GEOTECHNICAL INVESTIGATION
FOR LUCAS RIDGE SUBDIVISON

Property location:
11010 LUCAS LANE
SOUTH JORDAN, UTAH

Prepared for:
FREISS DEVELOPMENT
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July 13, 2012

PREPARED BY:

WILDING ENGINEERING

14721 SOUTH HERITAGE CREST DRIVE
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APPENDIX

LIST OF TABLES AND FIGURES

1. INTRODUCTION

This report presents the geotechnical investigation for Lucas Ridge Subdivision to be located near the intersection of Lucas Lane and Samee Ridge Drive in South Jordan, Utah, see the Site Map and Vicinity Map in the appendix. The geotechnical investigation was performed in accordance with Wilding Engineering's proposal dated May 2, 2012 and authorized by Dave Freiss.

The field investigation consisted of five (5) test pits excavated to depths ranging from 12 feet to 13 feet below the existing ground surface. Detailed Test Pit Logs (TP-1 through TP-5) can be found in the Appendix. Recommendations in this report are based upon information gathered from the field investigation, site inspection, lab testing, and from reviewing geologic maps and reports of the area.

2. SITE AND PROJECT INFORMATION

2.1. Proposed Project Description

Based on the information provided, the proposed development consists of construction of single family residences with associated utilities and driveways. We understand the houses will be constructed using typical wood framed walls and a below grade basement. Exact Structural loads were not provided at the time of this report. Based on our experience on similar projects, maximum column and continuous wall loads are assumed to be about 50 kips and 4 kip/ft, respectively. We understand that basements are planned and the bottom of the footing is about 7 to 8 feet below existing site grade. A site plan is located in the Appendix of this report.

Recommendations presented in this report are based upon the current available information. If the assumed building loads or any information presented has changed, please inform Wilding Engineering in writing so that we may amend the recommendations presented in this report appropriately.

3.2 Existing Site Conditions

The subject site is located near the southwest corner of intersection of Lucas Lane and Samee Ridge Drive in South Jordan, Utah. More specifically, the site is located at Longitude -111.975516° W and Latitude 40.551095° N.

At the time of our field investigation, the site was vacant land vegetated with various grasses, and some trees in the central portion of the property. We observed an existing single family residence on Lot 6 (see Site Map) of the proposed subdivision and it is our understanding that proposed construction will exclude Lot 6. Current land use in the vicinity of the area is residential.

Based on available topographic information, the east half of the subject site slopes down from east to west about 10 feet. The west half of the site is relatively flat gently sloping downward to the southwest. Ground surface elevation ranged from 4640 feet near the eastern portion of the site to 4625 feet near the western portion of the site. The property is bound by existing Lucas Lane (3510 West Street) on the east, existing single family residences on the north and south, and vacant land on the west side.

3. GENERAL GEOLOGY AND HYDROLOGY

3.1. Surficial Geology

Based on the available geologic maps, the project site is underlain by Lacustrine Sand deposits. The site is mapped with the USGS soil unit; "Qls-Lacustrine sand – Transgressive and regressive shoreline sand; tan, brown, and gray, calcareous, moderately well-sorted, silty, fine-grained sand; grains are mostly quartz, but chert, calcite, biotie, hornblende, and unidentified black grains are present; ranges from 1 to 35 feet (0.3 – 11 m)[1]".

3.2. Geologic Hazards

3.2.1. Faulting

The site is located about 7¾-miles west of the Wasatch Fault Zone, which runs along the foothills of the Wasatch Mountain Range from Davis to Utah County. There is no fault mapped through the project area.

3.2.2. Liquefaction

Liquefaction is a common earthquake condition in which soils lose virtually all shear strength and act as viscous liquids during severe ground shaking. A physical change occurs to the soil transforming it "from solid ground capable of supporting a structure, to a quicksand-like liquid with a greatly reduced ability to bear the weight of a building."[2] Based on the Salt Lake County Hazards map, the site is mapped as having a "very low" potential for liquefaction to occur. This suggests that the probability of liquefaction to occur at the project site is less than five (5%) percent in 100 year return period.

4. FIELD EXPLORATIONS

5.1 Subsurface Investigation

Subsurface conditions at the project site were evaluated with five (5) test pits designated as TP-1 through TP-5 as indicated on Site Map with Test Pit Locations presented in the Appendix. The test pits were excavated using a backhoe to depths ranging from 12 feet to 13 feet below the existing site grades at locations presented in Figure A-2 in Appendix. Stratigraphy and classification of the soils were logged under the direction of a geotechnical engineer.

Disturbed and undisturbed samples were obtained at various depths and examined in the field and representative portions were stored in sealed plastic bags. The samples

[1] Geologic Map of the Midvale Quadrangle, Salt Lake County, Utah; U.S. Geological Survey, Fitzhugh D. Davis, 2000.
[2] Liquefaction- A Guide To Land Use Planning, Craig V. Nelson, S.L. County Public Works- Planning Division.

were transported to our laboratory for further examination and testing. The test pit was backfilled to the ground surface with on-site soils. Sample types with depths are shown in detail in the Test Pit Logs found in the Appendix.

5.2 Subsurface Conditions

5.2.1 Soils

The soil profile generally consists of Silty Sand (SM), Silt with Sand (ML), and Lean Clay (CL) to the maximum depth explored of about 13 feet. For a detailed description of the materials and conditions encountered at test pit locations, please refer to the Test Pit Logs in the Appendix.

The subsurface profile description above is a generalized interpretation provided to highlight the major subsurface stratification features and material characteristics. The test pit log included in the Appendix should be reviewed for more specific information. The stratifications shown on the test pit logs represent the conditions only at the test pit log locations. The stratifications represent the approximate boundary between subsurface materials and the transition may be gradual.

5.2.2 Groundwater

Groundwater was not encountered in any of the test pits to the maximum depth of exploration of 13 feet below existing site grades. It should be noted that it is possible for the groundwater levels to fluctuate during the year depending on the season and climate. Additionally discontinuous zones of perched water may exist at various locations and depths beneath the ground surface. This could result in encountering groundwater conditions during construction which may have been different than during our field investigation. If the groundwater level encountered during construction, Wilding Engineering must be notified to observe changing conditions and provide recommendations.

6 LABORATORY TESTING

Representative soil samples were tested to evaluate physical and engineering properties. Laboratory testing included: natural water content, grain size analysis, and Atterberg Limit. Lab results are presented on the Test Pit Logs and Summary of Lab Results in the Appendix.

7 RECOMMENDATIONS AND CONCLUSIONS

7.1 Geotechnical Discussion

Wilding Engineering, Inc. has provided the following recommendations based on the information provided by the client and the soils encountered during our field investigation for the proposed construction. The proposed site is suitable for the development of the residential property if the recommendations of this report are followed.

7.2 Site Work

7.2.1 Site Preparation

It is the contractor's responsibility to locate and protect all existing utility lines, whether shown on the drawings or not.

In general six (6) inches of topsoil was encountered during our investigation. All topsoil or any soil containing organic or deleterious materials shall be removed from the site where structures or pavement are to be placed. Topsoil may be stockpiled on site for subsequent use in landscape areas. Any unsuitable material (loose, soft, saturated, or otherwise unstable soils where structures are to be placed), shall be replaced with structural fill according to the standards set forth in section 7.2.3 and 7.2.4 of this report.

Upon completion of site grubbing and prior to placement of any fill, the exposed subgrade should be evaluated by a representative of the Geotechnical Engineer. Proof rolling with loaded construction equipment may be a part of this evaluation. Soils that are observed to rut or deflect excessively (typically greater than 1-inch) under the moving load of a loaded rubber-tired dump truck or other suitable construction vehicle should be over-excavated down to firm undisturbed native soils and backfilled with properly placed and compacted structural fill.

We recommend that site preparation, earthwork, and pavement subgrade preparation be accomplished during warmer, drier months, typically extending from mid-May to mid-October of the year. Any modifications to the grading plans should be reviewed by the Geotechnical Engineer.

7.2.2 Excavation Consideration

All excavations shall be carefully supported, maintained, and protected during construction in accordance with OSHA Regulations as stated in 29 CFR Part 1926. It is solely the responsibility of the contractor to have safe working conditions. Temporary construction excavations should be properly sloped or shored, in compliance with current federal, state, and local requirements.

Wilding Engineering does not assume responsibility for construction site safety or the contractor's or other parties' compliance with local, state, and federal safety or other regulations. As stated in the OSHA regulations, "a competent person shall evaluate the soil exposed in the excavations as part of their safety procedures". In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations.

7.2.3 Structural Fill Material

Structural fill shall consist of well-graded granular material, with a maximum aggregate size of 2 inches, and a maximum of 15% passing the #200 sieve. The fill material which is finer than the number 40 sieve shall have a liquid limit (LL) less than 35 and a Plastic Index (PI) less than 25, see table 7.1 for gradation specification. This material shall be free from organics, garbage, frost, and other loose, compressible, or deleterious materials.

Table 7.2.3 Structural Fill Requirements

Grain Size	Percent Passing
2-inch	100
¾-inch	85 to 100
No. 4	15 to 45
No. 200	< 15
Plastic Index (PI)	< 25
Liquid Limit (LL)	< 35

Fine-grained materials (clays and silts) are not suitable for use as fill in areas that will be carrying a structural load such as roads, buildings, and utility trenches in roadways. However, they may be used as site grading fills in landscaped areas.

7.2.4 Fill Placement and Compaction

Fill under interior floor slabs, driveway, and utilities should be placed in nine (9) inch lifts (loose) and shall be compacted to at least 95% of the modified proctor (maximum dry density as determined by the ASTM D 1557 method of compaction). Landscaped areas are to be compacted to at least 90% of the modified proctor. Each lift shall be tested for adequate compaction (see section 7.3.1 for fills placement and compaction under foundations).

7.2.5 Utility Trenches

Construction of the pipe bedding shall consist of preparing an acceptable pipe foundation, excavating the pipe groove in the prepared foundation and backfilling from the foundation to 12 inches above the top of the pipe. All piping shall be protected from lateral displacement and possible damage resulting from impact or unbalanced loading during backfilling operations by being adequately bedded. In our experience individual municipalities will have local requirements regarding installation of utilities. However, in the absence of specified requirements the following is recommended:

The soils in the utility pipe zones are fine grained. These soils are not suitable as trench backfill as they do not meet the specified structural fill requirements in Section 7.2.4.

> **Pipe foundation:** shall consist of native soils if the soils are stable and undisturbed. Wherever the trench subgrade material does not afford a sufficiently solid foundation to support the pipe and superimposed load, the trench shall be excavated below the bottom of the pipe to such depth as may be necessary, and this additional excavation filled with compacted well-graded, granular soil (per 7.2.4), compacted to 95% of the modified proctor.

Pipe groove: shall be excavated in the pipe foundation to receive the bottom quadrant of the pipe so that the installed pipe will be true to line and grade. Bell holes shall be dug after the trench bottom has been graded. Bell holes shall be excavated so that only the barrel of the pipe bears on the pipe foundation.

Pipe bedding: (from pipe foundation to 12 inches above top of pipe) shall be deposited and compacted in layers not to exceed 9 inches in uncompacted depth. Deposition and compaction of bedding materials shall be done simultaneously and uniformly on both sides of the pipe. All bedding materials shall be placed in the trench in such a manner that they will be scattered alongside the pipe and not dropped into the trench in compact masses.

Backfill for utility trenches located beneath roads, driveways, sidewalks or building foundations shall be compacted to 95% of the modified proctor. In non-load bearing areas (landscape), trenches shall be compacted to 90% of the modified proctor (ASTM D 1557).

7.2.6 Native Soil As Fill

The native soils generally consist of silty sand and clayey soils in the upper 5 feet. Clayey and silty soils are generally not acceptable as fill, because of the difficulty in achieving compaction due to their moisture sensitivity. We recommend that a well-graded granular material be imported. Any tested fill material that does not achieve either the required dry density or moisture content requirements should be recorded, the location noted, and reported to the contractor and owner. A retest of that area shall be performed after the contractor has completed all necessary remedial measures including moisture conditioning (wetting to drying) and reworking the fill.

7.2.7 Surface Drainage

A grading and drainage plan shall be prepared for the site by a qualified engineer, and adhered to for the site drainage. Generally, the building site shall be graded in such a manner that surface water will flow away from the buildings foundations. Natural drainage is generally from east to west. Surface water should be prevented from entering trenches during construction. An embankment may be used to divert any storm water from construction areas and directed into temporary retention basin.

7.3 Foundations

7.3.1 Installation and Bearing Material

Footings must be placed entirely on firm undisturbed native soils or entirely on structural fill which is bearing on native soils and is compacted to 95% of the modified proctor (maximum dry density as determined with ASTM D1557 method of test). Any existing topsoil shall be removed from the areas where footings are to be located. All load bearing soils which are disturbed or considered soft or loose areas are unsuitable for support for foundations and should be removed down to firm native soils and properly replaced and compacted with structural fill within ±2% of the optimum moisture content.

All organic material, soft areas, frozen material or other inappropriate material shall be removed from the footing zone to a depth determined by the Geotechnical Engineer and be replaced with structural fill. Foundations shall have minimum dimensions of 18-inches for continuous wall footings and 24-inches for isolated column footings correlating to the prescribed bearing pressure. Footings placed on slopes shall be "benched" so that all footing bases are horizontal and do not follow the natural slope.

Footing excavations shall be inspected by a Geotechnical Engineer prior to placement of structural fill, concrete or reinforcement steel to verify their suitability for placement of the footings.

7.3.2 Bearing Pressure

Footings bearing on undisturbed native soils may be designed with a maximum allowable bearing capacity of 1,500 psf. Bearing capacity was estimated using Terzaghi's One-Dimensional Consolidation Theory in over-consolidated soils. Consolidation settlement was limited to 1 inch. The recommended allowable bearing pressure refers to the total dead load and may be increased by 1/3 to included the sum of all transient loads including wind and seismic.

The soils encountered in the test pits consisted of predominantly fine grained (cohesive) soils. These soils are "not" considered "free draining". **A footing drain is required in these soil types**.

7.3.3 Settlement

Several factors are generally considered in settlement. They are immediate settlement, consolidation settlement, and secondary settlement. Immediate settlement occurs very quickly, as structures are constructed. Since this factor is generally small and adjustments are made during construction to compensate, this factor is usually neglected. Consolidation and secondary settlement or creep occurs over a very long period of time.

The total settlement is anticipated not to exceed 1-inch, which is the recommended maximum settlement for these types of structures. Differential settlement is expected to approach about 50 to 75 percent of the total settlement under static conditions. Settlement does not control bearing capacity and our recommendation remains 1,500 psf. Settlement calculations are found in the appendix.

7.3.4 Frost Depth

All exterior footings are to be at least 30 inches below the ground surface to protect against possible frost heave. This includes walk-out areas. This may require fill to be placed around buildings. Interior footings require 18 inches of cover. If foundations are constructed through the winter months, all soils on which footings will bear shall be protected from freezing.

7.3.5 Construction Observation

A geotechnical engineer shall periodically monitor excavations prior to installation of footings. Inspection of soil before placement of structural fill or concrete is required to detect any field conditions not encountered in the investigation, which would alter the recommendations of this report. All structural fill material shall be tested under direction of the geotechnical engineer for adequate compaction.

7.4 Lateral Forces

7.4.1 Resistance for Footings

Wind and seismic forces, which cause lateral loads on foundations, are resisted by friction and passive earth pressures at the foundation ground interface. In the design of spread footings against shear forces, the total dead weight is multiplied by the coefficient of friction for lateral sliding (μ) which is estimated to be 0.25 for sands, and the resistance of lateral sliding is 130 psf for clays and silts. [3]

7.4.2 Lateral Earth Pressures on Foundation Walls

The following equivalent fluid weights are given for the design of sub-grade walls and retaining structures. Basement, foundation and retaining walls shall be designed to resist lateral soil loads.

Basement walls and other walls in which horizontal movement is restricted at the top and bottom (non-yielding) shall be designed for at-rest lateral earth pressure based on the equivalent fluid having a unit weight of 55 pcf for horizontal backfill and 70 pcf for backfill slopes upward at 2H:1V (26.7°). At-rest equivalent fluid pressure is a product of the soil unit weight times the coefficient of earth pressure at rest for coarse grained soils (Jaky, 1944) and for cohesive soils the coefficient of earth pressure is estimated using plasticity index properties of on site soils(Massarsch 1979).

Retaining walls free to move and rotate at the top are permitted to be designed for active pressure (Coulombs 1776). **Exception:** Basement walls extending not more than 8 feet below grade and supporting flexible floor systems shall be permitted to be designed for active pressure."[4] Both active and passive earth pressure coefficients and equivalent fluid pressures are provided in Table 7.4.1. Passive earth pressures are typically neglected in design to be conservative. However, they may be used, if required, as it can be expected that they will develop as active pressure increases. The equivalent fluid pressures below assume that the backfill material is fully drained where pore water pressures are not allowed to build up behind the wall.

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[3] International Building Code 2006, Ch. 18, Table 1804.2

[4] International Building Code 2006, Section 1610, Table 1610.1

Table 7.4.2 Static Conditions

Equivalent Fluid Pressures and Coefficients				
Conditions	**$K\gamma$**	**γ**	**K**	**2H:1V Slope**
At-rest ($K_o\gamma$)	55 pcf	100	K_o=0.45	70 pcf
Active ($K_a\gamma$)	35 pcf	100	K_a=0.29	55 pcf
Passive ($K_p\gamma$)	415 pcf	100	K_p=3.45	Not Applicable

7.4.3 Seismic Conditions

Under dynamic conditions, at rest earth pressure for non-yielding walls can be estimated using the procedure presented by Seed and Whitman (1970). The static component is known to act at H/3 above the base of the wall. Seed and Whitman (1970) recommended that it would be appropriate for the dynamic component be taken to act at approximately 0.6H for non-yielding walls. Non-yielding walls can be designed based on a seismic at-rest component of 40 pcf. This component shall be included in addition to the static equivalent at-rest earth pressure value from above.

The Mononobe-Okabe M-O Method (Mononobe and Matsuo (1929); Okabe (1924) and Kapila (1962)) is reused in determining active and passive, respectively, seismic earth pressure coefficients. Determining seismically induced active and passive lateral earth pressures is an extension of the Coulomb theory for static stress conditions. The method entails three fundamental assumptions:

- The driving soil wedge and the retaining structure act as rigid bodies and therefore experience uniform accelerations throughout the respective bodies.
- The driving soil wedge inducing the lateral earth pressures is formed by a planar failure surface starting at the base and extending to the free surface at the top of the wall with backfill. The maximum shear strength of the backfill is mobilized along this failure plane
- Wall movement (flexibility) is sufficient to ensure either active or passive conditions, as the case may be.

Active and passive seismic components have been estimated using the M-O method for seismic design in retaining walls. Coulomb's theory overestimates the passive resistance of walls and is generally neglected in wall design.

Table 7.4.3 Dynamic Conditions

Yielding Wall Dynamic Pressures and Coefficients			
Conditions:	**Component**	**γ**	**K**
Active	65 pcf	100	K'_a=0.65
Passive	226 pcf	100	K'_p=2.25

The active seismic component shall be included in addition to the static equivalent active pressure value and, if relied upon, the passive seismic component shall be included as a reduction in the static passive resistance value.

During backfill placement and compaction below grade or behind retaining walls, the contractor shall use caution. Retaining walls can experience excessive build up of lateral pressures when backfill is over-compacted. We recommend using manual compaction practices (jumping jack, etc.). Avoid unnecessary large equipment or heavy items from being placed or operated within 5 feet of any un-braced concrete foundation wall. Backfill material should meet IBC 2006 requirements and should not have aggregate greater than 3 inches in size.

7.5 Concrete Slabs on Grade

Floor slabs are to be entirely supported on either suitable native soils or on imported structural fill which shall be compacted to 95% of the modified proctor (maximum dry density as determined by the ASTM D 1557 method of compaction) extending to the undisturbed native soils. It is recommended that areas immediately below any exposed concrete, i.e., driveway, sidewalks and patios, be placed with six (6) inches coarse aggregate base to distribute floor loads and provide proper drainage. Floor slabs to receive tile flooring shall have a minimum of four (4) inches of coarse aggregate base placed immediately below slabs. Floor slabs shall have adequate number of joints set by the structural engineer to reduce cracking resulting from any differential movements and shrinkage.

7.6 Seismic Information

7.6.1 Faulting

Based on the Salt Lake County Geologic Hazards Map the project site is located about 7¾-miles west of the Wasatch Fault Zone. Surface rupture has not been mapped and was not observed at the site. The International Building Code (IBC 2006), and the USGS National Earthquake Hazards Reduction Program (NEHRP) interpolated probabilistic ground motion values for S_S an S_1 are 1.12g and 0.44g, respectively. Values from the NEHRP were estimated with 40.551095 degrees and longitude of -111.975516 degrees. (See table below)

	10% PE in 50 year	2% PE in 50 year
Peak Ground Acceleration (PGA)	0.221	0.457
0.2 sec Spectral Acceleration (g)	0.527	1.117
1.0 sec Spectral Acceleration (g)	0.178	0.442

USGS science for a changing world

Figure 7.6.1 USGS Earthquake Hazards Estimated Horizontal Ground Acceleration Maps and Values[5]

The design spectral accelerations were determined according to IBC 2006 and ASCE 07-05 and were found to be 0.78g and 0.46g for S_{DS} and S_{D1} respectively. The figure

[5] Source: http://earthquake.usgs.gov/research/hazmaps/interactive/index.php

below shows the spectral response parameters used to develop the design values and a code specified response spectrum for the site based upon a site class of "D.

Seismic Provisions ASCE 7-05

		Mapped MCE Spectral Response Acceleration Parameters F_a and F_v				
Site Class: D	Short Period	1.6	1.4	1.2	1.1	1.0
	1 Second	2.4	2.0	1.8	1.6	1.5

Obtained S_s and S_1 from http://eqint.cr.usgs.gov/eq-men/cgi-bin/find-ll-2002-interp.cgi

S_S:	1.117	F_a=	1.05	S_{MS}=	1.176	S_{DS}=	0.784
S_1:	0.442	F_v=	1.55	S_{M1}=	0.686	S_{D1}=	0.458

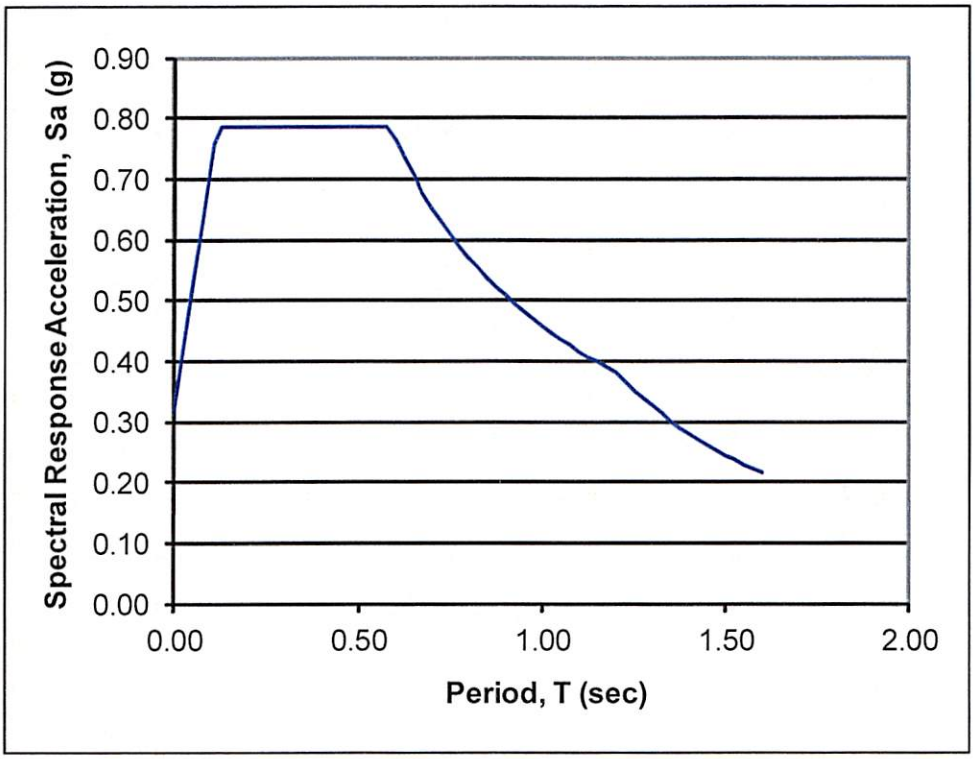

Figure 7.6.2 ASCE 7-05 Seismic Provisions

7.6.2 Liquefaction

A review of the geologic hazards maps for Salt Lake County indicate that the project site is located in an area designated as "very low" in liquefaction potential. This suggests that the probability of liquefaction to occur at the project site is less than 5% in 100 year return period. Liquefaction, should it occur on site, can cause induced ground settlement and lateral spreading, which can result in damage to structures. Three conditions must be present for liquefaction to occur, in soils:

- The soil must be susceptible to liquefaction, i.e., granular layers with less than fifteen percent fines, existing below the groundwater table.
- The soil must be in a loose state.
- Ground shaking strong enough to cause liquefaction.

Groundwater was not encountered in any of the test pits to the maximum depth of exploration of 13 feet below existing site grades. The subsurface exploration indicated soil layers predominantly consisting of fine grained soils with silty sand layers at varied depths to the maximum depth explored of about 13 feet below the existing site grades. Based on the soils encountered, it is our opinion that liquefaction is not likely to occur.

7.6.3 Structures

Structures are to be designed for lateral loading as defined in the International Building Code. The site location has a design spectral response acceleration of 0.78g for short periods (S_{DS}) and 0.46g for a one second period (S_{D1}). Lateral loading is to be the greater of seismic loads or wind loads.

7.7 Pavement Design and Construction

A pavement design has been prepared for the anticipated drive and parking areas to be located in front and around the proposed building. On-site soil characteristics from the test pit samples collected were used in determining soil strength. The pavement design assumptions consist of traffic of about 50,000 Equivalent Single Axle Loads (ESALs) with a twenty (20) year design period of 80% reliability, a California Bearing Ration CBR of 4, standard deviation of 0.35, and Initial and Terminal serviceability of 4.2 and 2.5, respectively. The following sections will provide preparation and design for pavement based on AASHTO design procedures.

7.7.1 Sub-grade Preparation

All topsoil, or any soil containing organic materials, must be removed from locations where structural loads will be applied. To evaluate its stability, the sub-grade shall be "proof rolled" with a loaded dump truck or tested with a nuclear density gauge. Any unsuitable soils shall be removed and replaced with structural fill according to Section 7.2.4. Any areas of fill or disturbed areas shall be compacted to 95% of the ASTM D1557 modified proctor. A geotechnical engineer shall observe unsuitable sub-grade remediation.

7.7.2 Base Course

A minimum of eight (8) inches of untreated base course is required for roadways and parking lot. The base course shall comply with a ¾-inch mix per UDOT Standard Specifications, Section 02721, "Untreated Base Course."

Table 7.7.2 Pavement Design Recommended Thickness

Pavement Materials	Recommended Minimum Thickness (inches)
	Drive Areas
Asphaltic Concrete	3
Granular Base Course.	8

7.7.3 Surface Course

A minimum if three (3) inches of asphalt concrete pavement is required for all roadways and parking surfaces. This asphalt concrete pavement is to comply with UDOT Standard Specifications, Section 02741, and "Hot Mix Asphalt (HMA)."

7.7.4 Concrete Pavement

Concrete pavement is anticipated for the driveway. It is recommended that concrete be used rather than asphalt to aid against excessive future maintenance. We recommend that concrete pavement be designed for a modulus of subgrade reaction, *k*, of 150 pci.

Table 7.7.4 Concrete Design Thicknesses

Pavement Materials	Recommended Minimum Pavement Thickness (inches)
Concrete (4,000 psi)	4
Granular Base Course	6

Sub-grade should meet structural fill requirements and be compacted using typical compaction methods with 95 percent compaction of the maximum dry density within +/- 2% of the optimum moisture determined by ASTM D1557. Prior to placement of concrete the sub-grade should be tested and inspected tested by the Geotechnical Engineer.

Concrete for exposed conditions should meet IBC 2006 requirements with six (6) to five (5) percent air content; maximum temperature of ninety degrees, maximum allowable slump shall not exceed four (4) inches. Joints shall be in a rectangular pattern and spacing shall not exceed thirty (30) times the thickness of the slab. This will allow for expansion and contraction of the concrete with the change in seasons.

7.7.5 Drainage and Maintenance

Drainage shall be designed to ensure direct positive surface water away from proposed buildings and into proper discharge locations. A storm drainage plan is suggested to detain and convey storm water. IBC 2006 recommends that a minimum of five percent gradient for a ten feet distance away from any structures.

The soils encountered in the test pits consisted of predominantly fine grained (cohesive) soils. These soils are "not" considered "free draining". **A footing drain is required in these soil types.**

8 LIMITATIONS AND PROFESSIONAL STATEMENT

This report has been prepared in accordance with generally accepted geologic and geotechnical engineering practices in the area for the use of the client for design purposes. The conclusions and recommendations included within the report are based on the information obtained from the test pits excavated at the locations indicated on the site plan, laboratory results, data obtained from the U.S.G.S. Library, and previous reports and studies. Variations in the subsurface conditions may not become evident until additional exploration or excavation is conducted. If the subsurface soil or ground water conditions are found to be significantly different than that which is described in this report, we should be notified so that we can re-evaluate recommendations.

We have correlated soil types and properties such as bearing pressure and equivalent fluid lateral pressure with U.S.G.S. surveys, the International Building Code, and surrounding investigations. Any assumptions made, based on these correlations, are conservative.

We appreciate the opportunity of providing this service for you. If you have any questions concerning this report or require additional information or services please contact us at 801-553-8112.

Report prepared by:

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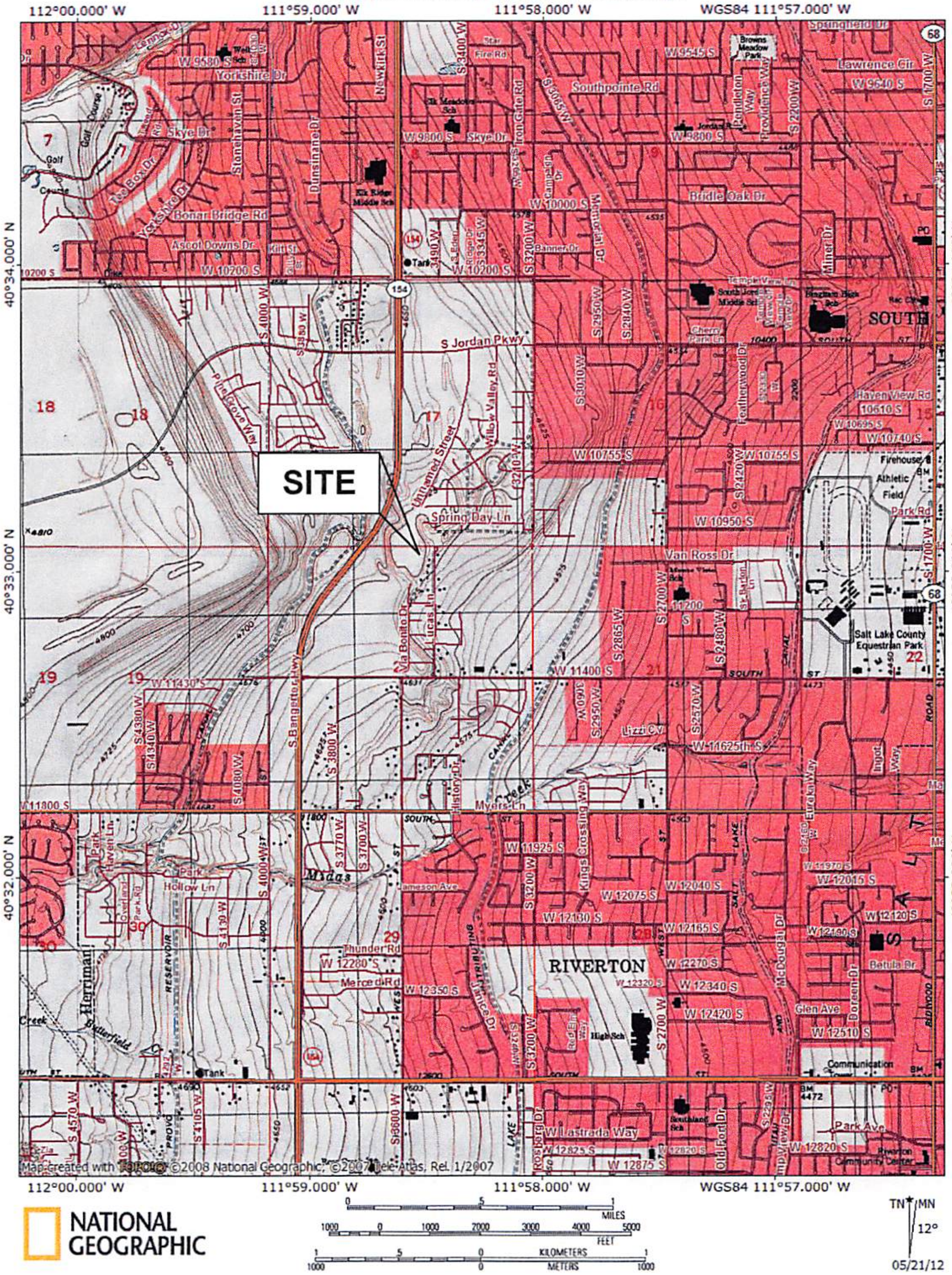
Geotechnical Engineer

APPENDIX

VICINITY MAP

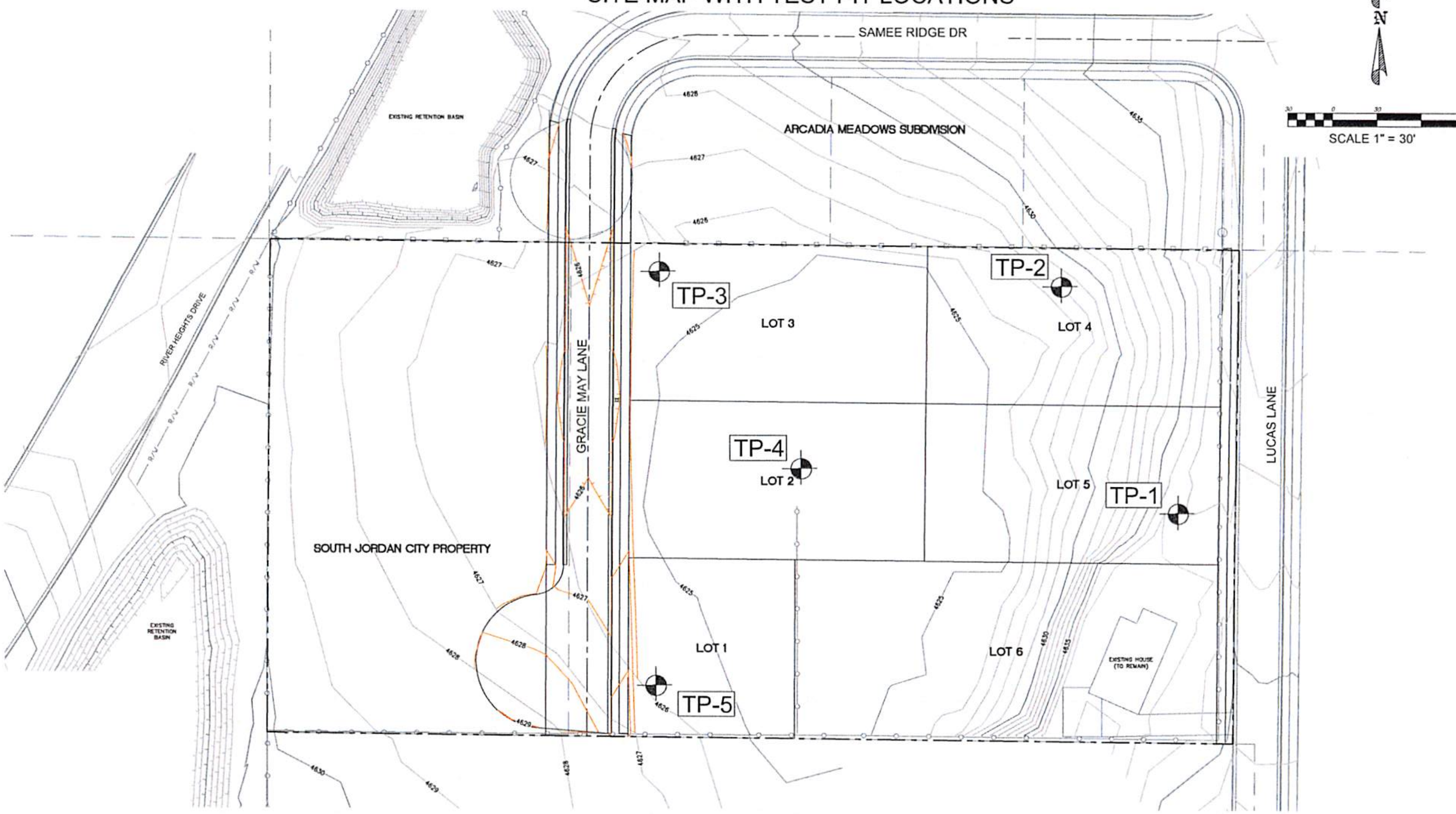
TOPO! map printed on 05/21/12 from "Untitled.tpo"



Project: **Lucas Ridge Subdivision** **11010 Lucas Lane** **South Jordan, Utah** Project No: **12036**	Date: May 2012 Drawn By: CPB Figure: A-1	WILDING ENGINEERING, INC 14721 SOUTH HERITAGE CREST WAY BLUFFDALE, UTAH 84065 (801)553-8112

LUCAS RIDGE SUBDIVISION

SITE MAP WITH TEST PIT LOCATIONS



Approximate Test Pit Location

WILDING ENGINEERING, INC

DRAWING TITLE	PROJECT NAME	DATE
TEST PIT LOCATIONS	LUCAS RIDGE SUBDIVISION	5/21/12
LOCATION: 11010 LUCAS LANE	DRAWN: JRP / CHECKED: DPW	SCALE: 1" = 30'
SOUTH JORDAN, UTAH	FILE NAME: G:\DATA\12036...\dwg\Test Pit Locations.dwg	SHEET: 1 OF 1

NO.	REVISION	DATE

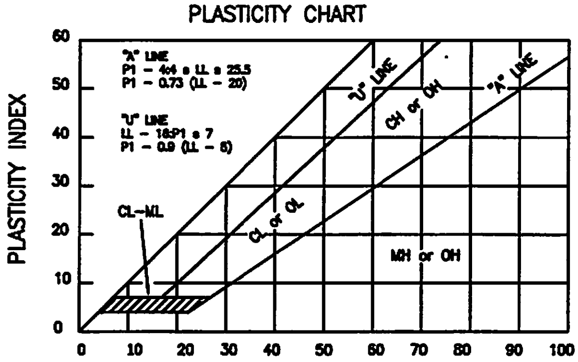
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified for engineering purposes by the Unified Soil Classification System. Grain-sized analyses and Atterberg Limits tests often are performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. Graphic symbols are used on boring logs presented on this report. For a more detailed description of the system, see "Standard Pratice for Description and Identification of Soils (Visual-Manual Procedure)" ASTM Designation:2488-84 and "Standard Test Method for Classification of Soils for Engineering Purposes" ASTM Designation: 2487-85.

MAJOR DIVISIONS				GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS Less than 50% passes No. 200 sieve	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)			GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, OR SAND -GRAVEL-COBBLE MIXTURES
					GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, OR SAND-GRAVEL-COBBLE MIXTURES
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Lines plot below "A" line & hatched zone on plasticity chart		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			Lines plot above "A" line & hatched zone on plasticity chart		GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS (50% or more of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)			SW	WELL GRADED SANDS, GRAVELLY SANDS
					SP	POORLY GRADED SANDS, GRAVELLY SANDS
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Lines plot below "A" line & hatched zone on plasticity chart		SM	SILTY SANDS, SAND-SILT MIXTURES
			Lines plot above "A" line & hatched zone on plasticity chart		SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS Limited plot below "A" line & hatched zone on plasticity chart	SILTS OF LOW PLASTICITY (Liquid limit less than 50)			ML	INORGANIC SILTS, CLAYEY SILTS OF LOW TO MEDIUM PLASTICITY
		SILTS OF HIGH PLASTICITY (Liquid limit 50 or more)			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS, ELASTIC SILTS
	CLAYS Limited plot above "A" line & hatched zone on plasticity chart	CLAYS OF LOW PLASTICITY (Liquid limit less than 50)			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY, SANDY, AND SILTY CLAYS
		CLAYS OF HIGH PLASTICITY (Liquid limit 50 or more)			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS, SANDY CLAYS OF HIGH PLASTICITY
	ORGANIC SILTS AND CLAYS	ORGANIC SILTS AND CLAYS OF LOW PLASTICITY (Liquid limit less than 50)			OL	ORGANIC SILTS AND CLAYS OF LOW TO MEDIUM PLASTICITY, SANDY ORGANIC SILTS AND CLAYS
		ORGANIC SILTS AND CLAYS OF HIGH PLASTICITY (Liquid limit 50 or more)			OH	ORGANIC SILTS AND CLAYS OF HIGH PLASTICITY, SANDY ORGANIC SILTS AND CLAYS
ORGANIC SOILS		PRIMARILY ORGANIC MATTER (dark in color and organic odor)			PT	PEAT

NOTE: Coarse-grained soils with between 5% and 12% passing thru No. 200 sieve and fine-grained soils with limit plotting in the hatched zone on the plasticity chart have dual classifications.

PLASTICITY CHART



DEFINITION OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Boulders	Above 12 in.
Cobbles	12 in. to 3 in.
Gravel	3 in. to No. 4 sieve
Coarse Gravel	3 in. to 3/4 in.
Fine Gravel	3/4 in. to No. 4 sieve
Sand	No. 4 to No. 200 sieve
Coarse sand	No. 4 to No. 10 sieve
Medium sand	No. 10 to No. 40 sieve
Fine sand	No. 40 to No. 200 sieve
Fines(silt and clay)	Less than No. 200 sieve

TEST PIT NUMBER TP-1

WILDING ENGINEERING, INC

Wilding Engineering Inc

CLIENT Freiss Development

PROJECT NAME Lucas Ridge Subdivision

PROJECT NUMBER 12036

PROJECT LOCATION South Jordan, Utah

DATE STARTED 5/8/12 COMPLETED 5/8/12

GROUND ELEVATION 4639 ft TEST PIT SIZE N/A inches

EXCAVATION CONTRACTOR Earthcore Drilling

GROUND WATER LEVELS:

EXCAVATION METHOD Backhoe

AT TIME OF EXCAVATION ---

LOGGED BY JGW CHECKED BY CPB

AT END OF EXCAVATION ---

NOTES

AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0			SM		**SILTY SAND:** moist, light brown, with vegetation in upper 6 inches.
	GB 1				
2.5					
	GB 2	MC = 9% Fines = 36%			-- increasing moisture.
5.0					
7.5	GB 3				-- with iron oxide staining.
9.0	GB 4	MC = 21% LL = NP PL = NP Fines = 72%	ML		4630.0 **SILT WITH SAND:** moist, light brown, with iron oxide staining.
10.0	GB 5				
12.0	GB 6				4627.0

Bottom of test pit at 12.0 feet.

TEST PIT NUMBER TP-2

WILDING ENGINEERING, INC
Wilding Engineering Inc

CLIENT Freiss Development
PROJECT NAME Lucas Ridge Subdivision
PROJECT NUMBER 12036
PROJECT LOCATION South Jordan, Utah
DATE STARTED 5/8/12 **COMPLETED** 5/8/12
GROUND ELEVATION 4635 ft **TEST PIT SIZE** N/A inches
EXCAVATION CONTRACTOR Earthcore Drilling
GROUND WATER LEVELS:
EXCAVATION METHOD Backhoe
AT TIME OF EXCAVATION ---
LOGGED BY JGW **CHECKED BY** CPB
AT END OF EXCAVATION ---
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0.0			SM		**SILTY SAND:** moist, light brown, with vegetation in upper 6 inches.	
2.5	GB 1					
5.0	GB 2	MC = 12% Fines = 49%				
6.5						4628.5
			CL		**LEAN CLAY:** moist, brown.	
7.5	GB 3					
	GB 4	MC = 32% LL = 43 PL = 21 Fines = 99%			-- reddish brown.	
10.0						
	GB 5					
	GB 6				-- light brown.	
12.5	GB 7				-- olive green.	
13.0						4622.0

Bottom of test pit at 13.0 feet.

TEST PIT NUMBER TP-3

WILDING ENGINEERING, INC
Wilding Engineering Inc

CLIENT Freiss Development	**PROJECT NAME** Lucas Ridge Subdivision
PROJECT NUMBER 12036	**PROJECT LOCATION** South Jordan, Utah
DATE STARTED 5/8/12 **COMPLETED** 5/8/12	**GROUND ELEVATION** 4629 ft **TEST PIT SIZE** N/A inches
EXCAVATION CONTRACTOR Earthcore Drilling	**GROUND WATER LEVELS:**
EXCAVATION METHOD Backhoe	**AT TIME OF EXCAVATION** ---
LOGGED BY JGW **CHECKED BY** CPB	**AT END OF EXCAVATION** ---
NOTES	**AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0			CL		**LEAN CLAY:** moist, light brown, with vegetation in upper 6 inches.
	GB 1				
2.5	GB 2				
	GB 3	MC = 26%			-- light gray.
5.0	GB 4				-- light brown.
7.5	GB 5	MC = 20% LL = 38 PL = 21 Fines = 98%			-- with iron oxide staining.
10.0	GB 6				
	GB 7			12.0	4617.0

Bottom of test pit at 12.0 feet.

TEST PIT NUMBER TP-4

WILDING ENGINEERING, INC
Wilding Engineering Inc

CLIENT	Freiss Development	**PROJECT NAME**	Lucas Ridge Subdivision
PROJECT NUMBER	12036	**PROJECT LOCATION**	South Jordan, Utah
DATE STARTED	5/8/12 **COMPLETED** 5/8/12	**GROUND ELEVATION**	4629 ft **TEST PIT SIZE** N/A inches
EXCAVATION CONTRACTOR	Earthcore Drilling	**GROUND WATER LEVELS:**	
EXCAVATION METHOD	Backhoe	**AT TIME OF EXCAVATION**	—
LOGGED BY	JGW **CHECKED BY** CPB	**AT END OF EXCAVATION**	—
NOTES		**AFTER EXCAVATION**	---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0			CL		**LEAN CLAY:** moist, light brown, with vegetation in upper 6 inches.
	GB 1	MC = 10%			
2.5					
	GB 2	MC = 18% LL = 41 PL = 19 Fines = 99%			-- light gray.
5.0					
	GB 3				-- light brown.
	GB 4				
7.5					
	GB 5				
10.0	GB 6	MC = 22%			
	GB 7				12.0 — 4617.0

Bottom of test pit at 12.0 feet.

WILDING ENGINEERING, INC
14721 SOUTH HERITAGE CREST WAY
BLUFFDALE, UTAH 84065
(801) 553-8112
Wilding Engineering Inc

TEST PIT NUMBER TP-5

CLIENT Freiss Development
PROJECT NAME Lucas Ridge Subdivision
PROJECT NUMBER 12036
PROJECT LOCATION South Jordan, Utah
DATE STARTED 5/8/12 **COMPLETED** 5/8/12
GROUND ELEVATION 4631 ft **TEST PIT SIZE** N/A inches
EXCAVATION CONTRACTOR Earthcore Drilling
GROUND WATER LEVELS:
EXCAVATION METHOD Backhoe
AT TIME OF EXCAVATION ---
LOGGED BY JGW **CHECKED BY** CPB
AT END OF EXCAVATION ---
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0			SM		**SILTY SAND:** moist, light brown, with vegetation in upper 6 inches.
2.5	GB 1				
	GB 2				
5.0					
6.0	GB 3	MC = 30% LL = 44 PL = 22 Fines = 99%	CL		4625.0 **LEAN CLAY:** moist, brown.
7.5	GB 4				
10.0	GB 5	MC = 25%			-- light brown.
	GB 6				
12.0					4619.0 -- light gray.

Bottom of test pit at 12.0 feet.

SUMMARY OF LABORATORY TEST RESULTS

WILDING ENGINEERING, INC
Wilding Engineering Inc

CLIENT Freiss Development
PROJECT NAME Lucas Ridge Subdivision
PROJECT NUMBER 12036
PROJECT LOCATION South Jordan, Utah

Borehole	Depth (ft)	Moisture (%)	Dry Density (pcf)	Liquid Limit	Plastic Limit	Plasticity Index	Gravel (%)	Sand (%)	Fines (%<#200 Sieve)	Classification
TP-1	4.0	8.6					0	64	36	
TP-1	9.0	20.9		NP	NP	NP			72	ML
TP-2	5.0	11.6					0	51	49	
TP-2	9.0	31.7		43	21	22			99	CL
TP-3	4.0	26.0								
TP-3	7.0	20.4		38	21	17			98	CL
TP-4	2.0	10.1								
TP-4	4.0	17.8		41	19	22			99	CL
TP-4	10.0	22.2								
TP-5	6.0	30.3		44	22	22			99	CL
TP-5	10.0	24.6								

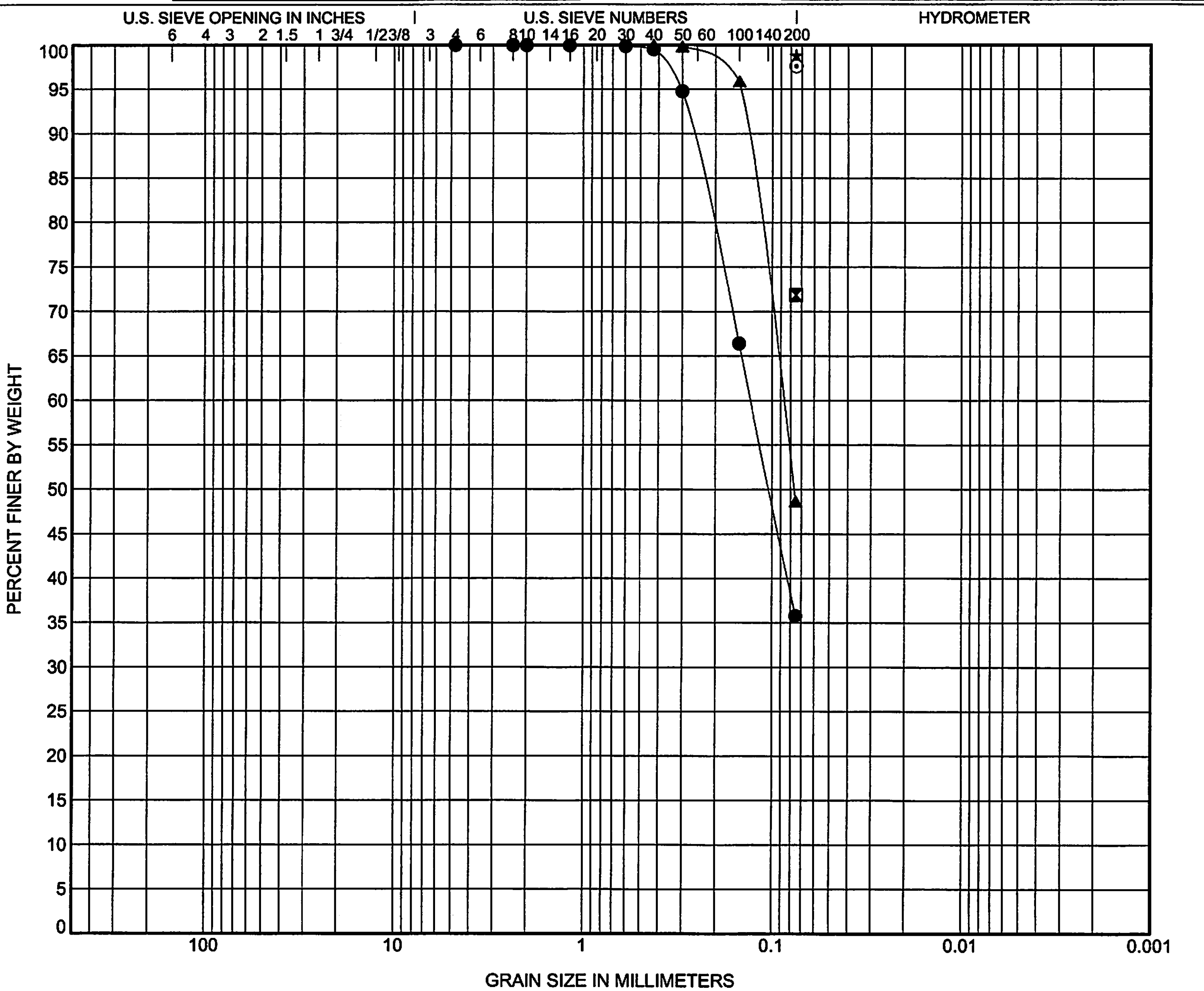
GRAIN SIZE DISTRIBUTION

WILDING ENGINEERING, INC

Wilding Engineering Inc

CLIENT Freiss Development **PROJECT NAME** Lucas Ridge Subdivision

PROJECT NUMBER 12036 **PROJECT LOCATION** South Jordan, Utah



BOREHOLE		DEPTH	Classification	LL	PL	PI	Cc	Cu
●	TP-1	4.0						
⊠	TP-1	9.0	SILT with SAND(ML)	NP	NP	NP		
▲	TP-2	5.0						
★	TP-2	9.0	LEAN CLAY(CL)	43	21	22		
⊙	TP-3	7.0	LEAN CLAY(CL)	38	21	17		

BOREHOLE		DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt / %Clay
●	TP-1	4.0	4.75	0.13			0	64	35.8
⊠	TP-1	9.0	0.075						71.9
▲	TP-2	5.0	0.425	0.089			0	51	48.7
★	TP-2	9.0	0.075						98.8
⊙	TP-3	7.0	0.075						97.6

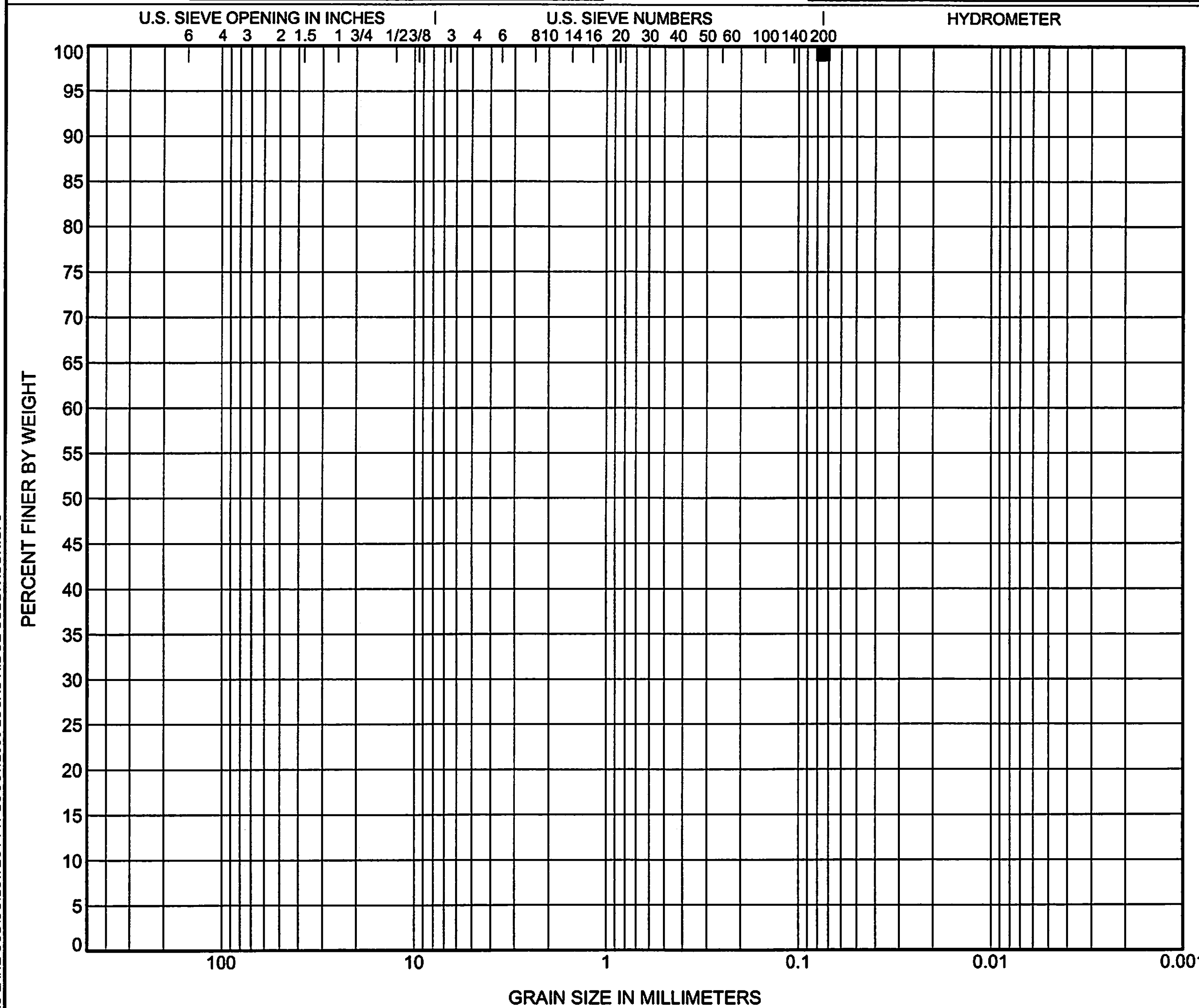
GRAIN SIZE - GINT STD US LAB.GDT - 5/21/12 16:43 - G:\DATA\12036 LUCAS LANE SUB\SOILS\TEST PIT LOGS\12036 LUCAS RIDGE SUBDIVISON.GPJ

GRAIN SIZE DISTRIBUTION

Wilding Engineering Inc

CLIENT Freiss Development **PROJECT NAME** Lucas Ridge Subdivision

PROJECT NUMBER 12036 **PROJECT LOCATION** South Jordan, Utah



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**TP-4**	**4.0**	**LEAN CLAY(CL)**	**41**	**19**	**22**		
⊠	**TP-5**	**6.0**	**LEAN CLAY(CL)**	**44**	**22**	**22**		

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**TP-4**	**4.0**	**0.075**						**99.2**	
⊠	**TP-5**	**6.0**	**0.075**						**99.1**	