREAS LIGHT DUTY*		TRUCK DRIVE AREAS MEDIUM DUTY**	
PORTLAND CEMENT CONCRETE: Air Entrained 4,000 Psi Compressive *650 Psi Flexural*		5.0		6.0
ASPHALTIC CONCRETE: Surface Course (BM-2, KDOT Mix) and Base Course (BM-4, KDOT Mix)	2.0 3.5		2.0 5.0	
MODIFIED SUBGRADE: Class C Fly Ash (about 14% to 16%) or Hydrated Lime (about 4% to 6%) or Crushed Limestone (Silty Gravel) meeting KDOT Specification AB-3 or Crushed Concrete or Limestone on Tensar BX 1100 geo-grid or Mirafi 370 (or equivalent) 5-inch thickness beneath parking areas 7-inch thickness beneath drives	8.0	8.0	8.0	8.0

*Based on automobile traffic only. Heavier traffic loads (such as wandering heavy trucks) would require greater pavement thickness (a minimum of 6 inches)

**Based on 15,000 moderate to heavy trucks during the life of the pavement in drive areas. Higher traffic loads would require greater pavement thickness

We recommend dumpster pickup areas be constructed using at least 7 inches of reinforced concrete pavement. Minimizing subgrade saturation is an important factor in maintaining subgrade strength. Water allowed to pond on or adjacent to the pavement could saturate the pavement subgrade and cause premature pavement deterioration. We recommend sloping all pavement surfaces to provide rapid surface drainage. Typically, 2% slopes are used to facilitate rapid surface drainage. Positive surface drainage beyond the edge of the paved areas should be maintained. Design measures that could reduce the risk of subgrade saturation and improve long-term pavement performance would include crowning the pavement subgrades to drain toward the edges of the pavement area, rather than to the center, and installing surface drains next to any area where surface water can pond. Also, all pavement joints and cracks should be sealed to prevent the infiltration of surface water. Thicker pavement sections will reduce the necessity for regular maintenance over the design life of the pavement.

Preventive maintenance provides the highest return on investments for pavements and should be planned and provided for through an on-going pavement management program. Preventive maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Preventive maintenance consists of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing).

Openings in pavements, such as foliage areas installed to comply with landscape code requirements, are sources for water to collect and migrate beneath pavements thereby degrading the subgrade support and increasing the potential for frost damage. This is especially applicable for islands with raised concrete curbs, irrigated foliage, and near-surface site soils of impervious clay. The civil design for the pavements with these conditions should include features to restrict, or to collect and discharge excess water from the islands. This could include:

- Installing an impervious membrane liner beneath the entire island. As a minimum, rolled sheeting should be installed around the perimeter of the island that seals against the concrete curb of the island and extends from the ground surface to a depth of at least 3 feet.
- Alternately, trench drains could be installed around the perimeter of the islands at depths of 2 or 3 feet and backfilling them with free-draining granular material. The trench drains should be connected to: sumps with pumps; collector drain lines that flow to storm sewers or positive outfalls; or, possibly, deep, vertical aggregate drains.

Pavement design methods are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support. The support characteristics of the subgrade for pavement design do not account for shrink/swell movements of a moderately expansive clay subgrade such as the soils encountered on this project. Thus, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade. It is, therefore, important to minimize moisture changes in the subgrade to reduce shrink/swell movements.

We recommend the pavement areas be rough graded and then thoroughly proofrolled with a loaded tandem axle dump truck prior to final grading and paving. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills. All pavement areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to paving.

Site grading is generally accomplished early in the construction phase. However, as construction proceeds, the subgrade may be disturbed due to utility excavations, construction traffic, desiccation, or rainfall. As a result, the pavement subgrade may not be suitable for pavement construction and corrective action will be required. The subgrade should be carefully evaluated at the time of pavement construction for signs of disturbance or excessive rutting. If disturbance has occurred, pavement subgrade areas should be reworked, moisture conditioned, and properly compacted to the recommendations in this report immediately prior to paving.

7.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide testing and observation during excavation, grading, foundation and construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be under taken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

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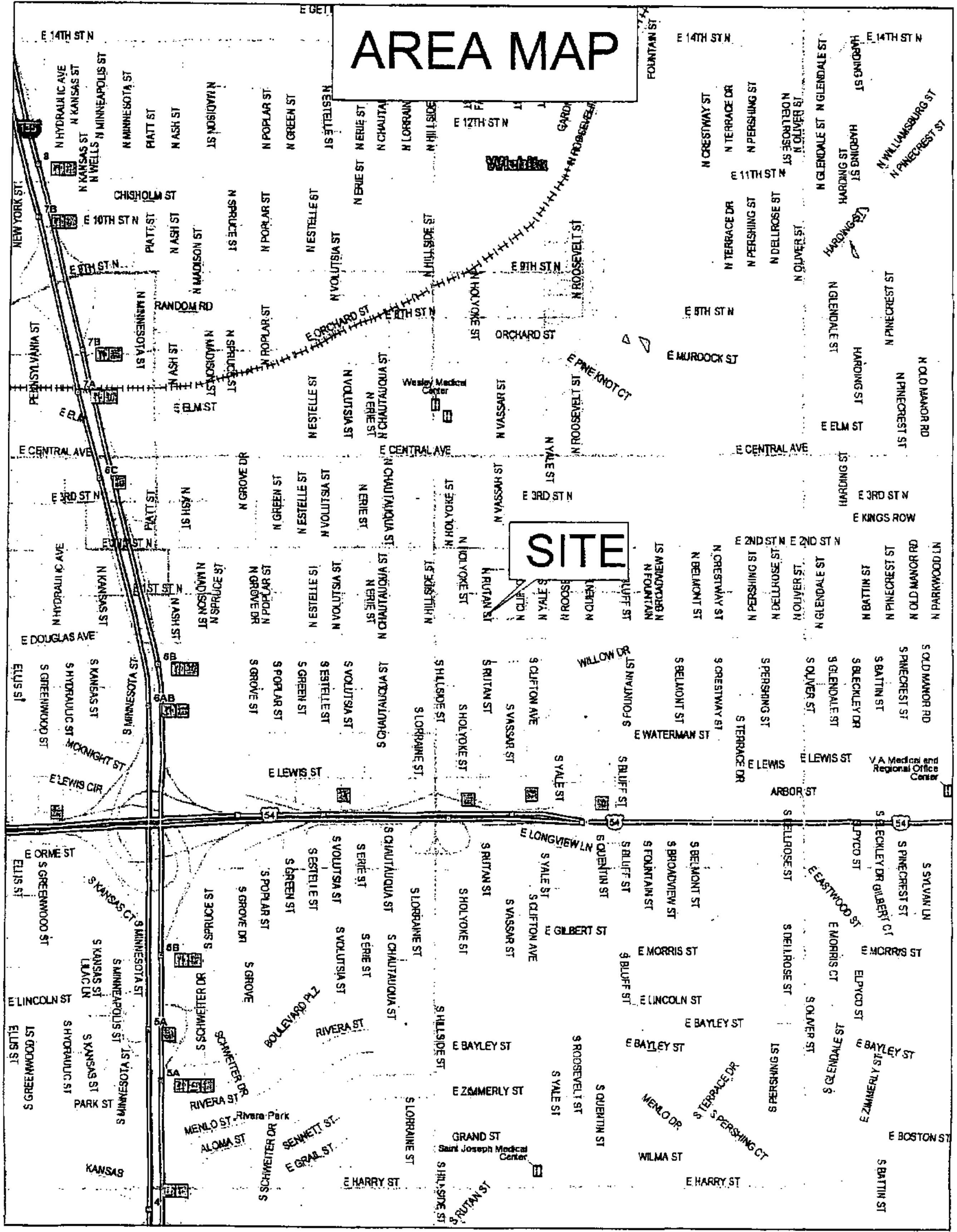
DeLORME Street Atlas USA® 2005



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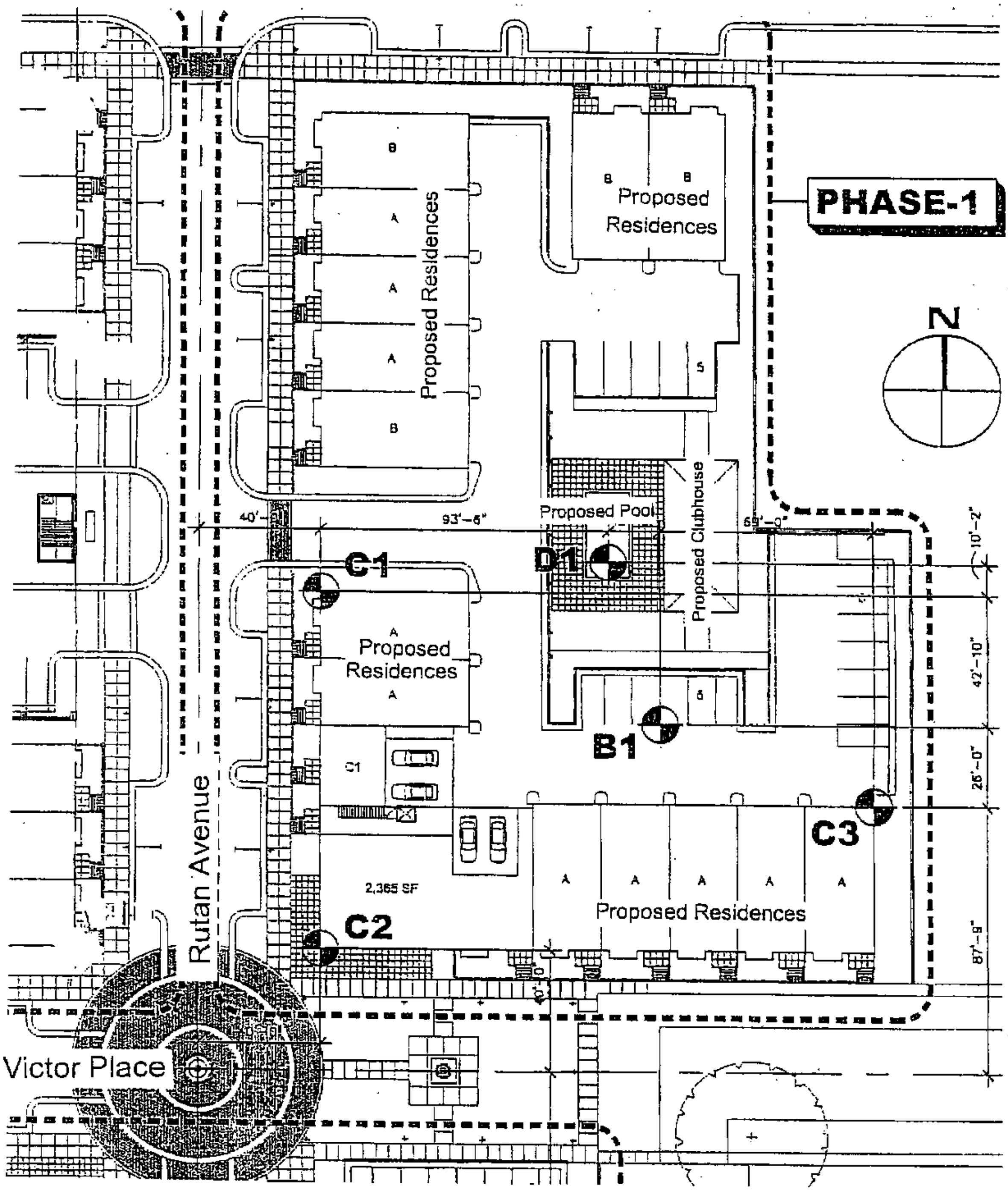
Data Zoom 13-2



BORING LOCATION DIAGRAM

Proposed Parkstone Development-Phase 1
Douglas at Hillside
Wichita, Kansas

Job #	01075066	Date	Jun-07	Scale:	0 50'

Terracon

LOG OF BORING NO. B-1

Page 1 of 1

OWNER **Parkstone at College Hill**	ARCHITECT **Gossen-Livingston Associates**
SITE **Douglas near Hillside Wichita, KS**	PROJECT **Proposed Condominiums**

GRAPHIC LOG	DESCRIPTION Approx. Surface Elev.: 100.5 ft		DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	TYPE	RECOVERY, in.	SPT - N BLOWS / ft.	TESTS WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf
0.5	Asphalt pavement 5"	100				PA					
2	**FILL:LEAN TO FAT CLAY** Very dark gray-brown	98.5			1	SS	18	10	18		5000*
	FAT CLAY Olive-gray with yellow-brown, very stiff					PA					
				CH	2	ST	18		25	101	6500*
6		94.5	5			PA					
	HIGHLY WEATHERED CLAY SHALE** Olive-gray										
10	Trace limestone below 9'	90.5			3	SS	18	18	33		6000*
	BOTTOM OF BORING		10								

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

*Calibrated Hand Penetrometer

WATER LEVEL OBSERVATIONS, ft			
WL	▽ Dry	WS	▼ Dry AB
WL	▽		▽
WL			

Terracon

BORING STARTED			5-15-07
BORING COMPLETED			5-15-07
RIG	978	DRILLER	CD
APPROVED	KJS	JOB #	01075066

LOG OF BORING NO. C-1

Page 1 of 1

OWNER **Parkstone at College Hill**	ARCHITECT **Gossen-Livingston Associates**
SITE **Douglas near Hillside** **Wichita, KS**	PROJECT **Proposed Condominiums**

GRAPHIC LOG	DESCRIPTION Approx. Surface Elev.: 98.5 ft		DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT - N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, psf
0.5	Asphaltic Pavement - 5"	98				PA					
	FILL:LEAN CLAY Very dark gray-brown				1	SS	18	6	22		2000*
3		95.5				PA					
	HIGHLY WEATHERED CLAY SHALE** Olive to olive gray- with yellow				2	ST	18		24	107	9000*
			5			PA					
	Dark olive-gray mottled yellow below 8'				3	SS	18	27	28		9000+*
			10			PA					
					4	SS	18	9	28		8500*
			15			PA					
18		80.5									
	MODERATELY WEATHERED SHALE** With gypsum seams, gray				5	SS	17	47 50/5"	24		9000+*
20		78.5	20								
	BOTTOM OF BORING										

**Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

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

*Calibrated Hand Penetrometer

WATER LEVEL OBSERVATIONS, ft			
WL	∇ Dry	WS	▼ Dry AB
WL	∇		▼
WL			

Terracon

BORING STARTED			5-15-07
BORING COMPLETED			5-15-07
RIG	978	DRILLER	CD
APPROVED	KJS	JOB #	01075066

LOG OF BORING NO. C-2

Page 1 of 1

OWNER **Parkstone at College Hill**	ARCHITECT **Gossen-Livingston Associates**
SITE **Douglas near Hillside** **Wichita, KS**	PROJECT **Proposed Condominiums**

GRAPHIC LOG	DESCRIPTION Approx. Surface Elev.: 98.0 ft		DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT - N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, psf
	0.5 Concrete pavement 5" thick	97.5				PA					
	FILL:LEAN CLAY Trace sand, very dark gray-brown				1	SS	18	2	29		
						PA					
	4	94									
	FAT CLAY Olive-gray, stiff			CH	2	SS	18	11	21		3000*
			5			PA					
	8	90									
	HIGHLY WEATHERED CLAY SHALE** Light olive-gray, mottled yellow				3	SS	18	16	35		5000*
			10			PA					
	Olive-gray to gray, blocky below 13'				4	SS	18	28	25		7000*
			15			PA					
					5	SS	18	32	30		5500*
	20	78	20								
	BOTTOM OF BORING										

**Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

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

*Calibrated Hand Penetrometer

WATER LEVEL OBSERVATIONS, ft			
WL	∇ 3.0 WD	▼ 1.0 AB	
WL	∇	∇	
WL			

Terracon

BORING STARTED			5-15-07
BORING COMPLETED			5-15-07
RIG	978	DRILLER	CD
APPROVED	KJS	JOB #	01075066

LOG OF BORING NO. C-3

Page 1 of 1

OWNER **Parkstone at College Hill**	ARCHITECT **Gossen-Livingston Associates**
SITE **Douglas near Hillside** **Wichita, KS**	PROJECT **Proposed Condominiums**

Approx. Surface Elev.: 102.0 ft

Depth, ft	DESCRIPTION	Elev., ft
0.5	Asphalt pavement 5" thick	101.5
3	**FILL:LEAN CLAY** Very dark gray-brown	99
8	**LEAN CLAY** Dark gray-brown, stiff	94
20	**HIGHLY WEATHERED CLAY SHALE**** Olive-gray and yellow, very stiff Olive-gray below 13'	82

BOTTOM OF BORING

**Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

USCS SYMBOL	SAMPLES NUMBER	TYPE	RECOVERY, in.	SPT - N BLOWS / ft.	TESTS WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf	
		PA						
	1	SS	18	3	15		3000*	LL=31 PL=15 PI=16
		PA						
CL	2	SS	18	9	21		2000*	LL=35 PL=16 PI=19
		PA						
	3	SS	18	17	19			
		PA						
	4	SS	18	18	33		7000*	
		PA						
	5	SS	18	33	24		9000*	

DEPTH, ft.: 5, 10, 15, 20

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

*Calibrated Hand Penetrometer

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 7 WD	▼ Dry	AB
WL	▽	▽	
WL			

Terracon

BORING STARTED			5-14-07
BORING COMPLETED			5-14-07
RIG	978	DRILLER	CD
APPROVED	KJS	JOB #	01075066

LOG OF BORING NO. D-1

Page 1 of 1

OWNER **Parkstone at College Hill**	ARCHITECT **Gossen-Livingston Associates**
SITE **Douglas near Hillside** **Wichita, KS**	PROJECT **Proposed Condominiums**

Approx. Surface Elev.: 101.0 ft

Depth	DESCRIPTION	Elev.
0.5	Asphalt pavement 7" thick	100.5
1	Concrete pavement 5" thick	100
3	**FILL:FAT CLAY** Very dark olive-gray	98
15	**HIGHLY WEATHERED CLAY SHALE**** Light gray, gypsiferous Becoming olive to red and blocky below 7'	86
	BOTTOM OF BORING	

**Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

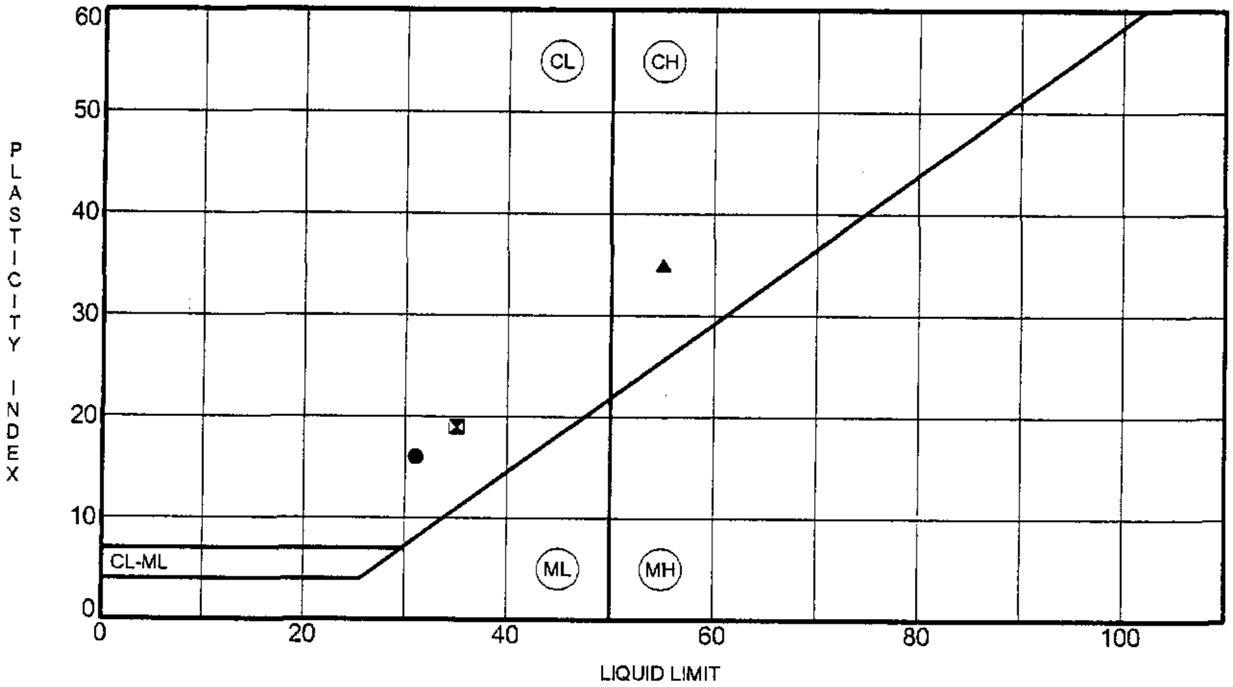
DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS			
		NUMBER	TYPE	RECOVERY, in.	SPT - N BLOWS / ft.	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf	
			PA						
		1	SS	18	7	26		3000*	LL=55 PL=20 PI=35
			PA						
		2	SS	18	9	23		5000*	
5			PA						
		3	SS	18	21	31		9000+*	
10			PA						
		4	SS	18	19	29		5500*	
15									

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

*Calibrated Hand Penetrometer

WATER LEVEL OBSERVATIONS, ft				
WL	▽ Dry	WS	▼ Dry	AB
WL	▼		▽	
WL				

BORING STARTED			5-15-07
BORING COMPLETED			5-15-07
RIG	978	DRILLER	CD
APPROVED	KJS	JOB #	01075066



	Specimen Identification		LL	PL	PI	%Fines	Classification
●	**C-3**	**1.0ft**	**31**	**15**	**16**		FILL:LEAN CLAY
☒	**C-3**	**3.5ft**	**35**	**16**	**19**		LEAN CLAY
▲	**D-1**	**1.0ft**	**55**	**20**	**35**		FILL:FAT CLAY

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ATTERBERG LIMITS RESULTS

Project: Proposed Condominiums
Site: Douglas near Hillside Wichita, KS
Job #: 01075066
Date: 6-13-07

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon - 1-^{3}/8" I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube - 2" O.D., unless otherwise noted	PA:	Power Auger
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", N, B	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling	N/E:	Not Encountered
WCI:	Wet Cave in	WD:	While Drilling		
DCI:	Dry Cave in	BCR:	Before Casing Removal		
AB:	After Boring	ACR:	After Casing Removal		

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	<2	Very Soft
500 - 1,000	2-3	Soft
1,001 - 2,000	4-6	Medium Stiff
2,001 - 4,000	7-12	Stiff
4,001 - 8,000	13-26	Very Stiff
8,000+	26+	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
50+	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1-10
Medium	11-30
High	30+

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UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]					Soil Classification	
					Group Symbol	Group Name[B]
Coarse Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]		GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]		GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH		GM	Silty gravel[F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]		SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]		SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH		SM	Silty sand[G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]		CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]		ML	Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit - not dried			Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line		CH	Fat clay[K,L,M]
			PI plots below "A" line		MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried			Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

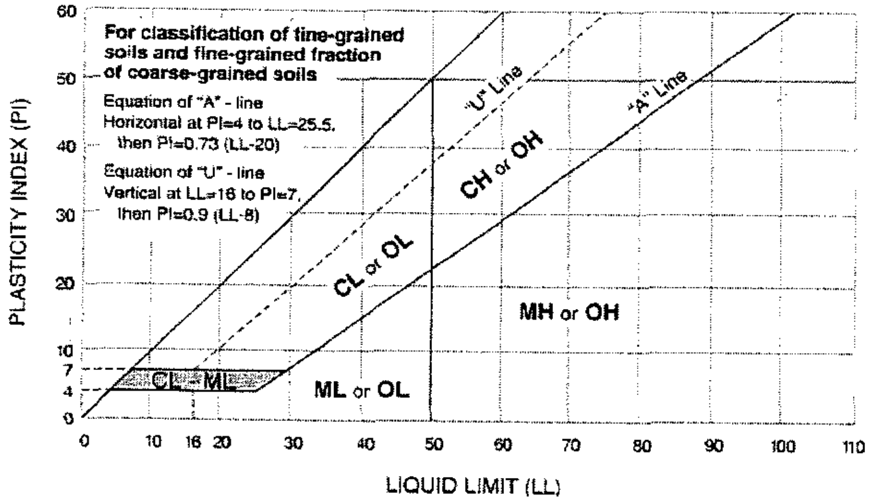
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



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Form 111—6/98

GENERAL NOTES

Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

Sedimentary rocks are composed of cemented clay, silt and sand sized particles. The most common minerals are clay, quartz and calcite. Rock composed primarily of calcite is called limestone; rock of sand size grains is called sandstone; and rock of clay and silt size grains is called mudstone or claystone, siltstone, or shale. Modifiers such as shaly, sandy, dolomitic, calcareous, carbonaceous, etc. are used to describe various constituents. Examples: sandy shale; calcareous sandstone.

LIMESTONE	Light to dark colored, crystalline to fine-grained texture, composed of $CaCo_3$, reacts readily with HCl.
DOLOMITE	Light to dark colored, crystalline to fine-grained texture, composed of $CaMg(CO_3)_2$, harder than limestone, reacts with HCl when powdered.
CHERT	Light to dark colored, very fine-grained texture, composed of micro-crystalline quartz (SiO_2), brittle, breaks into angular fragments, will scratch glass.
SHALE	Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone.
SANDSTONE	Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate.
CONGLOMERATE	Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size (½ inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together.

DEGREE OF WEATHERING:

SLIGHT	Slight decomposition of parent material on joints. May be color change.
MODERATE	Some decomposition and color change throughout.
HIGH	Rock highly decomposed, may be extremely broken.

Classification of rock materials has been estimated from disturbed samples.
Core samples and petrographic analysis may reveal other rock types.

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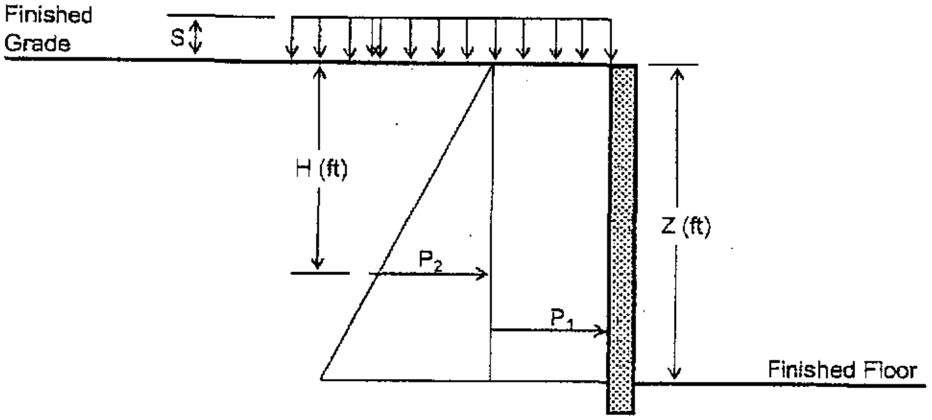
AT-REST EARTH PRESSURE ON 1-FOOT WIDE VERTICAL STRIP

(NO WALL ROTATION)

Clay Backfil

S = Uniform surcharge at grade, load in psf
Z = Wall height (ft)
P_1 = 0.59 x S = Effect of uniform surface surcharge
P_2 = 68 x H = Earth Pressure (drained)
P_2 = 100 x H = Earth Pressure (undrained)



CONDITIONS

- Coefficient of at-rest earth pressure = 0.59
- Units of P_1, P_2 in psf
- Horizontal backfill
- Backfill is compacted to 95% of Standard Proctor maximum dry density
- In-situ soil weight = 116 pcf
- No safety factor included

- Uniform surcharge
- Negligible wall friction
- No ground water acting on wall
- Loading from heavy compaction equipment not included
- No wall rotation