Geotechnical Exploration Study
Lot 64, Cordillera Subdivision, Filing 3
420 Little Andorra Road
Eagle County, Colorado

Project No. 12-129.01

April 19, 2012

Prepared For:

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1.0 PURPOSE AND SCOPE OF STUDY

Gore Range Engineering (GRE) is pleased to submit this Geotechnical Exploration Study for the proposed residence at 420 Little Andorra Road near Edwards, Colorado. This study was conducted in accordance with our Proposal to Apex Mountain Homes, Inc. dated April 9, 2012. The purpose of this study was to explore the subsurface conditions at the site and provide foundation design recommendations. Our conclusions and recommendations are presented in this report. Evaluation of potential geologic hazards is beyond the scope of this study.

The exploration was accomplished by observing three exploratory pits at the locations shown on Figure 1. Samples of the soils encountered were tested in our laboratory to determine their classification, compressibility or swell and other engineering characteristics. This report, which is based on visual observation of site conditions, results of laboratory testing, and our experience in the area, summarizes the data obtained and includes recommendations for:

- Foundation type and depth including allowable soil bearing pressure.
- Lateral earth loadings against foundation walls and site retaining walls.
- Backfill placement and compaction.
- Floor slab support.
- Surface and subsurface drainage.

2.0 PROPOSED CONSTRUCTION

No building plans have been developed for the proposed residence. We assume the residence will be a one or two story structure over a walkout basement with an attached garage. Conventional wood frame construction is assumed above grade with cast-in-place concrete foundation walls below grade. The lower level and garage floors will likely be slab-on-grade.

Grading for the development is expected to be relatively minor. Cut depths for the foundation are not expected to exceed about 10 feet. Fills are not expected to exceed 5 feet above existing grade. Foundation loads are expected to be light to moderate and typical of the proposed type of construction.

If foundation loadings, building location or grading plans are not similar to those conditions described above, or if the proposed construction has changed, we should be notified to re-evaluate the recommendations contained in this report.

3.0 SITE CONDITIONS

The project site was vacant at the time of our field exploration. The ground surface across the building envelope slopes moderately to steeply down towards the southwest. The property is bordered by residential lots to the north, east and south, and Little Andorra Road to the west. A 40-foot drainage and utility easement exists along the south property boundary. Vegetation across the site generally consists of grasses, sage brush and scattered juniper trees.

4.0 FIELD EXPLORATION

The field exploration for the project was conducted on April 12, 2012. Two exploratory pits (Pits 1 and 2) were excavated in the assumed building area to evaluate the subsurface conditions for the residence (see Figure 1). The pits were excavated with a John Deere 510C rubber-tired backhoe and logged by a representative of GRE.

Samples of the subsoils were taken with relatively undisturbed sampling methods. The depths at which the samples were taken are shown on the Exploratory Pit Logs, Figure 2. The samples were reviewed by the project engineer and returned to our laboratory for testing.

We also observed a Profile Pit that was excavated in the assumed area of the Onsite Wastewater Treatment System (OWTS) absorption field (see Figure 1).

5.0 SUBSURFACE CONDITIONS

Logs of the subsurface conditions encountered at the site are shown on Figures 2 and 3. The soils encountered generally consisted of 6 inches of topsoil overlying loose, slightly silty, very clayey sand (SC) to a depth of 8½ feet in Pits 1 and 2 and to the depth explored of 8½ feet in the Profile Pit. Below the SC soils in Pits 1 and 2, we encountered firm to hard Eagle Valley Formation bedrock (claystone/siltstone/sandstone) to the depth explored of 10 and 11 feet. Excavating the hard bedrock with a backhoe was difficult and practical digging refusal was encountered in Pit 1 at the maximum depth.

No free water was encountered in the pits at the time of excavation. The subsoils were slightly moist to moist. Groundwater levels in mountainous regions can fluctuate during seasonal runoff and heavy precipitation events.

Results of the laboratory testing performed on samples obtained from the pits are shown in the Table below.

Table 1 - Laboratory Test Results

Pit No.	*Depth*	*In-place moisture content*	*In-place density*	*Liquid Limit*	*Plasticity Index*	*Percent passing the No. 200 sieve*	*Swell/Consol*
1	3.5 ft	10.2%	88 pcf	32%	10%		-3.6%
2	4.5 ft	9.8%	86 pcf	-	-	39%	-5.4%

Results of swell-consolidation testing performed on relatively undisturbed drive samples of the natural SC soils indicate moderate to high compressibility when wetted under a relatively light surcharge (see Figure 4).

6.0 DESIGN RECOMMENDATIONS

6.1 FOUNDATIONS AND RETAINING WALLS

Considering the soil conditions encountered in the exploratory pits and the nature of the proposed construction, we recommend the residence be founded with spread footings bearing on the natural, hard Eagle Valley Formation bedrock. All existing topsoil and SC soils should be removed beneath footing areas. Once the SC soils have been removed to expose the hard bedrock, the footings can be extended down to bear directly in the bedrock. As an alternative, the removed soils can be moisture-conditioned and compacted as structural fill up to design footing subgrade elevation. Our recommendations for the overexcavation are given on Figure 6, Typical Overexcavation Detail. Inundation of the foundation excavations should be avoided during construction. If water seepage is encountered, the footing areas should be dewatered before concrete placement and we should be contacted for further evaluation. The subgrade soils should not be allowed to dry excessively.

Our recommendations for a spread footing foundation system and foundation/retaining wall design are presented in the Tables below. It should be noted that soil conditions in this region can change abruptly within a relatively small area. A representative of GRE should observe the footing subgrade prior to concrete placement to confirm the recommendations in this report are appropriate.

Table 2 - Footing Dimension Information - Spread Footings

Footing Dimension Information		
Parameter	*Value*	
Allowable Soil Bearing Pressure	2,000 psf	
Minimum Dead Load	0 psf	
Minimum Footing Widths	Continuous walls - 16 inches	Isolated pads - 24 inches
Footing Notes: 1. Based on experience, we expect settlement of footings designed and constructed as discussed will be approximately 1 inch or less. 2. Exterior footings and footings beneath unheated areas should be provided with adequate soil cover for frost protection. A minimum of 42 inches of soil cover is typical in the area. 3. Concrete should not be placed on frost, frozen soil, snow or ice.		
psf - pounds per square foot		

Table 3 - Foundation Wall Information

Parameter	*Value*
At-rest Condition[3]	52 pcf - EFP, on-site SC soils as backfill[7]
Active Condition[4]	42 pcf - EFP, on-site SC soils as backfill[7]
Passive Resistance[5]	300 pcf - EFP, on-site SC soils as backfill[5]
Base Friction Coefficient[5]	0.3 (unitless)

Foundation Wall Notes:

1. All foundation and retaining walls should be designed for appropriate hydrostatic and surcharge pressures such as adjacent footings, traffic, construction materials and equipment. The above pressures assume drained conditions behind the walls and a horizontal backfill surface. The buildup of water or upward sloping backfill behind a wall will increase the lateral earth pressures imposed on the structure.
2. An underdrain and wall drain system should be provided behind all foundation and retaining walls to prevent hydrostatic pressure buildup.
3. The at-rest condition is typically appropriate for walls that are laterally supported and expected to undergo only a slight amount of deflection.
4. The active condition is normally selected for cantilevered retaining structures that can be expected to deflect sufficiently to mobilize the full active earth pressure condition.
5. Lateral resistance of retaining wall footings will be a combination of the sliding resistance of the footing on the foundation materials and passive earth pressure against the side of the footing. The friction coefficient and passive pressure value recommended above assume ultimate soil strength. Suitable factors of safety should be included in the design to limit the strain which will occur and ultimate strength, particularly in the case of passive resistance. Fill placed against the sides of the footings to resist lateral loads should be a granular material compacted to at least 95% of Standard Proctor dry density at a moisture content near optimum.
6. Continuous foundation walls should be reinforced top and bottom to span an unsupported length of 10 feet.

Wall Backfill Notes:

7. Foundation wall backfill should have a maximum particle size of 6 inches.
8. Imported wall backfill should be a relatively well-graded granular material consisting primarily of sand and gravel and contain less than 15% passing the No. 200 sieve and no rocks larger than 6 inches in diameter.
9. The upper 1 to 2 feet of the backfill should be a relatively impervious material, such as the on-site SC soils, or a pavement structure should be provided, to reduce surface water infiltration into the backfill.
10. Compaction recommendations are given in the "Site Grading" section of this report.

pcf - pounds per cubic foot, EFP - equivalent fluid pressure

6.2 FLOOR SLABS

The on-site SC soils are moderately to highly compressible when wetted. We recommend that all SC soils beneath slab areas be removed, moisture-conditioned and re-compacted to a depth of at least 2 feet. Our recommendations are shown on Figure 6. Once the overexcavation/replacement is complete, the soils will be suitable to support lightly loaded slab-on-grade construction. All topsoil should be removed beneath slab areas. Required fill can consist of the on-site SC soils (no rocks larger than about 6 inches in diameter) or a relatively well-graded granular material such as CDOT Class 5 or 6 aggregate base course. Compaction recommendations for fill placed in slab areas are given in the "Site Grading" section of this report. Inundation of the underslab areas should be avoided during construction. The slab subgrade soils should not be allowed to dry excessively. Our recommendations for slab design are as follows:

- To reduce the effects of some differential movement, floor slabs should be separated from all bearing walls and columns with expansion joints which allow unrestrained vertical movement.

Floor slab control joints should be used to reduce damage due to shrinkage cracking. The requirements for joint spacing and slab reinforcement should be established by the designer based on experience and the intended slab use.

- A minimum 4 inch layer of CDOT Class 6 aggregate base course should be placed beneath the floor slabs to provide a flat, uniform subgrade. The base course should be compacted to at least 95%of the maximum Standard Proctor dry density at a moisture content within 3% of optimum.

6.3 UNDERDRAIN SYSTEM

Although free water was not encountered during our exploration, it has been our experience in mountainous areas, and where bedrock is shallow, that local perched groundwater can develop during times of heavy precipitation or seasonal runoff. Frozen ground during spring runoff can create a perched condition. We recommend below-grade construction, such as retaining walls, crawlspace and basement areas, be protected from wetting and hydrostatic pressure buildup by an underdrain and wall drain system. Our recommendations for a typical underdrain system are given below. It should be noted that these systems are not sized to account for large amounts of surface water or concentrated flow. If the client would like more guidance or detailed recommendations for this specific site, please contact us.

- The underdrain system should consist of drainpipe placed in the bottom of the wall backfill surrounded above the invert level with free-draining gravel. The drainpipe should be placed at each level of excavation at or below adjacent bottom of footing elevation and at least 12 inches below lowest adjacent finish grade (interior top of slab elevation or crawlspace grade). The drainpipe should be sloped at a minimum 1% to a suitable gravity outlet, or sump and pump system.
- If free water is encountered during excavation, we should be contacted to re-evaluate our recommendations.
- Free-draining gravel used in the underdrain system should contain less than 2% passing the No. 200 sieve, less than 50% passing the No. 4 sieve and have a maximum size of 2 inches. The drain gravel backfill should be at least 1½ feet deep and extend at least 1 foot above any water seepage observed in the excavation cut slope. The drain gravel should be covered with filter fabric prior to placement of backfill soils.
- A wall drain system consisting of a geocomposite or 1 foot of clean gravel should be placed adjacent to below grade construction walls. The wall drain system should connect to the underdrain and extend to within 1 to 2 feet of the ground surface. The wall drain should not extend to finish grade. A Typical Underdrain Detail is shown on Figure 7.

6.4 SITE GRADING

The risk of construction-induced slope instability at the site appears low provided cut and fill depths are limited. We assume the cut depths for the basement will not exceed about 10 feet. Fill depths are not expected to exceed 5 feet above existing grade.

Temporary excavation cut slopes should be made in accordance with OSHA requirements. A Type C soil may be assumed for temporary cuts and should be verified by the contractor's competent person.

All structural fills should be benched into the portions of the hillside exceeding 20% grade. Compaction recommendations for structural fill are given in the table below. Prior to fill placement, the subgrade should be carefully prepared by removing all vegetation and topsoil and compacting to at least 95% of the maximum standard Proctor dry density. Our recommendations for placement and compaction on structural fill at this site are shown below in Table 4.

Table 4 - Compaction Recommendations

Location/Type	*Minimum Compaction*	*Moisture Range*
Structural Fill Beneath Foundations	100%	±3%
Structural Fill Beneath Interior Floor Slabs	98%	±3%
Exterior foundation wall backfill- pavement/slab areas[1]	95%	±3%
Exterior foundation wall backfill- landscape areas[1]	90%	±3%
Embankment fill (driveway)	95%	±3%

1. Care should be taken not to overcompact the backfill or use large equipment near the wall, since this could cause excessive lateral pressure on the wall.
2. Some settlement of deep wall backfill should be expected, even if the material is place correctly, and could result in distress to facilities constructed on the backfill. Grading above the wall should be able to account for some settlement.
3. Structural fill and wall backfill should be placed and compacted in thin horizontal lifts. The thickness of the lift will be controlled by the required compaction level, material type and compaction equipment used. Typically, loose lift thickness range from 6 to 12 inches for proper compaction.
4. All compaction and moisture levels shown are based on Standard Proctor (ASTM D-698) dry density.

Permanent unretained cut and fill slopes should be graded at 2H:1V (horizontal to vertical) or flatter and protected against erosion by revegetation or other means. We assume a maximum cut slope height of 10 feet and a maximum fill embankment height of 6 feet. Slopes of greater height may need to be graded to a lesser slope. The risk of slope instability will be increased if seepage is encountered in cuts and flatter slopes may be necessary. If seepage is encountered in permanent cuts, an investigation should be conducted to determine if the seepage will adversely affect the cut stability. GRE should review site grading plans for the project prior to construction.

6.5 SURFACE DRAINAGE

Proper surface drainage is extremely important in mountainous regions with respect to foundation performance and preventing basement/crawlspace wetting. The following drainage precautions should be observed during construction and maintained after the residence has been completed:

- Inundation of the foundation excavations and underslab areas should be avoided during construction.
- The ground surface surrounding the exterior of the building should be sloped to drain away from the foundation in all directions. We recommend a minimum slope of 12 inches in the first 10 feet in unpaved areas and a minimum slope of 3 inches in the first 10 feet in paved areas. A swale

should be provided around the uphill side of the building to divert surface water. The grading around the residence should be able to account for some backfill settlement.

- Wall backfill compaction recommendations are given in the "Site Grading" section above.
- Roof downspouts and drains should discharge well beyond the limits of all backfill.
- Irrigation next to the residence should be minimized, particularly in areas adjacent to basement walls. Consideration should be given to the use of xeriscape vegetation to reduce the need for irrigation next to the building.

7.0 PERCOLATION TESTING

Percolation tests were performed in four test holes by a representative of GRE on April 13, 2012. The tests were completed at depths ranging from 23 to 31 inches below the adjacent ground surface. Percolation test results ranged from 8 to 16 minutes per inch with an average percolation rate of 12 minutes per inch. The percolation test results, presented on Figure 5, can be used to size the OWTS absorption field.

8.0 RADON

Radon is a gaseous, radioactive element that comes from the radioactive decay of uranium, which is commonly found in igneous rocks. The average indoor radon level in Eagle County is 5.5 pCi/L (http://county-radon.info/CO/Eagle.html), which is above the recommended action level of 4 pCi/L as recommended by the Environmental Protection Agency. Testing for radon gas at the site is beyond the scope of this study. Due to the many factors that affect the radon levels in a specific building, accurate testing of radon levels is usually only possible after construction is complete. Typically, radon mitigation systems in Eagle County consist of ventilation systems installed beneath lower level slabs and crawlspaces. The infrastructure for such a mitigation system can normally be installed during construction at a relatively low cost, which is recommended. The building(s) should be tested for radon once construction is complete. If test results indicate mitigation is required, the installed system can then be used for mitigation. We are not experts in radon testing or mitigation. If the client is concerned about radon, then a professional in this special field of practice should be consulted.

9.0 LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering principles and practices in this area at this time. No warranty is expressed or implied. Our recommendations and conclusions are based upon our field exploration, the proposed construction and our experience in the area. We have found that soil and groundwater conditions in this region can change abruptly within a relatively small area. Due to our mountainous environment, drastic spikes in groundwater levels can occur every year during seasonal runoff. For these reasons, we strongly recommend that our services are continued through the construction process (at an additional cost). If soil and/or groundwater conditions encountered during construction are different than what was encountered in our exploratory pits, changes to our recommendations may be required.

We are not experts in determining the presence, prevention or possibility of mold or other biological contaminants (MOBC) developing in the future. If the client is concerned about MOBC, then a professional in this special field of practice should be consulted.

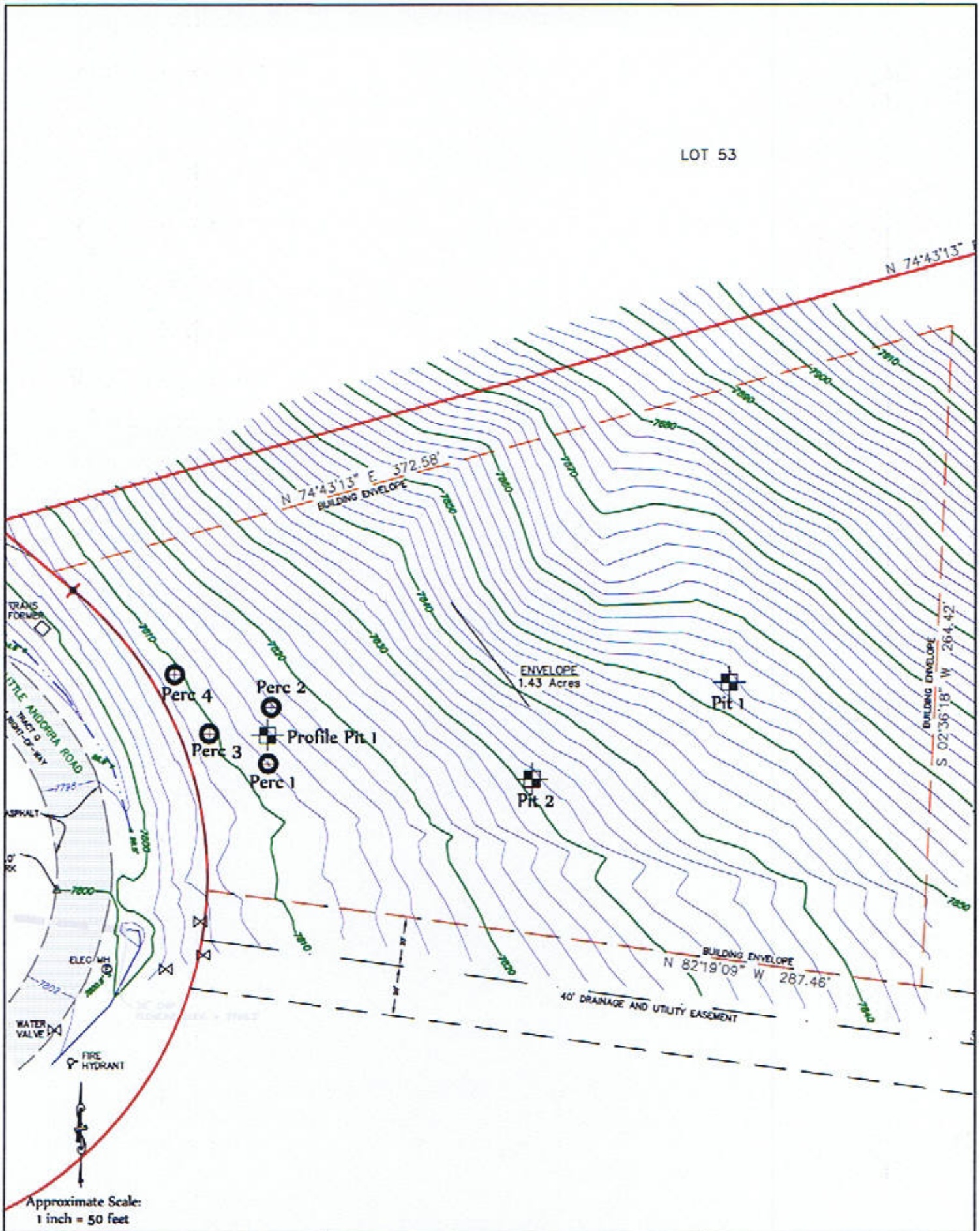
This report has been prepared for the exclusive use by our client for design purposes. We are not responsible for technical interpretations by others of our information. Changes to the building and/or site design may require additional analysis or modifications to the recommendations presented herein.

If you have any questions, please let us know.

Respectfully,
GORE RANGE ENGINEERING

George W. Benecke III, P.E.
Principal

Reviewed by: JAD



GORE RANGE ENGINEERING	LOT 64, CORDILLERA SUB., FILING 3 EXPLORATORY PIT LOCATIONS	PROJECT NO. 12-129.01 FIGURE 1

PIT 1

DEPTH (FT)	SAMPLE TYPE	SPT "N" BLOWS/FT.	USCS SYMBOL	SOIL DESCRIPTION	WATER CONTENT %	DRY DENSITY (pcf)	LIQUID LIMIT %	PLASTICITY INDEX %	% PASSING No. 200	% RETAINED No. 4	SWELL/ CONSOL. %	Digging Conditions/ Remarks	ELEVATION (FT)
0				TOPSOIL: clayey sand, with roots, slightly moist, loose, brown.									7853
			SC	SAND: slightly silty, very clayey, slightly gravelly to gravelly, with scattered sub-angular cobbles, loose, slightly moist to moist with depth, light brown.								Easy	
	HD				10.2	98	32	10	-	-	-3.60		
5													7848
			BR	EAGLE VALLEY FORMATION: claystone, siltstone, sandstone, firm to hard, slightly moist, light red to green to brown.								Difficult	
10													7843

* No free water encountered during excavation.
Practical digging refusal @ 10 feet.

PIT 2

DEPTH (FT)	SAMPLE TYPE	SPT "N" BLOWS/FT.	USCS SYMBOL	SOIL DESCRIPTION	WATER CONTENT %	DRY DENSITY (pcf)	LIQUID LIMIT %	PLASTICITY INDEX %	% PASSING No. 200	% RETAINED No. 4	SWELL/ CONSOL. %	Digging Conditions/ Remarks	ELEVATION (FT)
0				TOPSOIL: clayey sand, with roots, slightly moist, loose, brown.									7831
			SC	SAND: slightly silty, very clayey, slightly gravelly, loose, slightly moist, light brown.								Easy	
5	HD				9.8	86	-	-	39	-	-5.40		7826
			BR	EAGLE VALLEY FORMATION: claystone, siltstone, sandstone, firm to hard, slightly moist, light red to green to brown.								Difficult	
10													7821
													7816

* No free water encountered during excavation.
Bottom of Pit @ 11 feet

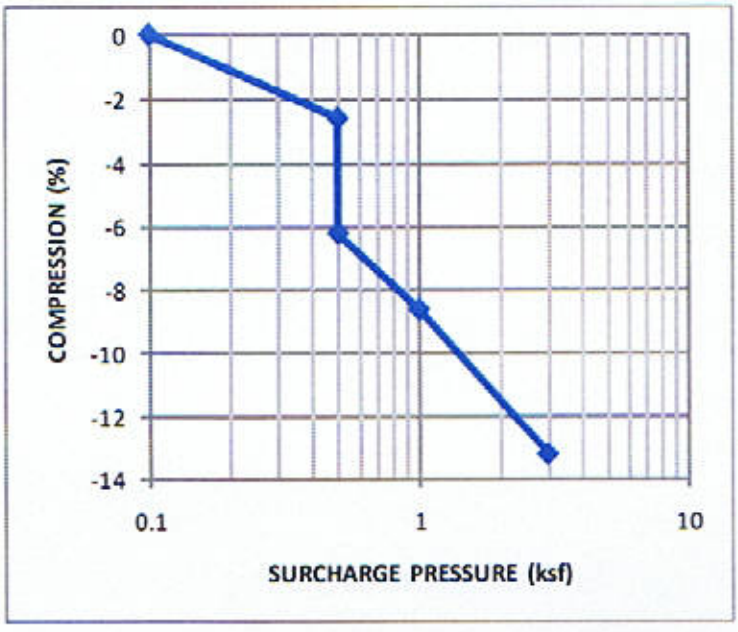
NOTES:

- DATE OF EXPLORATION: 04/12/12
- LOGGED BY: GB
- RIG TYPE: JOHN DEERE 510C
- METHOD: RUBBER-TIRED BACKHOE
- APPROXIMATE PIT LOCATIONS SHOWN ON FIGURE 1
- BOUNDARIES BETWEEN MATERIAL TYPES ARE APPROXIMATE AND ACTUAL CHANGES MAY BE GRADUAL.
- NO FREE WATER WAS ENCOUNTERED IN THE PIT AT THE TIME OF EXCAVATION.
- WATER LEVELS CAN FLUCTUATE DURING TIMES OF HEAVY PRECIPITATION AND SEASONAL RUNOFF.
- LD - LARGE DISTURBED SAMPLE, SD - SMALL DISTURBED SAMPLE, HD - HAND DRIVEN SAMPLE (RELATIVELY UNDISTURBED)

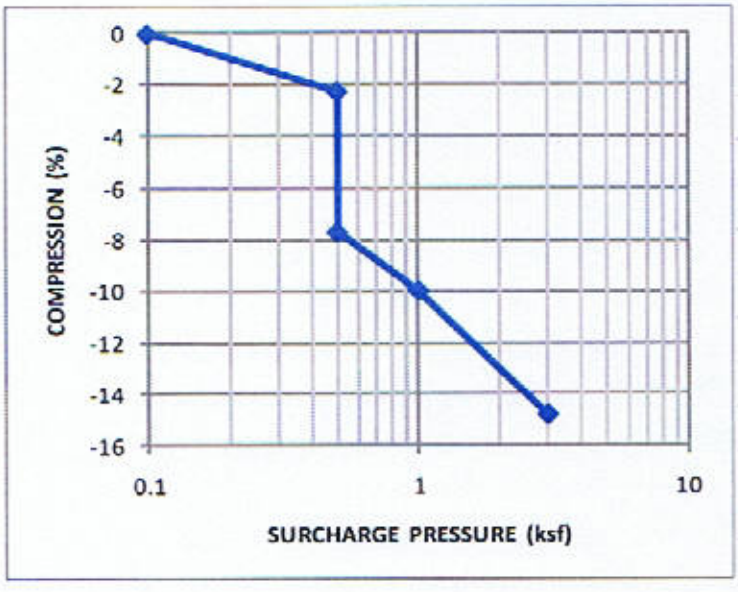
PROFILE PIT 1

DEPTH (FT)	SAMPLE TYPE	SPT "N" BLOWS/FL	USCS SYMBOL	SOIL DESCRIPTION	WATER CONTENT %	DRY DENSITY (pcf)	LIQUID LIMIT %	PLASTICITY INDEX %	% PASSING No. 200	% RETAINED No. 4	SWELL/ CONSOL. %	Digging Conditions/ Remarks	ELEVATION (FT)
0				TOPSOIL: clayey sand, with roots, slightly moist, loose, brown.									7814
			SC	SAND: slightly silty, very clayey, slightly gravelly, loose, slightly moist, light brown.								Easy	
5													7809
				* No free water encountered during excavation.									
10				Bottom of Pit @ 8.5 feet.									7804

GORE RANGE ENGINEERING	LOT 64, CORDILLERA SUB., FILING 3 PROFILE PIT LOG	PROJECT NO. 12-129.01 FIGURE 3



Pit No.	1
Depth	3.5
Soil Type	SC; very clayey sand
Moisture Content	10.2%
Dry Density (pcf)	88.0
Passing No. 200 Sieve	-
Liquid Limit	32%
Plasticity Index	10%
Wetted at (psf)	500
Result (%)	-3.60%



Pit No.	2
Depth	4.5
Soil Type	SC; very clayey sand
Moisture Content	9.8%
Dry Density (pcf)	86.3
Passing No. 200 Sieve	39%
Liquid Limit	-
Plasticity Index	-
Wetted at (psf)	500
Result (%)	-5.4

Test Hole 1		
Time Interval (min)	Water Level Drop (in)	Rate (MPI)
1	0.125	8
1	0.125	8
1	0.000	0
1	0.000	0
1	0.125	8
1	0.063	16
1	0.063	16
1	0.063	16
Soil Percolation Rate =		16

Trench Depth (in): 11
Hole Depth (in): 13
Total Depth (in): 24
Hole Width (in): 8
Soil Type: SC

Test Hole 2		
Time Interval (min)	Water Level Drop (in)	Rate (MPI)
2	0.625	3.2
2	0.500	4
2	0.250	8
2	0.250	8
2	0.250	8
2	0.250	8
2	0.250	8
2	0.250	8
Soil Percolation Rate =		8

Trench Depth (in): 13.5
Hole Depth (in): 15
Total Depth (in): 28.5
Hole Width (in): 8
Soil Type: SC

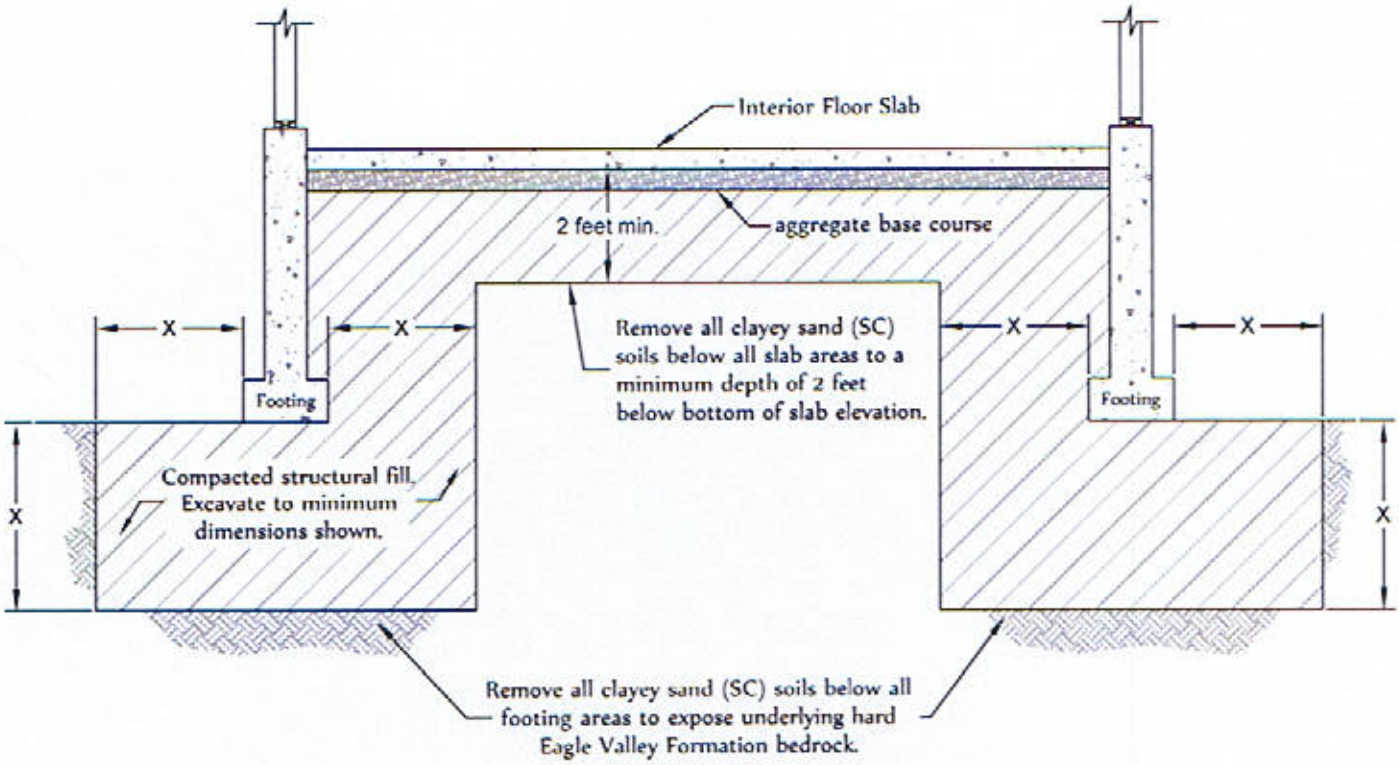
Test Hole 3		
Time Interval (min)	Water Level Drop (in)	Rate (MPI)
2	0.375	5.3
2	0.125	16
2	0.250	8
2	0.250	8
2	0.125	16
2	0.250	8
2	0.250	8
2	0.250	8
Soil Percolation Rate =		8

Trench Depth (in): 13
Hole Depth (in): 18
Total Depth (in): 31
Hole Width (in): 8
Soil Type: SC

Test Hole 4		
Time Interval (min)	Water Level Drop (in)	Rate (MPI)
2	0.25	8
2	0.125	16
2	0.125	16
2	0.125	16
2	0.125	16
2	0.125	16
2	0.125	16
2	0.125	16
Soil Percolation Rate =		16

Trench Depth (in): 11
Hole Depth (in): 12
Total Depth (in): 23
Hole Width (in): 9
Soil Type: SC

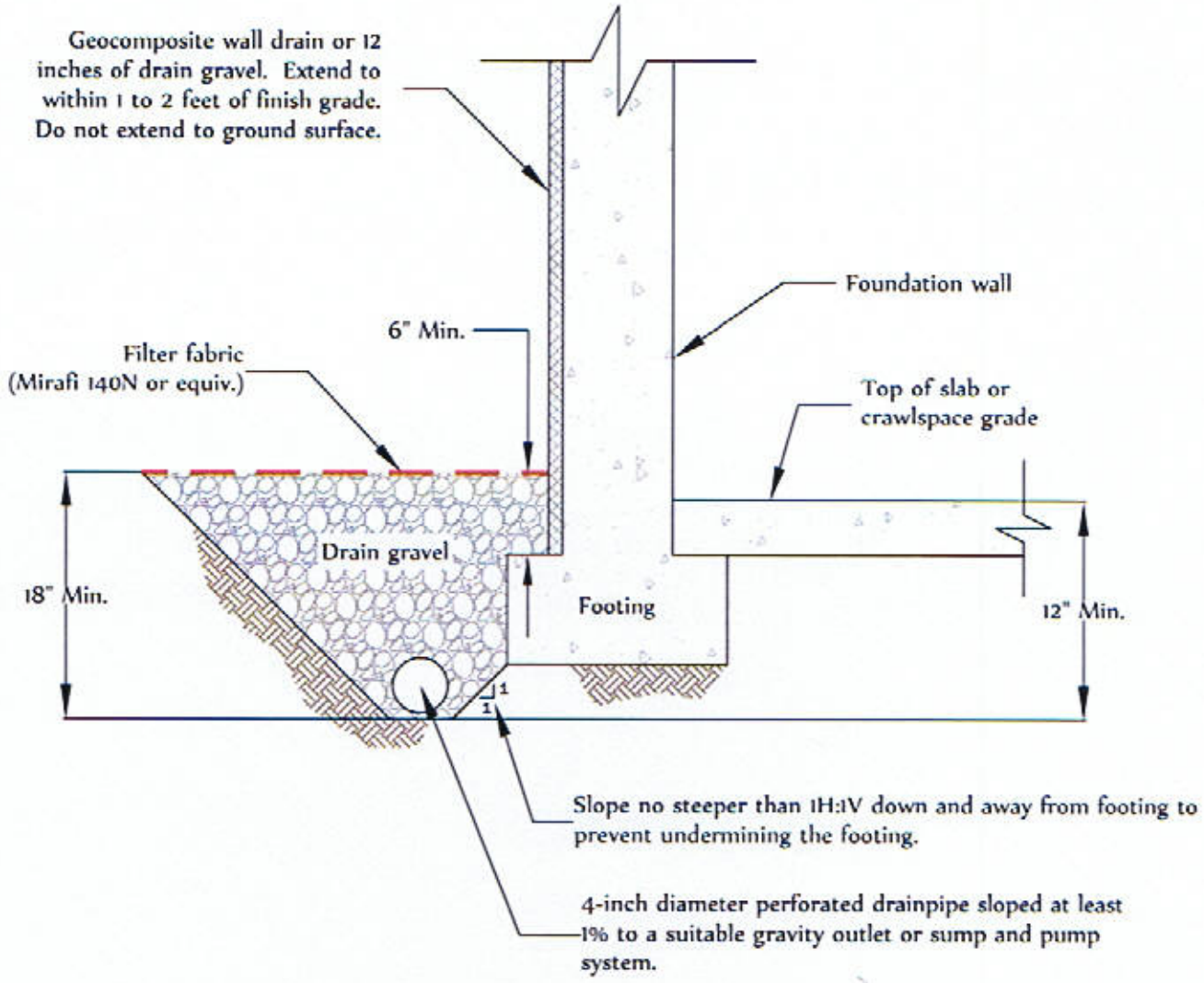
AVERAGE SOIL PERCOLATION RATE = 12



Notes:

- Structural fill beneath footing and slab areas can consist of the onsite clayey sand (SC) soils or an imported, relatively well-graded granular material such as CDOT Class 5 or 6 aggregate base course.
- Foundation recommendations given in Section 6.1 of report.
- Recommendations for structural fill placement and compaction are given in Section 6.4 of report.
- If water seepage is encountered, we should be contacted for further evaluation.
- A representative of GRE should observe the bottom of the overexcavation to confirm our recommendations are appropriate.
- It is very important that proper compaction of the structural fill be achieved beneath footing and slab areas. Inadequate compaction could lead to settlement and building/slab distress. We can provide nuclear moisture/density testing of the structural fill during placement to measure compaction levels.

GORE RANGE ENGINEERING	LOT 64, CORDILLERA SUB., FILING 3 TYPICAL OVEREXCAVATION DETAIL	PROJECT NO. 12-129.01 FIGURE 6



Not to scale

Notes:

- The upper 2 feet of wall backfill should consist of a relatively impervious on-site soil, or a pavement structure should be provided, to reduce surface water infiltration.
- Please see the surface drainage section of this report for surface grading recommendations.
- If free water is encountered during excavation, it may be necessary to lower the elevation of the drainpipe or increase drain gravel thickness. GRE should be contacted during excavation to re-evaluate our recommendations.

GORE RANGE ENGINEERING	LOT 64, CORDILLERA SUB., FILING 3 TYPICAL UNDERDRAIN DETAIL	PROJECT NO. 12-129.01 FIGURE 7