GEOTECHNICAL EVALUATION
VIVARIUM BUILDING
UNLV CAMPUS
CLARK COUNTY, NEVADA

January 22, 2016

GeoTek Inc. Nevada Project No. 12799-LV

Prepared For:

UNIVERSITY OF NEVADA LAS VEGAS
Planning and Construction
4505 Maryland Parkway
Box 451027
Las Vegas, Nevada 89154

GEOTEK, INC. - NEVADA

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January 22, 2016
Project No. 12779-LV

UNIVERSITY OF NEVADA LAS VEGAS
Planning and Construction
4505 Maryland Parkway
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Attention: Ms. Lisa Schock

Subject: Geotechnical Evaluation
New Vivarium Building
UNLV Campus
Clark County, Nevada

In accordance with your request, GeoTek, Inc. has completed a geotechnical evaluation for the proposed Vivarium Building. The proposed building is located on the north side of the University of Las Vegas (UNLV) campus. The site is generally located as shown on Figure 1, Site Location Map. The purpose of our study was to evaluate the soil underlying the proposed building and to provide recommendations for project design based on our findings. This report outlines the geologic and geotechnical conditions of the site based on current data, and provides foundation, earthwork, and construction recommendations with respect to those conditions.

SCOPE OF SERVICES

The scope of services included the following:

1. Review of soils reports and geologic maps for the site (Appendix A).

2. Site reconnaissance and review of aerial photos of the site.

3. Advancing and logging two exploratory borings around the site (Appendix B).

4. Obtaining samples of representative soil as the borings were advanced.

5. Performing laboratory testing on representative soil samples to measure selected physical and chemical properties (Appendix C).

6. Assessment of potential geologic conditions.

7. Engineering and geologic review and analysis regarding; foundation design/construction, foundation settlement, floor slab recommendations, and site preparation.

8. Preparation of this report.

PROJECT INFORMATION

It is our understanding that the project consists of the design and construction of a single story 5,000 square foot building. The proposed building will be adjacent to the existing Vivarium building on the UNLV campus. It is assumed the building will be of steel-frame, masonry, or concrete construction with a concrete slab-on-grade floor. Maximum column loading is anticipated to be up to 150 kips. Wall loading is anticipated to be up to 5 kips per foot. It is assumed there will be no structures below the current grade of the site and that final grade will be within 3 feet of existing site grade.

SITE EXPLORATION

This evaluation included a subsurface exploration. Subsurface conditions were explored by using a truck mounted drill rig equipped with a 5 inch diameter bit. Rotary-air was used to advance two exploratory borings within the proposed building footprint. The borings were advanced to depths of approximately 15 and 16¼ feet below existing site grade. Field studies were conducted on January 13, 2016 by an engineer who logged the borings, and obtained soil samples for laboratory testing. The approximate location of the borings are indicated on the enclosed Site Plan (Figure 2).

REGIONAL GEOLOGY

The subject site is situated within the Las Vegas Valley, which is near the southwestern portion of the Great Basin. The valley and surrounding mountains represent a transition zone between the Basin and Range Structural Province to the west and the Colorado Plateau to the east. Las Vegas Valley is aligned in a northwest-southeast direction and generally drains toward the southeast into Las Vegas Wash, where runoff is conveyed into Lake Mead. Surrounding the low-lying alluvial filled Las Vegas Valley are rugged mountain ranges. Mountains bounding the valley are the Pintwater, Desert, Sheep and Las Vegas Ranges on the north, McCullough and River Ranges on the south, Frenchman Mountain on the east and the Spring Mountain on the west. These mountain ranges are composed predominately of volcanic and sedimentary rocks. Between the alluvium in the valley floor and the mountain ranges is a gently sloping alluvial fan piedmont.

The alluvial fan is composed of many coalescing fans dissected by numerous drainage channels. The upper boundary is generally clearly defined by an abrupt change in slope and by the exposed rock outcroppings. The lower end of the boundary is generally obscured because the slope is relatively lobate and because of the migrational nature of the deposits (alluvial fan) lateral limits. The fan piedmonts are generally covered with a relatively thin layer of loose and compressible material that in turn is underlain with poorly sorted gravely, cobbly, silty sand, which at several locations is cemented.

Deposition typically started during the late Tertiary and continues today. The depositional environment for the valley floor is dominantly lake laid deposits of sand, silt, and clay. These materials were deposited during two periods of lake activity, one during the Miocene and the other during the Pleistocene. This valley infilling process has been subsequently truncated by down faulting within the valley, generating a series of compaction scarps that range from a few feet in height to over 50 feet in height. Younger alluvium has been, and continues to be, transported dominantly by water and deposited on the basins gently sloping valley floor and within low-level flood plains. Portions of the alluvial deposits are being down cut by intermittent streams to the flood plain, and as a result stream terraces are being formed. In addition, wind activity has generated varying sizes of sand dunes and affects deposition and erosion.

SITE CONDITIONS

Surface

At the time of our evaluation the ground surface at the proposed building location was landscaped with sod, trees, and rock mulch. The area was relatively flat and bordered by sidewalks on the north and west, and by masonry structures on the east and south.

Subsurface

Fill

As previously stated, the proposed building area was landscaped. As a result fill was encountered in the borings. The fill generally consisted of ½ foot of clayey sand with organic material. There could be deeper or poorer quality fill within the proposed building areas beyond and between the boring locations.

Native Soils

Native soils encountered in the borings generally consisted of loose to dense clayey sand. Very stiff sandy clay was encountered in boring B-2 at approximately 11 feet below the ground surface. Varying concentrations of gravel and gypsum were encountered through much of the upper soil profile. Moderately hard to hard caliche was encountered at approximately 10 feet below the ground surface. Laboratory test results indicate that the upper onsite soils have a low potential to expand (swell) with increasing moisture content. The boring logs presented in Appendix B should be referred to for more detailed information.

GROUNDWATER

Groundwater was not encountered within the depths explored. These observations reflect conditions at the time the water level was measured and do not preclude changes in local ground water conditions in the future from natural causes, damaged structures (pipe lines etc.), or heavy irrigation.

TECTONIC FAULTING AND REGIONAL SEISMICITY

The site is situated in an area of active as well as potentially active tectonic faults, however no faults were observed during our field evaluation. In addition, no photo lineaments were observed crossing the property in our review of aerial photographs. There are a number of faults in the regional area, which are considered active and would have an affect on the site in the form of ground shaking, should they be the source of an earthquake. In addition to the possible tectonic sources for a seismic event in the past, the Nevada Test Site posed a consistent source for the generation of a seismic event that would affect the site. The possibility of ground acceleration, or shaking at the site may be considered as approximately similar to the southern Nevada region as a whole. It is recommended that all structures be designed and constructed in accordance with the 2012 International Building Code (IBC).

Maps by Bell and Price (1991), Bell and DePolo (2000), and Clark County Soils Maps depict that the nearest mapped fault scarp is located approximately one mile west of the site. The nearest mapped fissure zone is located over two miles away.

Seismic Site Classification

The current Clark County Seismic Map indicates that the site classifies as Site Class C. The proposed building is located at approximately 36.11024° North Latitude and 115.14337° West Longitude. The spectral acceleration (SA) for 0.2 second and 1.0 second periods for Site Class C was determined from the USGS Website, Earthquake Hazards Program, Interpolated Probabilistic Ground Motion for the Conterminous 48 States by Latitude/Longitude, 2012 International Building Code Data Edition. The results are presented in the following Table:

Mapped Spectral Response Acceleration (percent of g)	
0.2 sec period Mapped Spectral Acceleration (S_S) - Site Class B	46.4
1.0 sec period Mapped Spectral Acceleration (S_1) - Site Class B	15.9
0.2 sec period Design Spectral Acceleration (SD_S) - Site Class C	37.1
1.0 sec period Design Spectral Acceleration (SD_1) - Site Class C	17.4

Secondary Seismic Conditions

The following list includes other potential seismic related hazards that have been evaluated with respect to the site, but in our opinion, the potential for these seismically related constraints to affect the site is considered negligible.

* Liquefaction
* Dynamic Settlements
* Surface Fault Rupture
* Ground Lurching or Shallow Ground Rupture

Summary

It is important to keep in perspective that if a seismic event were to occur on any major fault, intense ground shaking could be induced to this general area. Potential damage to any settlement sensitive structures would likely be greatest from the vibrations and impelling force caused by the inertia of the structures mass than that created from secondary seismic conditions. Considering the subsurface soil conditions and local seismicity, it is estimated that the site has a low risk associated with the potential for these phenomenon to occur; and adversely affect the building. These potential risks are no greater at this site than they are for other structures and improvements developed on the alluvial materials in this vicinity.

LABORATORY TESTING

Laboratory tests were performed on representative soil samples collected from the borings in order to evaluate some of their physical and chemical characteristics. Testing included gradation, Atterberg limits, expansion potential, in-situ dry density, moisture content, and chemical analysis. An explanation of the tests performed and the results obtained are presented in Appendix C.

CONCLUSIONS

The recommendations presented herein should be incorporated into the final design, grading, and construction phases of the project. The engineering analyses performed concerning site preparation and the recommendations presented below, have been completed using the information provided to us regarding the project. In the event that the information concerning proposed project is not correct, the conclusion and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report are modified or approved in writing by this office.

RECOMMENDATIONS

Earthwork

General

All grading should conform to the 2012 International Building Code except where specifically superseded in the text of this report. During earthwork construction, all removals, and grading procedures should be observed and the fill selectively tested by a representative of GeoTek, Inc. If unusual or unexpected conditions are exposed in the field, they should be reviewed by this office and if warranted, modified and/or additional recommendations will be offered.

If unusual or unexpected conditions are exposed in the field, they should be reviewed by this office and if warranted, modified and/or additional recommendations will be provided. It is recommended that the earthwork contractor(s) perform their own independent reconnaissance of the site to observe field conditions first hand. If the contractor(s) should have any questions regarding: site conditions, site preparation, or the recommendations provided, they should contact a representative of GeoTek for any

necessary clarifications. All applicable requirements of local and national construction and general industry safety orders, the Occupational Safety and Health Act, and the Construction Safety Act should be met.

The upper on-site native soils are generally loose in consistency and have low density. The upper loose soils are not suitable for support of the proposed structure in their current condition. We recommend that the soils within the building areas be overexcavated below the bottom of the foundations.

Site Clearing

All existing surface and subsurface features, within the proposed building area, should be removed. All existing sod, vegetation, fill, debris, and other deleterious material should be stripped/removed from the building site. Material collected during site clearing should be disposed of offsite. All undocumented fill materials should be removed to expose suitable soils. If existing improvements limit removals, condition specific recommendations can be provided.

All loose, soft, or firm soils should be overexcavated to expose soil with a consistency of at least medium dense. Site clearing should include the entire foundation footprints and at least 5 feet beyond in plan view, where possible.

Excavation

Based on the subsurface information collected from the boring and our observations at the site, it is our opinion that excavations to the depths anticipated may be accomplished with conventional earth moving equipment. Cemented sand and gravel (caliche) was encountered at approximately 10 feet below the existing ground surface. Heavy duty excavation equipment or a hoe-ram will be required to remove the cemented soils if excavations will be deeper than 10 feet.

Overexcavation

The upper on-site soils are generally loose in consistency and would not be suitable for support of proposed building in their current state. We recommend that the upper soils below structure be overexcavated and replaced with structural fill. In order to improve the long term support for the building, the native soils within 2 feet below the bottom of the foundations should be overexcavated and replaced with structural fill. The overexcavated soils can be reused as structural fill provided they meet the recommendations for on-site fill presented in this report. The overexcavation should include the entire building area and at least 5 feet beyond in plan view, where posable. Locally deeper removals may be necessary based on the field conditions exposed.

Fill Placement and Compaction

Subsequent to completing the recommended removals, the exposed soils should be observed to verify that the recommend removals have been preformed. The exposed soils should then be moisture conditioned to near optimum moisture and compacted as recommend in this report.

Fill soils should be placed in relatively thin lifts (with a maximum lift thickness of 8 inches), cleaned of vegetation and debris, brought to no less than minus 2 percent of optimum moisture content, and compacted to a minimum relative compaction of 90 percent of the laboratory standard ASTM D-1557 for fills within 5 feet of final grade.

It should be noted that the maximum lift thickness requirement to meet both the minimum relative compaction and moisture content requirements is a function of several variables including (but not limited to) the type of soil (e.g., clay, silt, sand, gravel, cobbles, etc.), type and size of compaction equipment (e.g., sheep's foot roller, scraper, jumping jack, etc.), number of passes, frequency of operation of compaction equipment, moisture content, confinement (e.g., relatively soft bottom versus bedrock), etc. Thus, the maximum lift thickness can vary considerably and still achieve proper moisture contents and relative compaction. The maximum lift thickness should be appropriately decreased based on the factors listed above. It is left to a representative of GeoTek (e.g., grading/field technician) to determine the appropriate lift thickness based on observation and testing of the fill. Excessive lift thickness (in the judgment of a GeoTek representative) will result in issuing of non-compliance.

A sufficient number of field density tests shall be performed to provide an opinion to the degree of compaction achieved. Field density tests should be performed at a minimum rate of one test for every one vertical foot of material placed, or where there is a change in material, whichever is greater.

Fill Material

Onsite soils - Onsite soils may be used as fill. Material should be within the following minimum recommendations:

* Maintain less than 4 percent expansion.
* 100 percent passing the three-inch screen.
* Maintain at least 5 percent passing the #200 screen.

Imported soils - Imported granular fill may be required at the site. A sample of any intended import material should first be submitted to GeoTek so that, if necessary, additional laboratory or chemical testing can be performed to verify that the intended import material is suitable as fill. The import material should be within the following minimum recommendations:

* Free of organic matter and debris.
* Less than 0.1 percent sulfate content.
* Non-soluble.
* Less than 0.2 percent sodium sulfate content.
* Less than 3.0 percent expansion.
* 100 percent passing the two-inch screen.
* Maintain 5 to 20 percent passing the #200 screen.

Observation and Testing

During earthwork construction all removal/processing and grading procedures should be observed and the fill selectively tested by a representative(s) of GeoTek. If unusual or unexpected conditions are exposed in the field, they should be reviewed by GeoTek and if warranted, modified and/or additional recommendations will be offered. All applicable requirements both the local and national construction and general industry safety orders, the Occupational Safety and Health Act, and the Construction Safety Act should be met.

Foundations

General

Foundation design recommendations are based on selective laboratory testing and engineering analysis performed on the soils collected at the site. The proposed foundation system should be designed and constructed in accordance with the guidelines contained herein and in the 2012 International Building Code (IBC). All foundation excavations should be observed by a representative of this office prior to placing reinforcement and concrete.

Foundation Recommendations

Dead and live loading conditions are anticipated to be up to 150 kips for column loads and 5 kips per lineal foot for wall loads. The recommendations offered below have been prepared using these anticipated loads and assuming the recommended earthwork is performed. The recommendations provided are from a geotechnical engineering perspective and are not meant to supersede the design by the project's structural engineer.

The proposed structure may be supported on conventional foundations established on structural fill. The bearing values indicated below are for the total dead plus frequently applied live loads and may be increased by one third for short duration wind or seismic forces. When combining passive pressure and friction for lateral resistance, the passive component should be reduced by one third.

Exterior footings should be founded at a minimum depth of 18 inches below lowest adjacent ground surface. Interior footings should have a minimum embedment of 18 inches below the lowest adjacent concrete slab surface. If new foundations will be constructed next to exiting foundations, the new foundations should be at least as deep as the existing foundations.

Footing Type	Minimum Footing Depth (inch)	Allowable Bearing Pressure (psf)	Coefficient of Friction	Passive Earth Pressure (psf/ft)	Maximum Earth Pressure (psf)
Spread, Strip	18	2,000	0.40	290	4,300

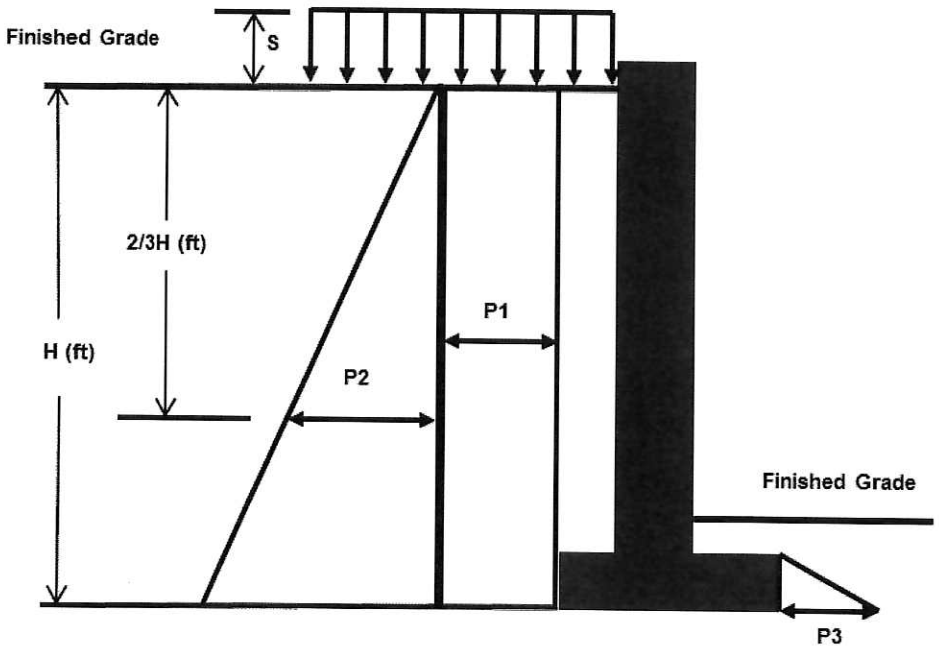
The bearing value may be increased 1,000 psf for each additional one foot of depth up to a maximum bearing value of 5,000 psf. Strip footings should have a minimum width of 1 foot and spread footings should have a minimum soil to concrete area of 4 square feet.

Settlement

Provided that the recommendations contained in this report are incorporated into final design and construction of building, total settlement is estimated to be less than 1 inch. Differential settlement should be less than one-half the total settlement. The settlement estimates presented assume that a stable subgrade soil moisture content will be maintained. It should be understood that if the soils below the foundations experience an increase in moisture content, additional foundation movement could occur and cause distress to the structures.

Lateral Earth Pressures

The following values may be used for design. The values presented below are for backfill soils with low expansion, no surcharge loading and level backfill.



In-Place Native Soils and Compacted Granular Fill

• Coefficient of friction (soil)	0.40
• Moist Unit Weight of Soil	130 pcf
• At-Rest Pressure P2 (level backfill)	60 pcf
• Active Pressure P2 (level backfill)	38 pcf
• Passive Pressure (ultimate)	440 pcf
• Passive Pressure P3 (allowable)	290 pcf
• Angle of Internal Friction Ø	33°

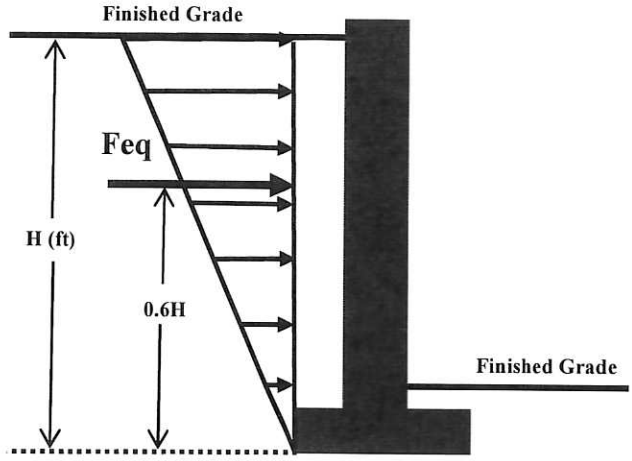
Additional Information

- S represents a uniform surcharge pressure
  - At-rest Condition P1 = (0.46)S
  - Active Condition P1 = (0.30)S
- No groundwater acting on the wall, for submerged conditions or where no drainage is provided the hydrostatic pressure should be added to the above pressures.
- No factor of safety is applied to the values.
- The lateral pressure from compaction equipment is not included.
- Passive pressure assumes level finished grade at toe of wall.
- 90 percent compaction (ASTM D1556) assumed.
- The values presented above assume non- to low expansive backfill.
- The passive earth pressure should not exceed 4,300 psf.

When combining passive pressure and frictional resistance, the passive pressure component should be reduced by one-third.

Restrained Walls

Any retaining walls that will be restrained prior to placing and compacting backfill material should be designed for an at-rest equivalent fluid pressure and any applicable surcharge loading. Additional lateral forces can be induced on restrained walls during an earthquake. For level backfill, above water, the minimum earthquake-induced force should be $19.3H^2$ (lbs/linear foot of wall). This force does not include any pressure from the water. These forces can be assumed to act at a distance of 0.6H above the base of the wall, where "H" is the height of the restrained wall measured from the base of the footing (in feet). The following Figure illustrates the distribution of the lateral pressure.



Cantilevered Walls

Active earth pressure may be used for retaining wall design, provided the top of the wall is not restrained from minor deflections. This pressure does not include other superimposed loading conditions such as traffic, structures, seismic events, or adverse geologic conditions.

Additional lateral forces can be induced on retaining walls during an earthquake. For level backfill above water, the minimum earthquake-induced force should be $7.2H^2$ (lbs/linear foot of wall). This force does not include any pressure from water. These forces can be assumed to act at a distance of 0.6H above the base of the wall, where "H" is the height of the retaining wall measured from the base of the footing (in feet). The previous Figure illustrates the distribution of the lateral pressure.

Wall Backfill

Walls below grade should be waterproofed. All retaining walls should be provided with an adequate backdrain and outlet system to prevent buildup of hydrostatic pressures and be designed in accordance with minimum standards presented herein (Figure 3). Gravel used in backdrain systems should be a minimum of 12 inches of ¾ to 1½ inch clean crushed rock wrapped in filter fabric that extends to within 18 to 24 inches of the surface. As an alternative to the gravel drain, a commercially available prefabricated drain system could be used. The surface of the backfill should be sealed by pavement or the top 24 inches compacted with low permeability soil. Proper surface drainage should also be provided.

Fill against the retaining walls should consisted of granular material with less than 15 percent passing the #200 sieve and have 100 percent passing the one inch screen. Backfill should be mechanically compacted in layers 6 to 8 inches to at least 90 percent of the maximum dry density obtainable by the ASTM D1557 method. Lightweight compactors or hand-operated compaction equipment should be used adjacent to the wall to prevent overcompaction and excessive lateral pressures on the walls.

Concrete Floor Slab Design

If the grading recommendations presented in this report are complied with, proposed concrete floor slabs may be supported on a 6-inch layer of compacted Type II material. It is recommend that the floor slab be at least 4 inches thick and be reinforced with steel reinforcing bar. A structural engineer should evaluate the proposed loading and determine the slab thickness, concrete strength, and the locations and size of the reinforcing steel.

It is recommended that a plastic water vapor retarder be utilized below the slab where floor coverings are anticipated. The vapor retarder should conform to the specifications presented in ASTM E1745-97 and should be placed as described in ASTM E1643-98 and the Guide for Concrete Floor and Slab Construction, published by the American Concrete Institute (ACI 302.1R-96).

A modulus of subgrade reaction (k-value) of 150 pounds per square inch per inch may be utilized for slab design if the slab is supported on at least 4 inches of compacted Type II.

Drainage

Positive site drainage should be maintained at all times in accordance with the IBC. Water should be directed away from foundations and not allowed to pond and/or seep into the ground. Roof gutters and down spouts may be considered to control roof drainage. If used, down spouts should outlet onto paved areas or a minimum of 5 feet from proposed structures or into a subsurface drainage system. Surface drainage should be diverted to a storm sewer conveyance or other approved point of collection. There is a provision within the IBC that allows a 2% slope in-lieu of a 5% slope away from the buildings. Since the upper soils are low-expansive and are composed of mostly sand, the Civil Engineer may elect to use a 2% slope in lieu of a 5% slope.

Soil Corosivity

Laboratory test results indicate that the onsite soils have a negligible corrosive potential to concrete and metal. However, we recommend that concrete use at the site be designed for severe sulfate conditions. Section 1904.3 of the 2012 IBC and Section 4.3 of ACI 318 recommend that concrete exposed to severe sulfate exposure conditions, must use Type V cement, have a minimum specified compressive strength (f'c) of 4,500 psi and a maximum water-cementitious materials ratio of 0.45. All concrete should be designed, mixed, placed, finished, and cured in accordance with the guidelines presented by the Portland Cement Association (PCA), the American Concrete Institute (ACI), and the International Building Code (IBC).

PLAN REVIEW

Final foundation and improvement plans should be submitted to this office for review and comment as they become available, to minimize any misunderstandings between the plans and recommendations presented herein. In addition, foundation excavations and earthwork construction performed on the site

should be observed and tested by this office. If conditions are found to differ substantially from those stated, appropriate recommendations would be offered at that time.

LIMITATIONS

The soils encountered on the project site and utilized in our laboratory study are believed representative of the area; however, soil conditions will vary across the site. These variations may become apparent during grading. Site conditions may vary due to seasonal changes or other factors. GeoTek, Inc. assumes no responsibility or liability for work, testing, or recommendations performed or provided by others. Since our study is based upon the site materials observed, selective laboratory testing and engineering analysis, the conclusions and recommendations are professional opinions. These opinions have been derived in accordance with current standards of practice and no warranty is expressed or implied. Standards of practice are subject to change with time.

If you have any questions concerning this report or if we may be of further assistance, please do not hesitate to contact the undersigned.

Respectfully submitted,
GeoTek, Inc.

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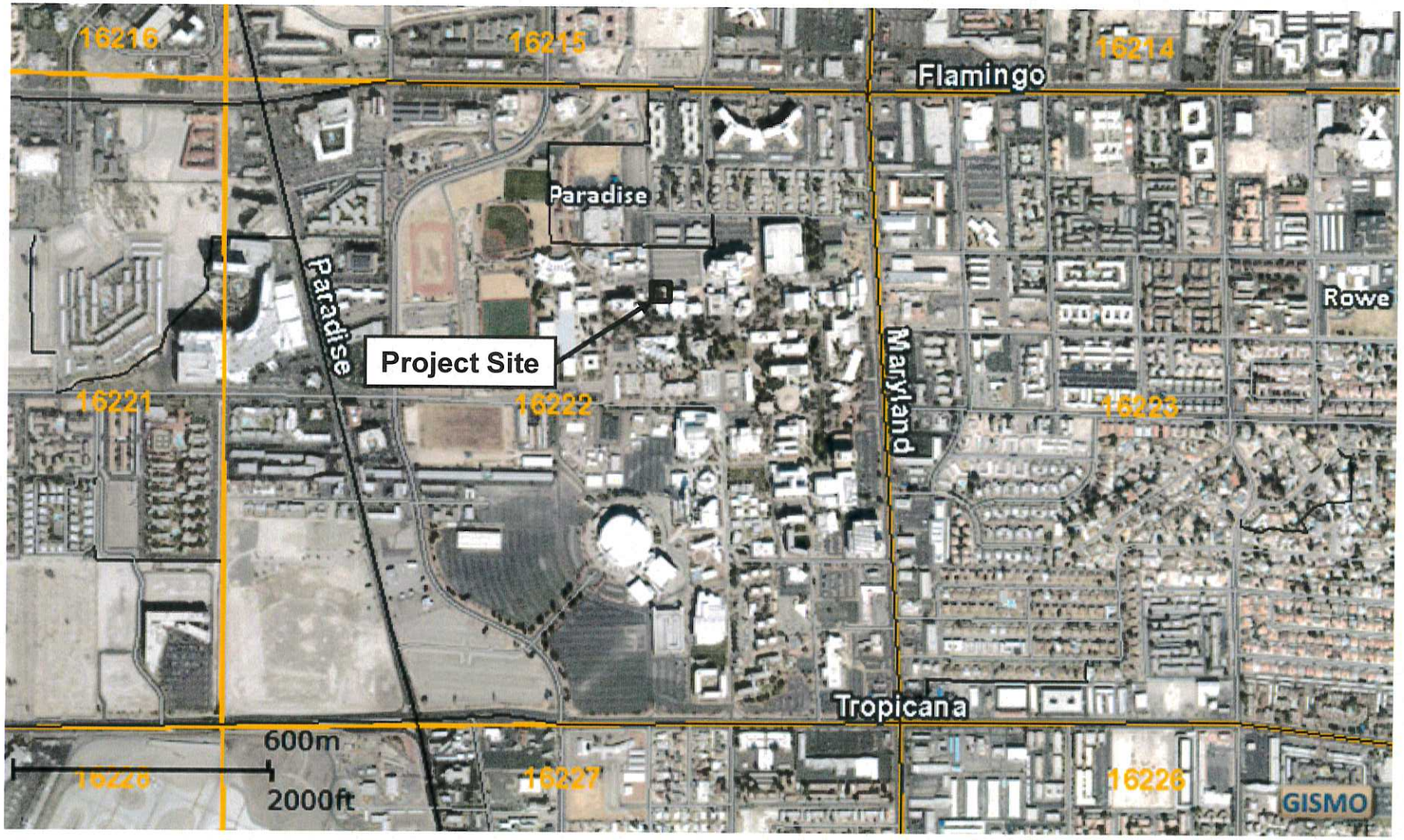

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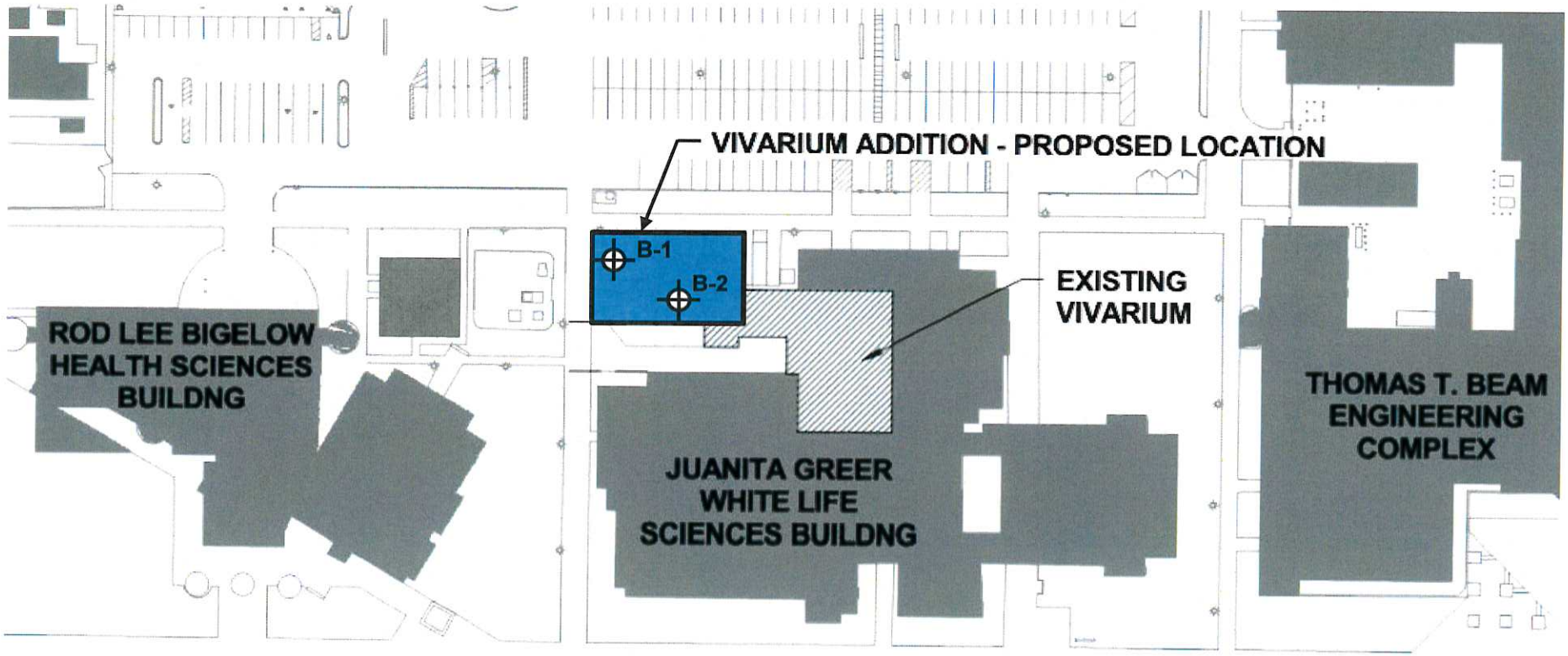
GEOTECHNICAL ENVIRONMENTAL MATERIALS

FIGURE 1
SITE MAP
Vivarium Building
UNLV Campus
Clark County, Nevada
Prepared for: University of Nevada Las Vegas

Project No.:	Report Date:	Drawn By:
12779-LV	January 2016	NW



Approximate Boring Location

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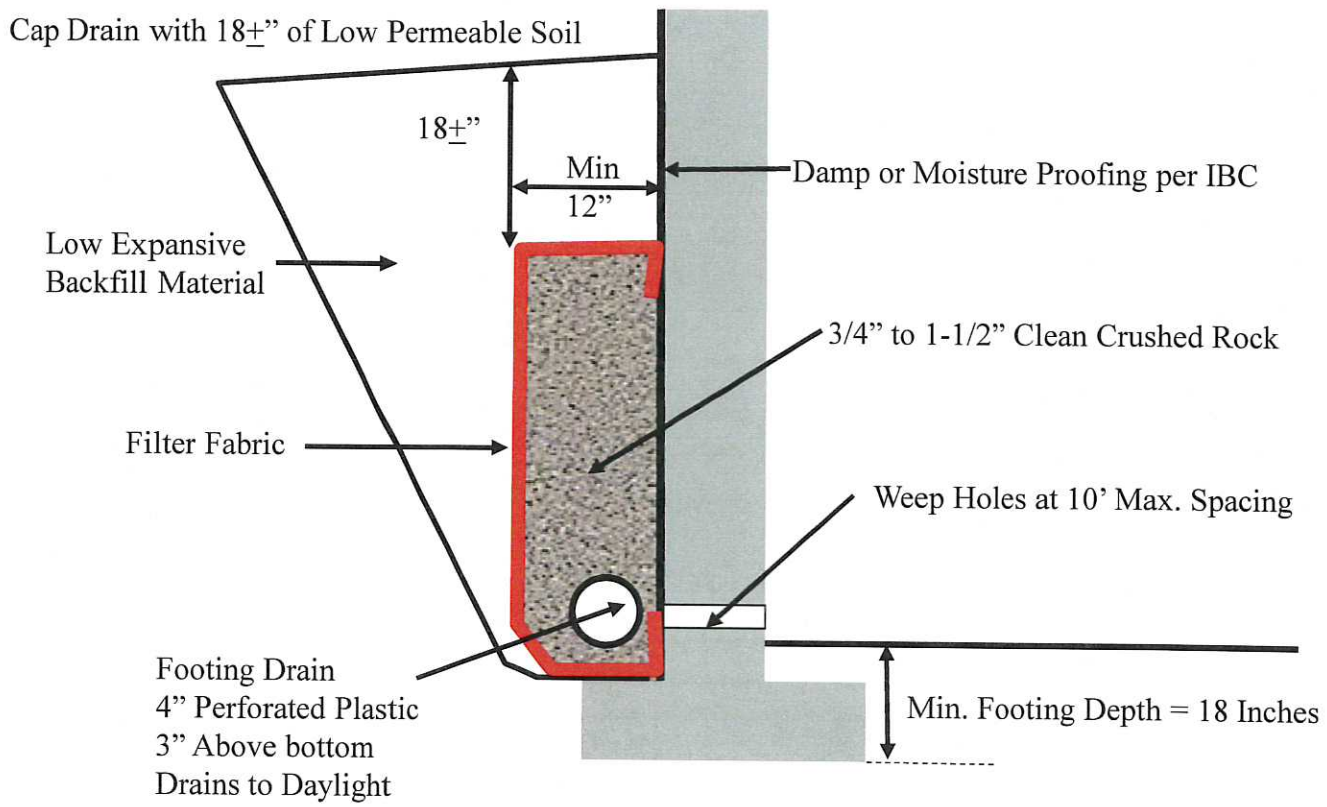
GEOTECHNICAL ENVIRONMENTAL MATERIALS

FIGURE 2
SITE PLAN
Vivarium Building
UNLV Campus
Clark County, Nevada
Prepared for: University of Nevada Las Vegas

Project No.:	Report Date:	Drawn By:
12799-LV	January 2016	NW



RETAINING WALL DETAIL

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GEOTECHNICAL ENVIRONMENTAL MATERIALS

FIGURE 3
RETAINING WALL DETAIL
Vivarium Building
UNLV Campus
Clark County, Nevada
Prepared for: University of Nevada Las Vegas

Project No.:	Report Date:	Drawn By:
12799-LV	January 2016	NW

APPENDIX A

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APPENDIX B

Site Exploration

Exploratory borings for this project were conducted on January 13, 2016. A truck-mounted rotary-air drill rig equipped with a 5-inch diameter bit was used to advance two borings at the site. The borings were advanced to depths of approximately 15 and 16¼ feet below existing site grade. Elite Drilling performed the drilling under subcontract to GeoTek.

The borings were located in the field by scaling an aerial photo and locating the proposed borings in the field by measuring from existing features at the site. The boring locations are approximate. The approximate locations of the borings are indicated on the Site Plan, Figure 2. A log of each boring, indicating the soils encountered, are attached in this Appendix.

Non-standard penetration tests using a ring sampler was performed at 2½ to 5-foot intervals using a cable hammer during drilling. Sampling was performed using a 3-inch outside diameter (2½-inch inside diameter) split-spoon sampler. The sampler was driven 18 inches into the soil using a 140-pound hammer free-falling 30 inches. The number of blows required to drive the sampler 6 inch intervals was recorded and is presented on the following boring logs. Testing was terminated if 50 or more blows were required to drive the sampler 6 inches or less.

UNIFIED SOIL CLASSIFICATION SYSTEM

ASTM D 2487

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[E]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[C]	GW	Well-graded gravel[D]
			$Cu < 4$ and/or $1 > Cc > 3$[C]	GP	Poorly graded gravel[D]
		Gravels with Fines More than 12% fines[E]	Fines classify as ML or MH	GM	Silty gravel[D,F,G]
			Fines classify as CL or CH	GC	Clayey gravel[D,F,G]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[I]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[C]	SW	Well-graded sand[H]
			$Cu < 6$ and/or $1 > Cc > 3$[C]	SP	Poorly graded sand[H]
		Sands with Fines More than 12% fines[I]	Fines classify as ML or MH	SM	Silty sand[F,G,H]
			Fines Classify as CL or CH	SC	Clayey sand[F,G,H]
Fine-Grained Soils 50% or more passes 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)/(Liquid limit - not dried) < 0.75	OL	Organic clay[K,L,M,N]
					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 lots below "A" line	MH	Elastic Silt[K,L,M]
		organic	(Liquid limit - oven dried)/(Liquid limit - not dried) < 0.75	OH	Organic clay[K,L,M,P]
					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] $Cu = D_{60}/D_{10}$ $Cc = (D_{30})^2/(D_{10} \times D_{60})$

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

[E] 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.

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

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

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

[I] 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

[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.

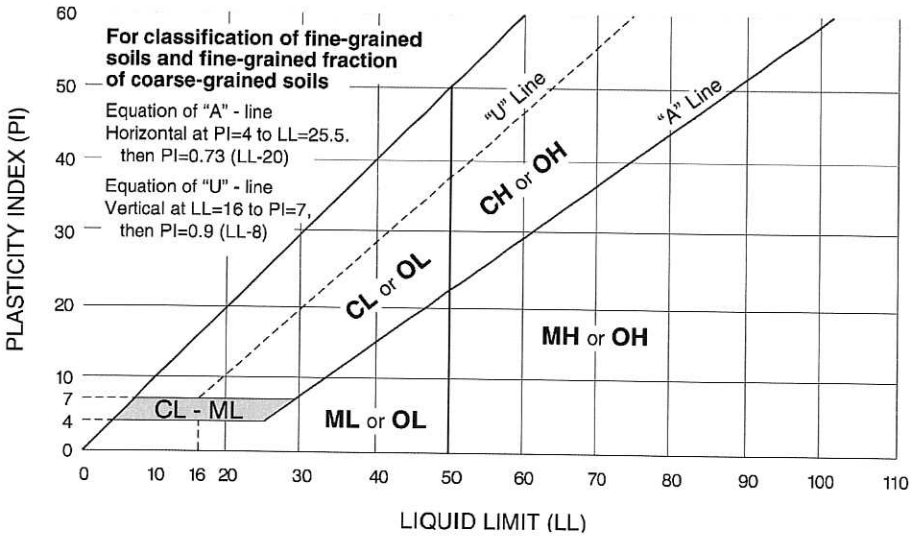
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[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.



BORING LOG GENERAL NOTES

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	Firm
2,001 – 4,000	7-12	Medium Stiff
2,001 – 4,000	13-26	Stiff (Hard)*
8,000+	27+	Very Stiff (Very Hard)*

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration (SPT) 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

SPT penetration test using 140 pound hammer, with 30 inch free fall on 2 inch outside diameter (1⅜ I.D.) sampler.

For Ring Sampler using 140 pound hammer, with 30 inch free fall on 3 inch outside diameter (2½ I.D.) sampler, N-value X 0.7.

For fine grained soil Consistency, thumb penetration also used per ASTM D 2488.

*The terms Stiff and Very Stiff are used in-lieu of Hard and Very Hard to avoid confusion with cemented soils.

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

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)

RELATIVE HARDNESS OF CEMENTED SOILS (CALICHE)

Description	General Characteristics
Very Dense to Moderately Hard	Partially Cemented Granular Soil - Can be carved with a knife and broken with force by hand.
Very Stiff to Moderately Hard	Partially Cemented Fine-Grained Soil - Can be carved with a knife and broken with force by hand.
Moderately Hard	Moderate hammer blow required to break sample.
Hard	Heavy hammer blow required to break sample.
Very Hard	Repeated heavy hammer blows required to break sample.

BORING LOG LEGEND

MATERIAL DESCRIPTION		
Soil Pattern	**USCS Symbol**	**USCS Classification**
	FILL	Artificial Fill
	GP or GW	Poorly/Well graded GRAVEL
	GM	Silty GRAVEL
	GC	Clayey GRAVEL
	GP-GM	Poorly graded GRAVEL with Silt
	GP-GC	Poorly graded GRAVEL with Clay
	SP or SW	Poorly/Well graded SAND
	SM	Silty SAND
	SC	Clayey SAND
	SP-SM	Poorly graded SAND with Silt
	SP-SC	Poorly graded SAND with Clay
	SC-SM	Silty Clayey SAND
	ML	SILT
	MH	Elastic SILT
	CL-ML	Silty CLAY
	CL	Lean CLAY
	CH	Fat CLAY
	PCEM	PARTIALLY CEMENTED
	CEM	CEMENTED
	BDR	BEDROCK

SAMPLING	
	SPT
	Ring Sample
NR	No Recovery
	Bulk Sample
	Water Table

CONSISTENCY					
Cohesionless Soils		**Cohesive Soils**		**Cementation**	
VL	Very Loose	So	Soft	MH	Moderately Hard
L	Loose	F	Firm	H	Hard
MD	Medium Dense	S	Stiff	VH	Very Hard
D	Dense	VS	Very Stiff		
VD	Very Dense				

BORING LOG B-1

GEOTEK

PROJECT #:	12799-LV	**LOGGED BY:**	N. Wasden
PROJECT:	Vivarium Building	**DRILL METHOD:**	Air Rotary
CLIENT:	UNLV	**DRILLER:**	Elite
LOCATION:	**36°06'36.9", -115°08'36.6"**	**DATE:**	1/13/16
		ELEVATION:	≈ 2031

Depth (ft)	SAMPLES: Sample Type	SAMPLES: Blows / 6 in.	SAMPLES: Soil Pattern	USCS Symbol	MATERIAL DESCRIPTION AND COMMENTS	Consistency	LABORATORY TESTING: Water Content (%)	LABORATORY TESTING: Dry Density (pcf)	LABORATORY TESTING: Swell (%)	LABORATORY TESTING: Other Testing
				FILL	Sod over Dark Brown Clayey Sand with Organics; V. Moist					
1				SC	Tan Clayey Sand with trace Gravel; Very Moist	L				
2					-with Gravel	MD				
3		14 13 24							1.3	
4							8.5	113		
5					-no gravel					
6		17 31 32				D	17.7	108		
7					- Light Gray; with Gravel					
8		13 11 18			-Light Brown	MD				
9					- Off-White; with Caliche Gravel - with Caliche lenses		16.9	106		
10		50/1		CEM	Off-White Cemented Sand and Gravel; Dry to Slightly Moist	H				
11										
12										
13						MH				
14						H				
15					**Bottom of Boring Approximately 15 Feet** **No Groundwater Encountered**					
16										
17										
18										
19										
20										

6835 S. Escondido Street, Las Vegas, Nevada 89119 (702) 897-1424 Fax: (702) 897-2213

BORING LOG B-2

GEOTEK

PROJECT #:	12799-LV	**LOGGED BY:**	N. Wasden
PROJECT:	Vivarium Building	**DRILL METHOD:**	Air Rotary
CLIENT:	UNLV	**DRILLER:**	Elite
LOCATION:	**36°06'36.6", -115°08'36.1"**	**DATE:**	1/13/16
		ELEVATION:	≈ 2030

Depth (ft)	SAMPLES: Sample Type	SAMPLES: Blows / 6 in.	Soil Pattern	USCS Symbol	MATERIAL DESCRIPTION AND COMMENTS	Consistency	LABORATORY TESTING: Water Content (%)	Dry Density (pcf)	Swell (%)	Other Testing
				FILL	Sod over Dark Brown Clayey Sand with Organics; V. Moist					
1				SC	Tan Clayey Sand with trace Gravel; Very Moist	L				
2						MD				
3		10 11			-with Gravel; Moist				1.9	
4		22			- moddled Ligth Brown and Light Gray; trace Gypsum		13.9	115		
5		11								
6		17 38			-Light Gray	D	8.7	123		
7					-no Gravel					
8		11 18				MD				
9		24			-Light Brown		15.1	109		
10		20/0		CEM	Off-White Cemented Sand and Gravel; Dry to Slightly Moist	MH				
11						H				
12				CL	Off-White Sandy Lean Clay with trace Caliche Gravel; Moist	VS				
13										
14										
15		22 42								
16		50/3					21.9	107		
17					**Bottom of Boring Approximately 16¼ Feet** **No Groundwater Encountered**					
18										
19										
20										

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APPENDIX C

Laboratory Tests Results

In-Situ Dry Density and Moisture Content
Testing was performed to determine the in-situ dry density and moisture content of the samples recovered from the borings. The test results are presented on the boring logs.

Particle Size Analysis
Sieve analyses were performed in general accordance with AASHTO test method T 27. The test results are presented on the attached plates.

Atterberg Limits
Atterberg limits were performed on representative samples in general accordance with ASTM D 4318. The test results are shown in the attached plates.

Expansion Tests
Swell tests were performed on remolded soil samples recovered from the borings. The samples were remolded at ± 90 percent of the material's maximum dry density, and then oven dried to below the materials shrinkage limit, placed under a 60 pound per square foot surcharge (unless otherwise noted), and inundated with water for at least 24 hours. The percent swell was then recorded as the amount of vertical rise compared to the original one-inch sample height.

Location	Percent Swell	Expansion Classification
B-1 @ 2½ ft.	1.3	Low
B-2 @ 2½ ft.	1.9	Low

Chemical Testing

Testing was performed to determine the amount of water soluble salt in a representative sample of the soil. Individual test results denote the percent analyte soluble in water at a 1:5 (soil to water) extraction ratio. Chemical Testing was performed by *Silver State Analytical Laboratories*. Test results are presented below and on the attached sheet.

Sample Number	27863
Sample Location	B-2
Depth	2½ feet
Test Methods Used	AWWA 4500 E AWWA 3500-Na D
Sampling Method	ASTM D-75
Sample Type (Single or Composite)	Single Location
Sampled By:	NW
Classification of Reduced Soil Sample	Clayey Sand
In-place moisture content	Moist
Sodium (Percent)	0.07
Water Soluble Sulfate (SO_4) (Percent)	0.09
Total Available Water Soluble Sodium Sulfate (Na_2SO_4) (Percent)	0.13

Geo Tek, Inc.
6835 S. Escondido Street, Suite A
Las Vegas, Nevada 89119-3828

Telephone: (702) 897 1424

Facsimile: (702) 897 2213

Aggregate/Soil Test Report

Report No: MAT:LNS16/27862
Issue No: 1

Client:	University of Nevada Las Vegas 4505 Maryland Parkway Las Vegas NV 89154-1027
Project:	12779-LV New Vivarium Building

This laborartory is accredited by AASHTO. The test(s) reported have been performed in accordance with its terms of accredidation

AASHTO R18

AASHTO Accredited LN

Date of Issue: 1/20/2016
Approved Signatory: Linda Coulter

Sample Details

Sample ID:	LNS16/27862
Field Sample ID:	
Date Sampled:	01/13/2016
Source:	
Material:	Geo
Specification:	Generic Sieve
Sampling Method:	
Location:	B-1 @ 2.5'

Other Test Results

Description	Method	Result	Limits
Liquid Limit	ASTM D 4318 - 05	26	
Method		Method B	
Plastic Limit		14	
Plasticity Index		12	
Sample history			
Material retained on 425µm (No. 40) (%)		0.0	
Swell (%)		1.3	

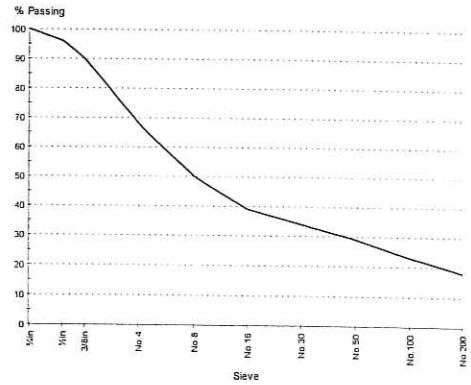
Particle Size Distribution

Method: ASTM C 136 - 06, ASTM C 117 - 04

Drying by:

Sieve Size	% Passing	Limits
¾in (19.0mm)	100	
½in (12.5mm)	96	
3/8in (9.5mm)	90	
No.4 (4.75mm)	68	
No.8 (2.36mm)	50	
No.16 (1.18mm)	39	
No.30 (600µm)	34	
No.50 (300µm)	29	
No.100 (150µm)	23	
No.200 (75µm)	18	

Chart



Comments

N/A

SilverState
Analytical Laboratories

LABORATORY REPORT

DATE: January 19, 2016

LABORATORY NO: 16-0394

CLIENT: GeoTek, Inc.
6835 South Escondido Street, Suite A
Las Vegas, NV 89119

PAGE: 1 of 1

CLIENT PROJECT: 12779

CLIENT PO #:

Sampled By: Client
Date Sampled: --
Time Sampled: --

Date Received: 01/19/16
Time Received: 0920

Analyst: SW

Sample ID: 27863, B-2 @ 2.5'

Analysis	Result	Unit	Method
Sodium (Na)	0.07	%	ASTM D2791
Water Soluble Sulfate (SO_4)	0.09	%	SM 4500 E
Total Available Water Soluble Sodium Sulfate (Na_2SO_4)	0.13	%	Calculation

NOTES: The results for each constituent denote the percentage (%) for that particular element which is soluble in a 1:5 (soil to water) extraction ratio and corrected for dilution.

REVIEWED BY:

John Sloan
Laboratory Director
EPA: NV00930

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