Grand Valley Consulting, LLC dba

GEOTECHNICAL ENGINEERING GROUP

GEOTECHNICAL INVESTIGATION
Crossroads Park, II
North and East of East Locust Road and 6600 Road
Montrose, Colorado

Prepared For:

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Job No. 4,737

February 21, 2022

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GEOTECHNICAL ENGINEERING GROUP

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SCOPE

This report presents the results of a Geotechnical Investigation for the proposed construction to be located North and West of East Locust Road and 6600 Road, Crossroads Park, II, in Montrose, Colorado. Our investigation was performed to explore subsurface conditions, provide recommendations for design and construction of foundations, floors and pavements for the proposed subdivision. The report includes a site description, descriptions of subsoil and groundwater conditions found in seven (7) exploratory borings, recommendations for site development, foundations, floors, pavement sections and discussion on details influenced by the subsurface conditions. The scope did not include stormwater basin testing or design. This investigation was performed in general conformance with our proposal No. 21-0856 dated January 17, 2022.

This report was prepared from data developed during our field exploration, laboratory testing, engineering analysis and experience with similar conditions. These geotechnical services involve a two phase approach. This is the first phase. The second phase is observation and testing during construction. The services will not be complete until the second phase is performed in order to confirm subsurface conditions are as anticipated and our recommendations are followed. A brief summary of our conclusions and recommendations follows. Detailed criteria are presented within the report.

SUMMARY OF CONCLUSIONS

1. Subsoils found in seven (7) exploratory borings consisted of clayey shale to the maximum depth of 25 feet below ground surface. Groundwater was found in TH-1 at 25 feet and rose to 12 feet at time of drilling.

2. We recommend a deep foundation system such as drilled micropiles to provide resistance against potential uplift pressures such as those anticipated at this site. Alternative recommendations for footing foundation supported by moisture conditioned and well compacted soil subgrade and at least 3 feet well compacted structural fill are also provided. A discussion is included in the text of the report.

3. An asphalt thickness of 3 inches asphalt over 15 inches crushed aggregate base course over scarified, moisture conditioned and well compacted subgrade soils are recommended for ESAL = 54,750 loading. Additional pavement section alternatives and design and construction criteria are presented in the text of the report.

4. Utility trench backfill should be placed in a well-compacted manner and tested during construction. Site drainage should be carefully planned and maintained to direct water away from pavements and proposed building areas.

SITE CONDITIONS

The subject site was located North and East of East Locust Road and 6600 Road in Montrose, Colorado. A vicinity map showing the site location is included as Fig. A-1. The subject site is barren. The site to the west was vacant. Existing rural single family residence to the north and east. The site to the south was Crossroad Park I duplex development. The subject site was relatively flat and sloped down towards the west at 3-4 percent and north at 1-2 percent as measured by hand level and rangefinder.

PROPOSED CONSTRUCTION

We understand proposed development includes 2 duplexes, 3 fourplexes and 3 condos. Construction will be one and 2 level with no below grade areas, wood framed structures. Wall loads of 1,000 to 2,000 pounds per lineal foot of foundation wall are anticipated. Shallow footing type foundations are desired. There will be associated paving for automobile access and parking. If the proposed construction changes or is different from that described in this report, we should be contacted to review actual construction and our recommendations.

SITE GEOLOGY

Near site geology was identified on the “Geologic Map of the Montrose East Quadrangle, Montrose County, Colorado” dated 2007 by David C. Noe, Matthew L.

Morgan, Paul R. Hanson, and Stephen M. Keller as Mancos shale. Mancos shale was encountered at time of drilling. The Mancos shale formation is known locally to have expansion potential which can cause movement and damages.

SUBSURFACE CONDITIONS

Subsurface conditions at the site were investigated by drilling and sampling the soils encountered in seven (7) exploratory borings. Locations of the exploratory borings are shown on Fig. A-2. A summary log of the soils found in the exploratory borings and field penetration resistance tests are presented on Figs. A-4 thru A-10. Subsurface conditions encountered in seven (7) exploratory borings consisted of clayey shale to the maximum depth of 25 feet below ground surface. The clayey shale was silty, sandy, hard to very hard, dry to moist, brown and calcareous. Groundwater was found in one exploratory boring, TH-1 at 25 feet and rose to 12 feet at time of drilling.

One silty, sandy clay sample from TH-1 at 9 feet depth was tested for one dimensional swell/consolidation characteristics. The sample tested had a moisture content of 12.9 percent, a dry density of 120 pcf, exhibited 2.5 percent swell when wetted under a confining pressure of 1,000 psf and had an estimated swell pressure of 5,400 psf. One silty, sandy clay sample from TH-2 at 4 feet depth was tested for one dimensional swell/consolidation characteristics. The sample tested had a moisture content of 8.5 percent, a dry density of 101 pcf, exhibited 2.0 percent swell when wetted under a confining pressure of 500 psf and had an estimated swell pressure of 1,700 psf. One silty, sandy clay sample from TH-3 at 9 feet depth was tested for one dimensional swell/consolidation characteristics. The sample tested had a moisture content of 12.7 percent, a dry density of 122 pcf, exhibited 1.9 percent swell when wetted under a confining pressure of 1,000 psf and had an estimated swell pressure of 8,200 psf. One silty, sandy clay sample from TH-4 at 4 feet depth was tested for one dimensional swell/consolidation characteristics. The sample tested had a moisture content of 11.1 percent, a dry density of 111 pcf, exhibited 0.1 percent consolidation when wetted under a confining pressure of 500 psf. One sandy clay sample from TH-4 at 9 feet depth tested had a moisture content of 15.4 percent, a liquid limit of 44 percent, a plasticity index of 18 percent and had 69 percent passing the No. 200 sieve (silt and clay sized particles). One silty, sandy clay sample from TH-5 at 9 feet depth was tested for one dimensional swell/consolidation characteristics. The sample tested had a moisture content of 14.0 percent, a dry density of 117 pcf, exhibited 3.0 percent when wetted under a confining pressure of 1,000 psf and had an estimated swell pressure of 7,500 psf. One sandy clay sample from TH-5 at 14 feet depth tested had a moisture content of 14.3 percent, a liquid limit of 49 percent, a plasticity index of 24 percent and had 55 percent passing the No. 200 sieve (silt and clay sized particles). One combined bulk sample from TH-6 and TH-7 at 0-5 feet depth tested had a moisture content of 12.0 percent, a liquid limit of 46 percent, a plasticity index of 22 percent, 68 percent passing the No. 200 sieve (silt and clay sized particles) and had 2,200 ppm water soluble sulfates. Standard Proctor testing and California Bearing Ratio (CBR) testing indicated a maximum dry density of 114 pcf, an optimum moisture content of 17.0 percent and a CBR value of 1.6. Results of laboratory testing are shown in Appendix B and summarized in Table I.

SITE DEVELOPMENT

Cuts should be minimized as much as practical. All pavement areas should be stripped of organic layers prior to cut or placement of fill. Pavement subgrade soils should be scarified a depth of 10-inches, moisture conditioned to within 2 percent of optimum moisture and compacted to at least 95 percent of maximum standard Proctor dry density (ASTM D698). Areas of existing man-made fill identified should be reviewed at time of development- portions of the fill will require removal and portions will require reworking in order to support the proposed construction. Dewatering may be required to determine existing fill depths, stabilize soft soils, recompact existing fill and install utilities. Structural fill material should be placed in maximum 10-inch loose lifts, moisture conditioned and compacted as stated above. On-site shale which is broken down into sandy, silty, clay soils free of deleterious materials, organics and particles over 2-inches diameter can be moisture conditioned and compacted as discussed above for reuse during grading. Our representative should be called to confirm complete removal of any existing fill and organic layers and to verify compaction of fill placement.

Buried Utilities

We believe utility installation in the natural clays can be accomplished using conventional excavation equipment. Utility trenches should be sloped or shored to meet local, State and Federal safety regulations. Based on our investigation, we believe soils at this site may be classified as either Type A, Type B or Type C, based on OSHA standards. Excavation slopes specified by OSHA are dependent upon types of soils and groundwater conditions encountered. Contractors should identify the conditions encountered in the excavation and refer to OSHA standards to determine appropriate slopes.

Ground water was found in TH-1 at 25 feet and rose to 12 feet at time of drilling. Ground water depths may vary during irrigation and wetter seasons.

Water and sewer lines will be constructed beneath pavements. Compaction of trench backfill can have a significant effect on the life and serviceability of pavements. We recommend trench backfill be placed in thin, loose lifts, moisture conditioned to within 2 percent of optimum moisture content and compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D698). Local code may also influence the compaction requirement. The placement and compaction of utility trench backfill should be observed and tested by a geotechnical engineer during construction.

FOUNDATIONS

This investigation indicates subsurface conditions at foundation levels consists of clayey shale. Mancos shale is known locally to have expansion characteristics which can cause movement and damages. In our opinion a deep foundation such as drilled micropiles can resist potential uplift pressures and related movement and damages. Deep micropile foundations can exhibit less total and differential movement than shallow footing foundations. We recommend micropile foundations for that reason. Alternative recommendations for footings placed on at least 3 feet well compacted structural fill underlain by well compacted or stabilized native soil subgrade are also presented. These criteria were developed from analysis of field and laboratory data and our experience. The additional requirements of the structural engineer and structural warrantor (as applicable) should also be considered.

Micropile Foundations

1. Piles may be designed for a maximum allowable end bearing pressure of 25,000 psf for micropiles bearing in the underlying soils. Micropiles may be designed using a skin friction value of 17 psi for the portion of pile at least 12 feet below the ground surface. Concrete must be placed the same day as drilling in order to preserve the skin friction value. The top 10 feet should be sleeved, and this design detail confirmed with the geotechnical engineer prior to starting construction. Piles should have a minimum length of at least 25 feet to penetrate the zone of seasonal moisture variation and obtain anchorage in the underlying strata.

2. We recommend as much minimum deadload as practical, at least 10 kips per pile. If the minimum deadload is not available, piles may be lengthened using 75% of the skin friction value stated above to create more resistance to uplift where needed.

3. Micropiles should be continuously reinforced to resist a cracked section and minimum tensile force of 4,500 psf at each location. Foundation walls and grade beams should be well reinforced to provide a simple span of at least 15 feet. The reinforcement should be designed by the registered structural engineer. A minimum 4 inch void should be provide between the bottom of grade beams between piles to reduce the influence of volume changes of soils beneath grade beams.

4. Small lateral earth pressures may be resisted by backfill against foundation wall which is below the frost level, about 18” depth. Backfill placed in a well compacted manner may be given an allowance of 150 psf equivalent fluid at rest earth pressure for this purpose.

5. Exterior foundations must be protected from frost action. We recommend referring to the local building code for frost protection requirements. We understand there is a 24-inch minimum frost depth in the Montrose area.

6. We recommend the first patio, porch or deck outside of doorways be constructed as a structurally supported system using the recommended deep foundations or haunches from the deep foundation system. This is to help control differential movement and damages at those locations.

7. In our experience, micropile system designs are largely proprietary and warranted by the contractor. A pre production test pile should be used to verifty design pressures and necessary lengths, prior to production. Installation of piles should be observed by a representative of our firm to identify the proper bearing strata and confirm production criteria. Our representative should be called at the time of the first pile, and perform tension testing on at least 10% of the production piers.

Footing Foundation

1. Bottom of footing foundations should be elevated as much as practical to help mitigate effects of underlying expansive soil conditions. Footing foundations bearing on scarified, moisture conditioned and well compacted native soil subgrade and at least 3 feet of well compacted granular structural fill can be designed for a maximum allowable soil bearing pressure of 3,000 pounds per square foot (psf).

2. Grade beams should be well reinforced, both bottom and top, to resist a simple span of at least 15 feet. Reinforcing should be designed by a competent Colorado registered structural engineer. We recommend a minimum continuous footing width of 18-inches and minimum isolated pad of 30 inches square.

3. The completed excavation, within 3 feet horizontally of foundation, should be scarified a depth of 10-inches, moisture conditioned to within 2 percent of optimum moisture content and compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D698) and tested prior to placing structural fill. If loose or yielding conditions are encountered in the open excavation, they should be removed and replaced with well compacted structural fill. Structural fill should consist of a crushed granular material or soil with a maximum particle site of 2 inches, a maximum liquid limit of 30 and a maximum of 15 percent passing the No. 200 sieve. The on site soils do not meet this criteria and not appropriate for reuse as structural fill. After excavation bottom proof roll using a heavy pneumatic tired vehicle such as a front end loader with full bucket and compaction testing show suitable subgrade preparation structural fill should be placed in 10-inch maximum loose lifts and compacted as stated above (imported granular fill compacted to at least 95% maximum modified Proctor dry density (ASTM D1557)). Our representative should be called to test compaction of subgrade (or provide stabilization recommendations, as applicable) and test compaction of each foot of the structural fill, prior to forming placement of the proceeding lift of structural fill.

4. Exterior walls must be protected from frost action. We understand there is a 24-inch minimum frost depth in the Montrose area. We recommend referring to the local building code for frost protection requirements.

5. Completed excavations should be inspected by a representative of our firm, prior to fill placement, to confirm that the soils are as anticipated from the exploratory test borings and to test compaction.

FLOOR SYSTEMS

Some movement must be assumed from an increase in moisture by site and adjacent area development, storm drainage and associated landscaping and irrigation. To our knowledge, the only reliable solution to control floor movement is the construction of a structurally supported floor with at least a 12-inch (likely 36-inches or greater) air space between the floor and subgrade. In our opinion, structural floors should be used in all finished areas to control differential movement and cracking. We understand floating slab floors are desired for unfinished garage areas. Floating slab floors and slabs may be used if the owner is aware and accepts risk of movement and damages. At minimum, we recommend slabs interior and first porch and patio slabs be constructed on a minimum 12-inches a well compacted structural fill. Care should be taken the fill is placed in a well compacted manner and tested prior to proceeding.

We recommend the following precautions for construction of slabs-on-grade at this site. These precautions will not prevent movement in the event the underlying soils become wetted; they only tend to reduce or mask damage if movement occurs. The owner and future owners must accept the risk of further maintenance, including possible replacement, of concrete slabs on grade.

1. Concrete slabs on grade should be supported on at least 12 inches, granular, well compacted structural fill. The subgrade should be prepared by scarifying at least 10-inches depth moistened and compacted to at least 95% maximum dry density by standard Proctor (ASTM D698) before placing fill. Fill should be placed in thin lifts, moisture conditioned to within 2 percent of optimum moisture content and compacted to at least 95 percent of the maximum standard Proctor (ASTM D698) dry density. Each foot

placed should be tested, as stated above. The recommended layer of compacted fill will not mitigate potential movement of slabs-on-grade due to soil volume changes of soils supporting the slabs. It will only help provide a more uniform support for the slabs-on-grade. Our representative should be called onsite prior to forming to verify soil types and proper subgrade and fill preparation.

2. Slab-on-grade construction should be limited to areas such as exterior flatwork.

3. Slabs should be separated from exterior walls and interior bearing members with a slip joint, which allows free vertical movement of slabs.

4. The use of slab-bearing partitions should be avoided. Where such partitions are necessary, a slip joint allowing at least 3 inches of free vertical slab movement should be used. The owner should be advised of potential movement and re-establish this void if it closes. Doorways and stairwells should also be designed for this movement. Sheetrock should not extend to slab-on-grade floors.

5. Underslab plumbing should be eliminated where feasible. Where such plumbing is unavoidable, it should be thoroughly pressure tested during construction for leaks and should be provided with flexible couplings. Gas and water lines leading to slab-supported appliances should be constructed with flexibility.

6. Plumbing and utilities, which pass through slabs, should be isolated from the slabs. Heating and air conditioning systems supported by the slabs should be provided with flexible connections capable of at least 6 inches of vertical movement so that slab movement is not transmitted to the ductwork.

7. Frequent control joints should be provided to reduce problems associated with shrinkage and curling. The American Concrete Institute (ACI) and Portland Cement Association (PCA) recommend a maximum panel size of 8 to 15 feet depending upon concrete thickness and slump, and the maximum aggregate size. We advocate additional control joints 3 feet off and parallel to grade beams and foundation walls.

8. Exterior patio, porch and sidewalk slabs should be designed to function as independent units. Movement of slabs-on-grade should not be transmitted

directly to the foundations. Stucco finish (if any) should terminate at least 6 inches above any flatwork.

PAVEMENT

The pavement subgrade soils consisted of clay shale. We visually classified each sample obtained from the test borings and tested samples in our laboratory. We tested a sample from TH-6 and TH-7 at 0-5 feet (bulk) for pavement design purposes. The sample was tested for Atterberg limits, -200 wash, standard Proctor, and California Bearing Ratio (CBR). The sample tested had a maximum dry density of 114 pcf, optimum moisture content of 17.0 percent and a California Bearing Ratio (CBR) of 1.6. The laboratory testing indicated sandy clay with relatively low pavement support characteristics. The results of laboratory testing for pavement design are included in Appendix B.

Our design utilized the computer program WinPAS, based on the 1993 AASHTO "Guide for Design of Pavements Structures" and our experience. We understand pavements will be used for general local residential street drive lanes. We used an Equivalent Single Axle Load (ESAL) of 54,750 and 328,500 in design calculations. We used a regional factor of 2.0 and a design serviceability index of 2.5. We used an AASHTO developed relationship to determine subgrade resilient modulus (M_r) from CBR for flexible pavement. Using this relationship, we calculated a M_r value of 2,678.2 psi. We used this M_r value for flexible pavement design. We calculated a modulus of subgrade reaction (k) value of 138 psi/in. We used this k value for rigid pavement design. Pavement design calculations are included in Appendix C. Table A below shows our recommendations:

TABLE A

SUMMARY OF RECOMMENDED PAVEMENT SECTIONS

Anticipated Traffic Volume	Asphalt Only*	Asphalt and Aggregate Base Course *	Portland Cement Concrete
ESAL = 54,750	7.25”	3” + 15” 4” + 11”	6” + 6” Class 6 ABC
ESAL = 328,500	9.75”	5” + 16” 6” + 12”	6” + 6” Class 6 ABC

*These pavement thickness alternatives are provided based on a stabilized subgrade. In our opinion, removal of existing man-made fill and use of a geotechnical subgrade stabilization grid and/or fabric such as a Mirafi 500X or better placed on the prepared subgrade soils may be required prior to placement of aggregate base course material.

If any existing fill is identified, it must be removed and replaced in a well compacted manner and tested to demonstrate a well compacted condition. The resulting native pavement subgrade should be scarified a depth of 10-inches, moisture conditioned to within 2 percent of optimum moisture content and compacted to at least 95 percent of standard Proctor (ASTM D698) maximum dry density prior to proceeding. Soft areas that require stabilization may be encountered. A Geotechnical Engineering Group representative should be called to observe a "proof roll" of the completed subgrade, made by a heavy pneumatic tired vehicle, prior to subgrade preparation and before paving. Soft subgrade conditions that require stabilization may be identified at that time. Care should be taken to avoid excessive construction traffic.

Our experience indicates asphalt pavement in areas which will be subjected to heavy trucks stopping and turning does not perform satisfactorily. We recommend placing a minimum 6 inch thick Portland cement concrete pavement in all areas where this heavy truck traffic may occur, including access aprons.

The design of a pavement system is as much a function of paving materials as supporting characteristics of the subgrade. The quality of each construction material is reflected by the strength coefficient used in the calculations. If the pavement system is constructed of inferior material, then the life and serviceability of the pavement will be substantially reduced.

The asphalt component of the pavement was designed assuming a minimum 75 gyration Superpave mix design with minimum stability of 28. Normally, an asphaltic concrete should be relatively impermeable to moisture and should be designed with a well-graded sand/gravel mix. The oil content, void ratio, flow and gradation need to be considered in the design. We recommend a job mix design be performed and periodic checks are made to verify compliance with these specifications.

If construction materials cannot meet the above requirements, then the pavement design should be evaluated based upon available materials. We recommend the materials and placement methods conform to the requirements listed in the Colorado

Department of Transportation "Standard Specifications for Road and Bridge Construction". All materials planned for construction should be submitted and tested to confirm their compliance with these specifications.

A primary cause of early pavement deterioration is water infiltration into the pavement system. The addition of moisture usually results in softening of untreated base course and subgrade and eventual failure of the pavement. We recommend drainage be designed for rapid removal of surface runoff. Curb and gutter should be backfilled and the backfill compacted to reduce ponding adjacent to pavements. Final grading of the subgrade should be carefully controlled so that design cross-slope is maintained and low spots in the subgrade which could trap water are eliminated. Seals should be provided between curb and pavement and at all joints to reduce moisture infiltration. Landscaped areas and detention ponds in pavements should be avoided.

We have included construction recommendations for flexible and rigid pavement construction in Appendix D. Routine maintenance, such as sealing and repair of cracks annually and overlays at 5 to 7-year intervals, are necessary to achieve the long-term life of an asphalt pavement system. If the design and construction recommendations cannot be followed or anticipated traffic loads change considerably, we should be contacted to review our recommendations.

CONCRETE

One combined bulk soil sample from TH-6 and TH-7 at 0-5 feet depth was tested for water-soluble sulfates. This sample had a sulfate concentration of 2,200 ppm, a severe exposure level. We recommend following the American Concrete Institute (ACI) guidelines for sulfate resistant cement. ACI recommends a Type V cement be used for concrete that comes into contact with soils that have a severe exposure on concrete. In addition, concrete should have a maximum water-cement ratio of 0.45 and minimum compressive strength of 4,500 psi.

SURFACE DRAINAGE

Performance of foundations and concrete flatwork is influenced by surface moisture conditions. Risk of wetting foundation soils can be reduced by carefully planned and maintained surface drainage. Surface drainage should be designed to provide rapid runoff of surface water away from the proposed construction. We recommend the following precautions be observed during construction and maintained at all times after the construction is completed.

1. The ground surface surrounding the exterior of the buildings and pavements should be sloped to drain away from the proposed construction in all directions. We recommend a slope of at least 12 inches in the first 10 feet around the structures, where possible. In no case should the slope be less than 6 inches in the first 5 feet. The ground surface should be sloped so that water will not pond adjacent to the structures.

2. Backfill around foundation walls should be moistened and compacted. Clayey backfill soils are suitable for reuse in the upper 24 inches of exterior wall backfill.

3. Roof downspouts and drains should discharge well beyond the limits of all backfill. Splash blocks and downspout extenders should be provided at all discharge points.

4. Landscaping should be carefully designed to minimize irrigation. Plants used close to foundation walls should be limited to those with low moisture requirements; irrigated grass and/or plants should not be located within 5 feet of the foundation. Sprinklers should not discharge within 5 feet of foundations. Irrigation should be limited to the minimum amount sufficient to maintain vegetation; application of more water will increase likelihood of slab and foundation movements.

5. Impervious plastic membranes should not be used to cover the ground surface immediately surrounding the structure. These membranes tend to trap moisture and prevent normal evaporation from occurring. Geotextile fabrics can be used to limit the weed growth and allow for evaporation.

CONSTRUCTION MONITORING

Geotechnical Engineering Group should be retained to provide general review of construction plans for compliance with our recommendations. Geotechnical Engineering Group should be retained to provide construction testing services during earthwork and foundation construction phases of the work. This is to observe the construction with respect to the geotechnical recommendations, to enable design changes in the event that subsurface conditions differ from those anticipated prior to start of construction and to give the owner a greater degree of confidence that the structure is constructed in accordance with the geotechnical recommendations.

LIMITATIONS

Seven exploratory borings were observed and sampled. The exploratory borings are representative of conditions encountered only at the exact borings locations. Variations in the subsoil conditions not indicated by the boring is always possible. Subgrade soils compaction and fill (if any) compaction should be tested during construction. Pavement subgrade soils and construction materials should be tested during construction. Utility trench backfill compaction should be tested during placement. Foundation excavations should be observed and tested prior to and during fill placement. We should be called to test micropile construction.

The scope of work performed is specific to the proposed construction and the client identified by this report. Any other use of the data, recommendations and design parameters (as applicable) provided within this report are not appropriate applications. Other proposed construction and/or reliance by other clients will require project specific review by this firm. Changes in site conditions can occur with time. Changes in standard of practice also occur with time. This report should not be relied upon after a period of three years from the date of this report and is subject to review by this firm in light of new information which may periodically become known.

We believe this investigation was conducted in a manner consistent with that level of care and skill ordinarily used by geotechnical engineers practicing in this area at this time. No other warranty, express or implied, is made. If we can be of further service in discussing the contents of this report or the analysis of the influence of the subsurface conditions on the design of the proposed construction, please call.

Sincerely,
Grand Valley Consulting, LLC dba
GEOTECHNICAL ENGINEERING GROUP

Chris Hill, E.I.T.
Staff Engineer

Reviewed by:

John Withers, P.E.
Engineer

(1 copy emailed)
Note: This report includes 23 pages text, and 5 appendixes (56 pages total). It should not be interpreted except in it's entirety.

APPENDIX A

FIELD EXPLORATION

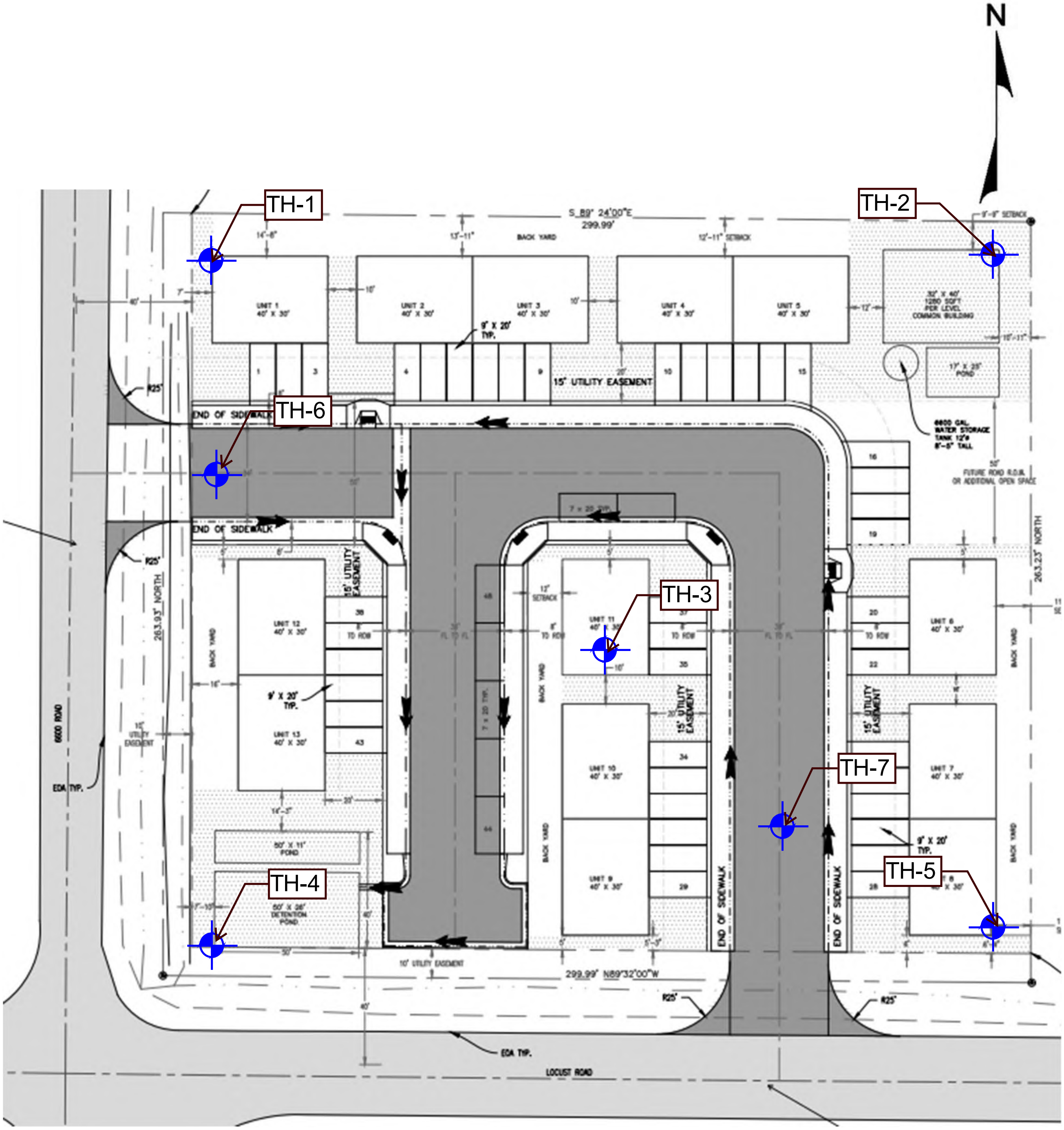
Note: This figure was prepared based on an image from Bing maps.

Project Manager: jpw	Project No. 4,737	GEOTECHNICAL ENGINEERING GROUP 3510 Ponderosa Way Grand Junction, Colorado 81506 P [970] 261 3415 jwithers@geotechnicalgroup.net
Drawn by: cjb	Scale: GRAPHIC	
Client: Tim Clifford	File Name: 4737.VMAP	
	Date: 2/8/2022	

VICINITY MAP

Crossroads Park, II
Montrose, Colorado

Fig. A-1



NOTE: THIS FIGURE WAS PREPARED BASED ON A SITE PLAN PROVIDED BY CLIENT. DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

- Indicates location of exploratory test borings.

Project Manager: JPW	Project No. 4,737	GEOTECHNICAL ENGINEERING GROUP 3510 Ponderosa Way Grand Junction, Colorado 81506 PH. (970) 261-3415 jwithers@geotechnicalgroup.net	LOCATIONS OF EXPLORATORY BORINGS	Fig.
Drawn by: CJB	Scale: N.T.S		**Crossroads Park, II** Montrose, Colorado	A-2
	File Name: BPLAN			
	Date: 2/8/2022			

Field Exploration Description

The proposed boring locations were laid out in the field by a GEG engineer using aerial imagery, stakes set in the ground by the client and measuring from available site features. The locations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

The borings were drilled with a truck-mounted rotary drill rig using continuous flight solid-stem augers to advance the boreholes. Samples of the soil encountered in the borings were obtained using the split-barrel and modified California barrel sampling procedures.

In the split-barrel and modified California barrel sampling procedure, the number of blows required to advance the sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in-situ relative density of cohesionless soils and consistency of cohesive soils. The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings prior to the drill crew leaving the site.

An automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT-N value. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

A field log of each boring was prepared by the staff engineer. These logs included visual classifications of the materials encountered during drilling as well as the driller’s interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

LOCATION: See Figure A-2
ELEVATION: -
DRILLER: Lakota
LOGGED BY: JW
DEPTH TO WATER INITIAL: 25' ATD Rose To 12'
AFTER 24 HOURS: -
DATE: 1-21-2022
DEPTH TO CAVING: -
DIAMETER: 4"
TOTAL DEPTH: 25'

Depth (feet)	Description	Graphic	Interval	Sample Type	Blow Counts	Notes
0	Topsoil, clay, silty, sandy and loose (CL)					Organics Noted in 0.5' Topsoil
	Shale, clayey, silty, sandy, very hard, dry to moist and brown (CL)					
			4'	CAL	50/7	
5						
			9'	CAL	50/10	Sulfates Noted
10						
			14'	CAL	50/10	
15						
20						Groundwater at 25', Rose to 12'
			24'	CAL	50/10	
25	Total depth 25 feet					Weathered Very Moist Zone at 25'
30						
35						

This information pertains only to this boring and should not be interpreted as being indicative of the site

Project No. : 4,737
Client: Tim Clifford
Drawn By: CJB
Date: 2-8-2022

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LOG OF EXPLORATORY TEST BORING TH-1

Crossroads Park, II

Montrose, Colorado

Fig.

A-4

LOCATION: See Figure A-2		**ELEVATION:** -	
DRILLER: Lakota		**LOGGED BY:** JW	
DEPTH TO WATER INITIAL: NATD		**AFTER 24 HOURS:** -	
DATE: 1-21-2022		**DEPTH TO CAVING:** -	
DIAMETER: 4"		**TOTAL DEPTH:** 15'	

Depth (feet)	Description	Graphic	Interval	Sample Type	Blow Counts	Notes
0	Topsoil, clay, silty, sandy and loose (CL)					Organics Noted in 0.5' Topsoil
	Shale, clayey, silty, sandy, very hard, dry and brown (CL)					
			4'	CAL	50/5	
5						
10						
			14'	CAL	50/3	
15	Total depth 15 feet					
20						
25						
30						
35						

This information pertains only to this boring and should not be interpreted as being indicative of the site

Project No. : 4,737 **Client:** Tim Clifford **Drawn By:** CJB **Date:** 2-8-2022	GEOTECHNICAL ENGINEERING GROUP 3510 Ponderosa Way, Grand Junction, Colorado 81506 (970) 261-3415	LOG OF EXPLORATORY TEST BORING TH-2 Crossroads Park, II Montrose, Colorado	Fig. A-5

LOCATION:	See Figure A-2	**ELEVATION:**	-
DRILLER:	Lakota	**LOGGED BY:**	JW
DEPTH TO WATER INITIAL:	NATD	**AFTER 24 HOURS:**	-
DATE:	1-21-2022	**DEPTH TO CAVING:**	-
DIAMETER:	4"	**TOTAL DEPTH:**	15'

Depth (feet)	Description	Graphic	Interval	Sample Type	Blow Counts	Notes
0	Topsoil, clay, silty, sandy and loose (CL)					0.5' Topsoil
	Shale, clayey, silty, sandy, hard to very hard, dry, brown and calcareous (CL)					
			4'	CAL	50/5	
5						
			9'	CAL	50/9	
10						
15	Total depth 15 feet					
20						
25						
30						
35						

This information pertains only to this boring and should not be interpreted as being indicative of the site

Project No.: 4,737
Client: Tim Clifford
Drawn By: CJB
Date: 2-8-2022

GEOTECHNICAL ENGINEERING GROUP
3510 Ponderosa Way, Grand Junction, Colorado 81506
(970) 261-3415

LOG OF EXPLORATORY TEST BORING TH-3

Crossroads Park, II

Montrose, Colorado

Fig. A-6

LOCATION:	See Figure A-2	**ELEVATION:**	-
DRILLER:	Lakota	**LOGGED BY:**	JW
DEPTH TO WATER INITIAL:	NATD	**AFTER 24 HOURS:**	-
DATE:	1-21-2022	**DEPTH TO CAVING:**	-
DIAMETER:	4"	**TOTAL DEPTH:**	15'

Depth (feet)	Description	Graphic	Interval	Sample Type	Blow Counts	Notes
0	Shale, clayey, silty, sandy, very hard to very stiff, dry, brown and calcareous (CL)					
			4'	CAL	50/6	
5						
			9'	CAL	29/12	Sulfates Noted
10						
15	Total depth 15 feet					
20						
25						
30						
35						

This information pertains only to this boring and should not be interpreted as being indicative of the site

Project No. : 4,737 **Client:** Tim Clifford **Drawn By:** CJB **Date:** 2-8-2022	GEOTECHNICAL ENGINEERING GROUP 3510 Ponderosa Way, Grand Junction, Colorado 81506 (970) 261-3415	LOG OF EXPLORATORY TEST BORING TH-4 Crossroads Park, II Montrose, Colorado	Fig. A-7

LOCATION:	See Figure A-2	ELEVATION:	-
DRILLER:	Lakota	LOGGED BY:	JW
DEPTH TO WATER INITIAL:	NATD	AFTER 24 HOURS:	-
DATE:	1-21-2022	DEPTH TO CAVING:	-
DIAMETER:	4"	TOTAL DEPTH:	15'

Depth (feet)	Description	Graphic	Interval	Sample Type	Blow Counts	Notes
0	Topsoil, clay, silty, sandy and loose (CL)					Organics Noted in 0.5' Topsoil
	Shale, clayey, silty, sandy, hard, dry and brown (CL)					
			4'	CAL	50/10	
5						
			9'	CAL	50/10	Sulfates Noted
10						
			14'	CAL	50/9	
15	Total depth 15 feet					
20						
25						
30						
35						

This information pertains only to this boring and should not be interpreted as being indicative of the site

Project No. : 4,737 Client: Tim Clifford Drawn By: CJB Date: 2-8-2022	GEOTECHNICAL ENGINEERING GROUP 3510 Ponderosa Way, Grand Junction, Colorado 81506 (970) 261-3415	LOG OF EXPLORATORY TEST BORING TH-5 Crossroads Park, II Montrose, Colorado	Fig. A-8

LOCATION:	See Figure A-2	ELEVATION:	-
DRILLER:	Lakota	LOGGED BY:	JW
DEPTH TO WATER INITIAL:	NATD	AFTER 24 HOURS:	-
DATE:	1-21-2022	DEPTH TO CAVING:	-
DIAMETER:	4"	TOTAL DEPTH:	6'

Depth (feet)	Description	Graphic	Interval	Sample Type	Blow Counts	Notes
0	Topsoil, clay, silty, sandy and loose (CL)					0.5' Topsoil
	Shale, clayey, silty, sandy, stiff, dry and brown (CL)					Bulk Sample From 0.5-6'
5						
	Total depth 6 feet					
10						
15						
20						
25						
30						
35						

This information pertains only to this boring and should not be interpreted as being indicative of the site

Project No. : 4,737
Client: Tim Clifford
Drawn By: CJB
Date: 2-8-2022

GEOTECHNICAL ENGINEERING GROUP
3510 Ponderosa Way, Grand Junction, Colorado 81506
(970) 261-3415

LOG OF EXPLORATORY TEST BORING TH-6

Crossroads Park, II

Montrose, Colorado

Fig. A-9

LOCATION:	See Figure A-2	**ELEVATION:**	-
DRILLER:	Lakota	**LOGGED BY:**	JW
DEPTH TO WATER INITIAL:	NATD	**AFTER 24 HOURS:**	-
DATE:	1-21-2022	**DEPTH TO CAVING:**	-
DIAMETER:	4"	**TOTAL DEPTH:**	6'

Depth (feet)	Description	Graphic	Interval	Sample Type	Blow Counts	Notes
0	Topsoil, clay, silty, sandy and loose (CL)					0.5' Topsoil
	Shale, clayey, silty, sandy, hard, dry and brown (CL)					Bulk Sample From 0.5-6'
5						
	Total depth 6 feet					
10						
15						
20						
25						
30						
35						

This information pertains only to this boring and should not be interpreted as being indicative of the site

Project No.: 4,737
Client: Tim Clifford
Drawn By: CJB
Date: 2-8-2022

GEOTECHNICAL ENGINEERING GROUP
3510 Ponderosa Way, Grand Junction, Colorado 81506
(970) 261-3415

LOG OF EXPLORATORY TEST BORING TH-7

Crossroads Park, II

Montrose, Colorado

Fig. A-10

APPENDIX B

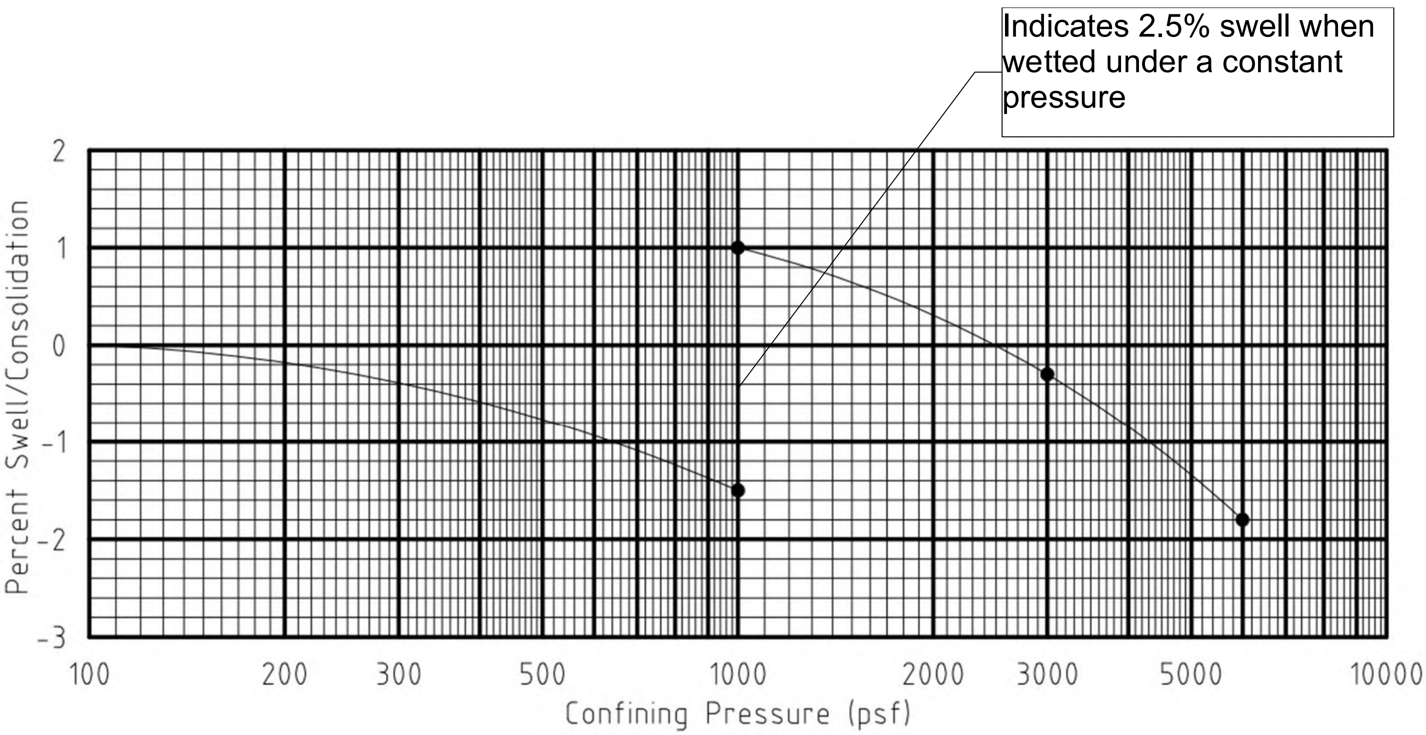
LABORATORY TESTING

Laboratory Testing

Soil samples were tested in the laboratory to measure their dry unit weight, natural water content, grain size distribution (sieve analysis) and plastic characteristics (Atterberg Limits). Swell/Consolidation tests of select samples were conducted to estimate soil response to loading and wetting of the samples tested. The test results are included in Appendix B.

Descriptive classifications of the soils indicated on the boring logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are estimated Unified Soil Classification Symbols. A brief description of this classification system is attached to this report. All classification was by visual manual procedures. Selected samples were further classified using the results of gradation and Atterberg limit testing.

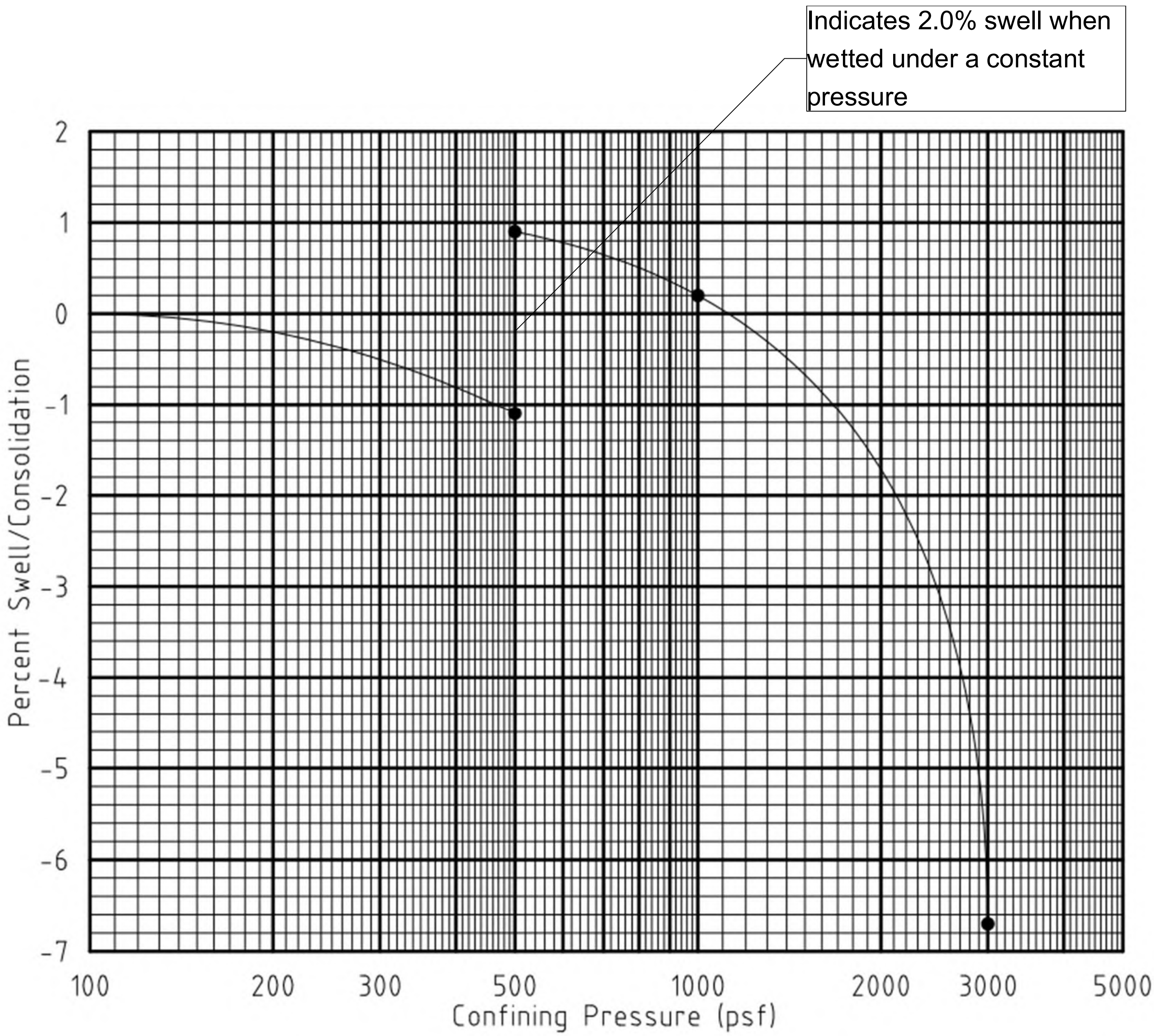
SWELL-CONSOLIDATION TEST REPORT



Test Results
Swell/Consolidation = 2.5%
Swell Pressures = 5,400 psf
Confining Pressure = 1,000 psf

Project No.: 4,737 **Client:** Tim Clifford	GEOTECHNICAL ENGINEERING GROUP 3510 Ponderosa Way, Grand Junction, Colorado 81506 (970) 261-3415	TH-1 at 9 Feet Depth **Crossroads Park, II** Montrose, Colorado	Fig. B-2

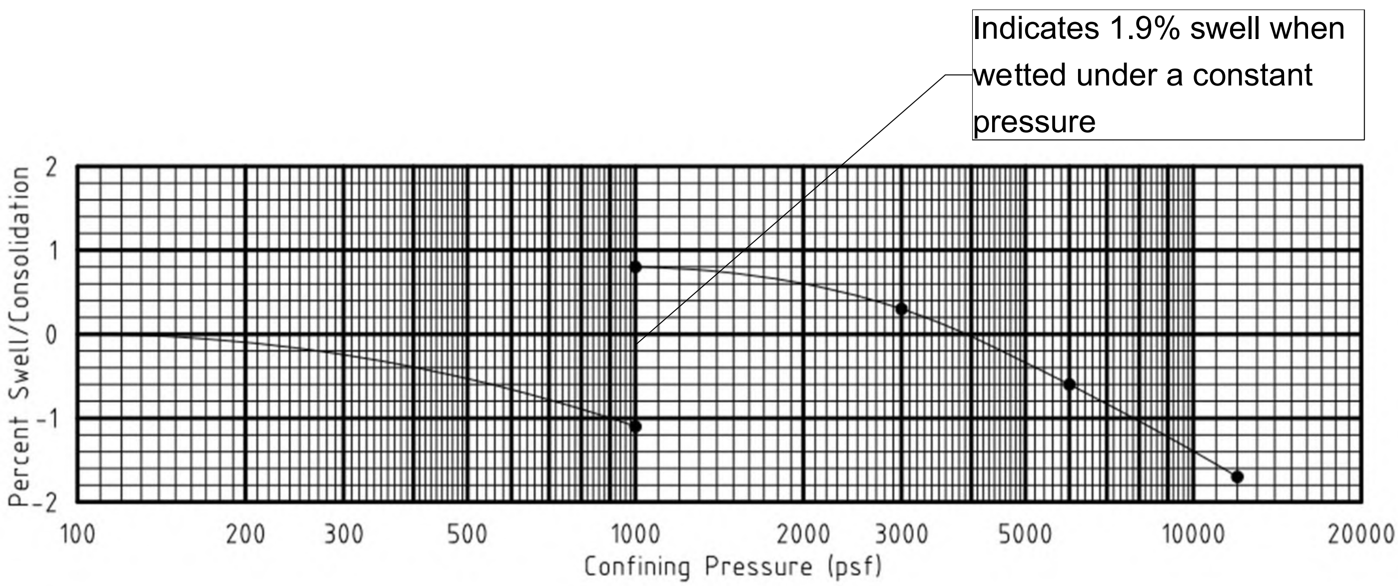
SWELL-CONSOLIDATION TEST REPORT



Test Results
Swell/Consolidation = 2.0%
Swell Pressures = 1,700 psf
Confining Pressure = 500 psf

Project No.: 4,737 Client: Tim Clifford	GEOTECHNICAL ENGINEERING GROUP 3510 Ponderosa Way, Grand Junction, Colorado 81506 (970) 261-3415	TH-2 at 4 Feet Depth **Crossroads Park, II** Montrose, Colorado	Fig. B-3

SWELL-CONSOLIDATION TEST REPORT



Test Results

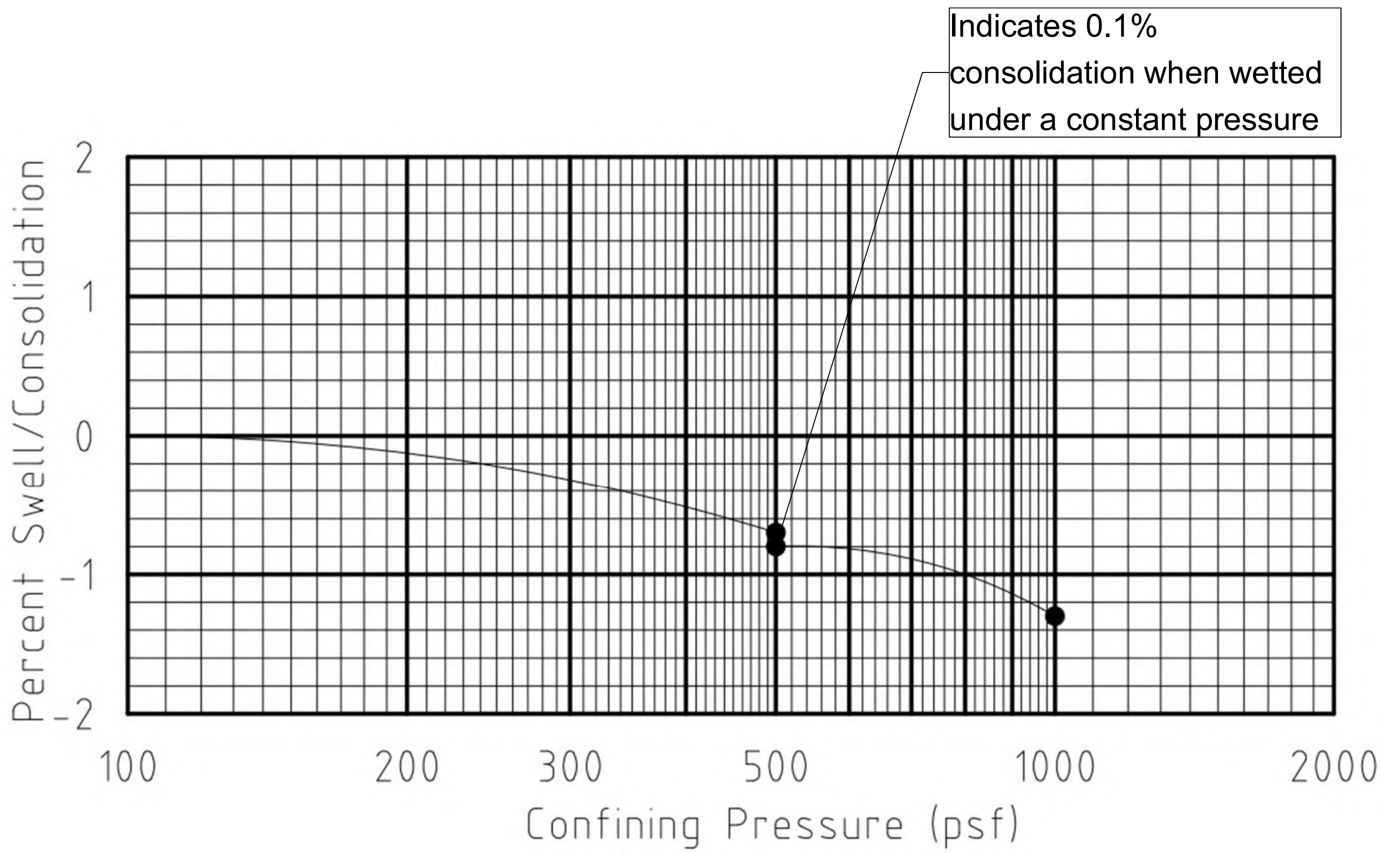
Swell/Consolidation = 1.9%

Swell Pressures = 8,200 psf

Confining Pressure = 1,000 psf

Project No.: 4,737 **Client:** Tim Clifford	GEOTECHNICAL ENGINEERING GROUP 3510 Ponderosa Way, Grand Junction, Colorado 81506 (970) 261-3415	TH-3 at 9 Feet Depth **Crossroads Park, II** Montrose, Colorado	Fig. B-4

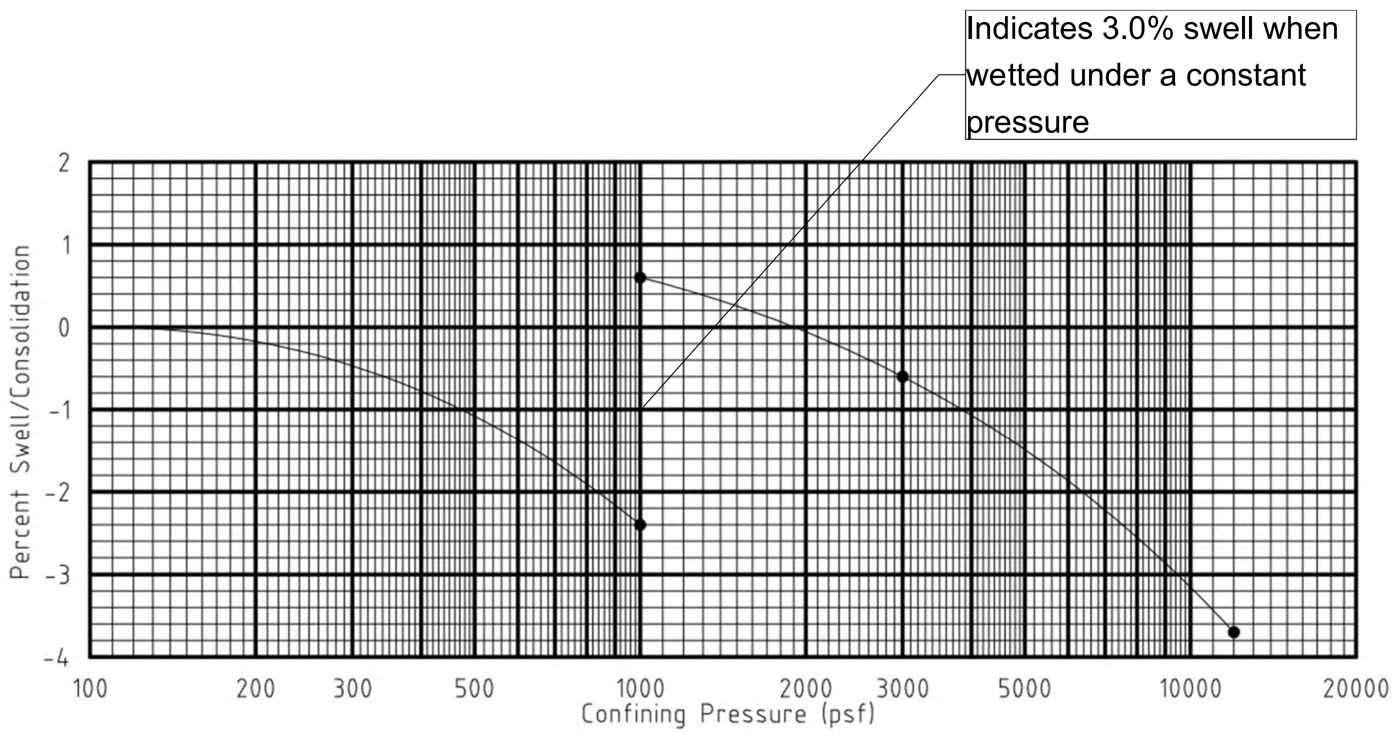
SWELL-CONSOLIDATION TEST REPORT



Test Results
Swell/Consolidation = -0.1%
Swell Pressures = NA
Confining Pressure = 500 psf

Project No.: 4,737 **Client:** Tim Clifford	GEOTECHNICAL ENGINEERING GROUP 3510 Ponderosa Way, Grand Junction, Colorado 81506 (970) 261-3415	TH-4 at 4 Feet Depth **Crossroads Park, II** Montrose, Colorado	Fig. B-5

SWELL-CONSOLIDATION TEST REPORT



Test Results

Swell/Consolidation = 3.0%

Swell Pressures = 7,500 psf

Confining Pressure = 1,000 psf

Project No.: 4,737 **Client:** Tim Clifford	GEOTECHNICAL ENGINEERING GROUP 3510 Ponderosa Way, Grand Junction, Colorado 81506 (970) 261-3415	TH-5 at 9 Feet Depth **Crossroads Park, II** Montrose, Colorado	Fig. B-6

MOISTURE-DENSITY RELATIONSHIP TEST REPORT

Project No.: 4,737 Date: 1-21-2022
Project: Crossroads Park, II

Elev./Depth:0-5' Sample No. 1

Source: TH-6 and TH-7 at 0-5'
Remarks:

MATERIAL DESCRIPTION

Description: Clay, sandy (CL)

Classification = USCS: (CL) AASHTO
Nat. Moist. = 12.0% SP.G. =
Liquid Limit = 46% Plasticity Index = 22%
% < No.200 = 68%

MATERIAL DESCRIPTION
Maximum Dry Density = 114 pcf Optimum Moisture = 17.0%

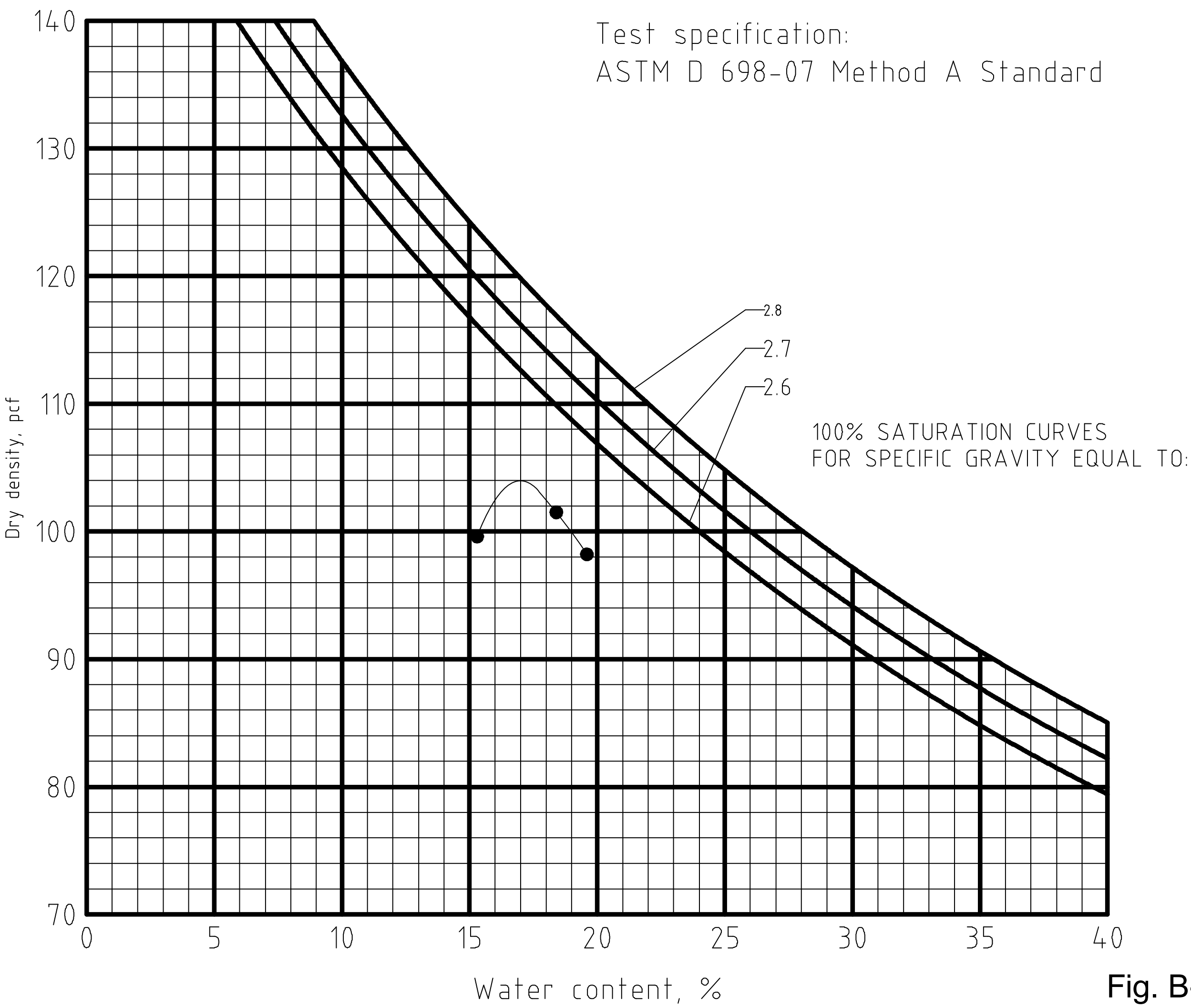
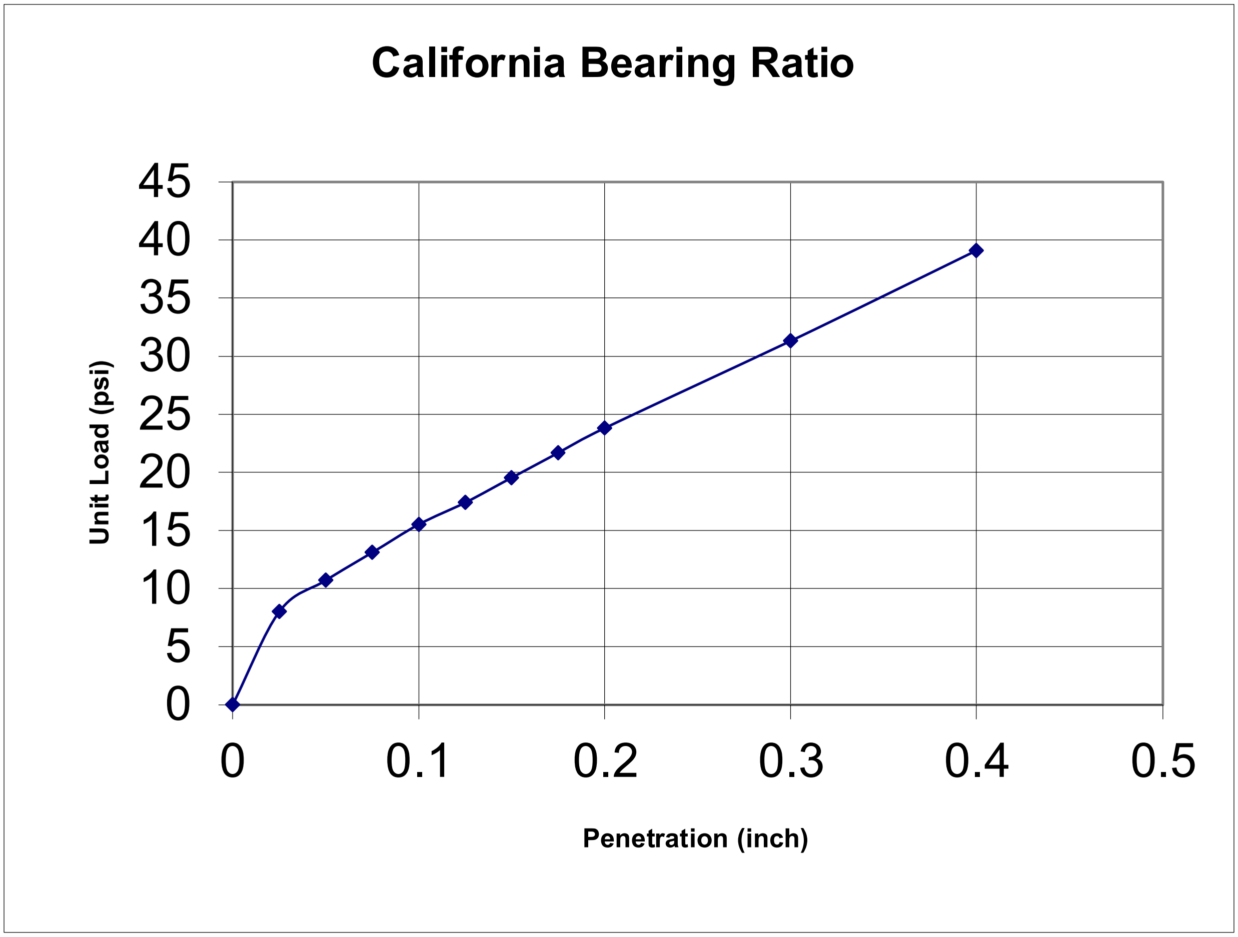


Fig. B-7



CBR @ 0.1" Penetration	1.6
CBR @ 0.2" Penetration	1.6
Maximum Dry Density (pcf)	114.0
Optimum Moisture Content (%)	17.0
Dry Density (pcf)	109.4
Dry Density (% Maximum)	0.96
Surcharge Weight (lbs)	12.6
Swell (%)	3.1
Before Soaking Moisture Content	16.7
After Soaking Moisture Content:	26.6
Top Inch	32.2
Average	20.9

GEOTECHNICAL ENGINEERING GROUP

Job No. 4,737 Crossroads Park, II

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Hole	Depth (feet)	Moisture (%)	Dry Density (pcf)	Atterberg Limits		Swell / Consolidation			Passing No. 200 Sieve (%)	Water Soluble Sulfates (ppm)	Soil Type
				Liquid Limit (%)	Plasticity Index (%)	Swell (%)	Confining Pressure (psf)	Estimated Swell Pressure (psf)			
TH-1	9	12.9	120			2.5	1,000	5,400			Clay shale
TH-2	4	8.5	101			2.0	500	1,700			Clay shale
TH-3	9	12.7	122			1.9	1,000	8,200			Clay shale
TH-4	4	11.1	111			-0.1	500	NA			Clay shale
	9	15.4		44	18				69		Clay shale
TH-5	9	14.0	117			3.0	1,000	7,500			Clay shale
	14	14.3		49	24				55		Clay shale
TH-6&7	0-5	12.0		46	22				68	2,200	Clay shale

APPENDIX C

PAVEMENT DESIGN

WinPAS

Pavement Thickness Design According to

1993 AASHTO Guide for Design of Pavements Structures

American Concrete Pavement Association

Flexible Design Inputs

Project Name: Crossroads Park, II
Route:
Location:
Owner/Agency:
Design Engineer:

Flexible Pavement Design/Evaluation

Structural Number	2.90		**Subgrade Resilient Modulus**	2,678.20	**psi**
Total Flexible ESALs	54,750		**Initial Serviceability**	4.50	
Reliability	80.00	**percent**	**Terminal Serviceability**	2.50	
Overall Standard Deviation	0.45				

Layer Pavement Design/Evaluation

Layer Material	Layer Coefficient	Drainage Coefficient	Layer Thickness	Layer SN
Asphalt Cement Concrete	0.40	1.00	3.00	1.20
Graded Stone Base	0.12	1.00	15.00	1.80
			ΣSN	3.00

Calculate alternative asphalt + base section : 2.90 = 0.4x(4.0-inches) + 0.12x(11.0-inches)
4.0-inches asphalt + 11.0-inches graded stone base

Calculate alternative asphalt only section : 2.90 = 0.4x(7.25-inches)
7.25-inches asphalt

Note: each section option described is underlain by native soil subgrade prepared by stabilization (as appropriate must pass proof roll described) and scarify 10", moisture condition near optimum and well compacted as described in report.

Thursday, February 10, 2022 3:30:30PM Engineer:Chris Hill, EIT

WinPAS

Pavement Thickness Design According to

1993 AASHTO Guide for Design of Pavements Structures

American Concrete Pavement Association

Flexible Design Inputs

Project Name: Crossroads Park, II
Route:
Location:
Owner/Agency:
Design Engineer:

Flexible Pavement Design/Evaluation

Structural Number	3.82		**Subgrade Resilient Modulus**	2,678.20	**psi**
Total Flexible ESALs	328,500		**Initial Serviceability**	4.50	
Reliability	80.00	**percent**	**Terminal Serviceability**	2.50	
Overall Standard Deviation	0.45				

Layer Pavement Design/Evaluation

Layer Material	Layer Coefficient	Drainage Coefficient	Layer Thickness	Layer SN
Asphalt Cement Concrete	0.40	1.00	5.00	2.00
Graded Stone Base	0.12	1.00	16.00	1.92
			ΣSN	3.92

Calculate alternative asphalt + base section : 3.82 = 0.4x(6.0-inches) + 0.12x(12.0-inches)
6.0-inches asphalt + 12.0-inches graded stone base

Calculate alternative asphalt only section : 3.82 = 0.4x(9.75-inches)
9.75-inches asphalt

Note: each section option described is underlain by native soil subgrade prepared by stabilization (as appropriate must pass proof roll described) and scarify 10", moisture condition near optimum and well compacted as described in report.

WinPAS

Pavement Thickness Design According to

1993 AASHTO Guide for Design of Pavements Structures

American Concrete Pavement Association

Rigid Design Inputs

Project Name:	Crossroads Park, II
Route:	
Location:	
Owner/Agency:	
Design Engineer:	

Rigid Pavement Design/Evaluation

Concrete Thickness	6.00	**inches**	**Load Transfer Coefficient**	2.00	
Total Rigid ESALs	328,500		**Modulus of Subgrade Reaction**	138	**psi/in.**
Reliability	80.00	**percent**	**Drainage Coefficient**	1.00	
Overall Standard Deviation	0.45		**Initial Serviceability**	4.50	
Flexural Strength	500	**psi**	**Terminal Serviceability**	2.50	
Modulus of Elasticity	3,375,000	**psi**			

Modulus of Subgrade Reaction (k-value) Determination

Resilient Modulus of the Subgrade	2,678.2	**psi**
Unadjusted Modulus of Subgrade Reaction	138	**psi/in**
Depth to Rigid Foundation	0.00	**feet**
Loss of Support Value (0,1,2,3)	0.0	

Modulus of Subgrade Reaction	138	**psi/in.**

APPENDIX D

PAVEMENT CONSTRUCTION RECOMMENDATIONS

FLEXIBLE PAVEMENT CONSTRUCTION RECOMMENDATIONS

Experience has shown that construction methods can have a significant effect on the life and serviceability of a pavement system. We recommend the proposed pavement be constructed in the following manner:

1. The subgrade should be stripped of organic matter and deleterious materials, scarified, moisture treated, and compacted. Soils should be moisture treated to within 2 percent of optimum moisture content and compacted to at least 95 percent of maximum standard Proctor dry density (ASTM D 698).

2. After final subgrade elevation has been reached and the subgrade compacted, the area should be proof-rolled with a heavy pneumatic-tired vehicle (i.e., a loaded 10-wheel dump truck). Subgrade that is pumping or deforming excessively should be stabilized.

3. If areas of soft or wet subgrade soils are encountered, the material should be sub excavated and replaced with properly compacted structural backfill. Where extensively soft, yielding subgrade is encountered, we recommend the excavation be inspected by a representative of our office.

4. Aggregate base course should be laid in thin, loose lifts, moisture treated to within 2 percent of optimum moisture content and compacted to at least 95 percent of maximum modified Proctor dry density (ASTM D 1557, AASHTO T 180).

5. Asphaltic concrete should be hot plant-mixed material compacted to at least 92 to96 percent of maximum theoretical density. The temperature at laydown time should be at least 235 degrees F. The maximum compacted lift should be 3.0 inches and joints should be staggered.

6. The subgrade preparation and the placement and compaction of all pavement material should be observed and tested. Compaction criteria should be met prior to the placement of the next paving lift. The additional requirements of City of Montrose, Colorado Specifications should apply in areas to be accepted by themunicipality.

RIGID PAVEMENT CONSTRUCTION RECOMMENDATIONS

Rigid pavement sections are not as sensitive to subgrade support characteristics as flexible pavement. Due to the strength of the concrete, wheel loads from traffic are distributed over a large area and the resulting subgrade stresses are relatively low. The critical factors affecting the performance of a rigid pavement are the strength and quality of the concrete, and the uniformity of the subgrade. We recommend subgrade preparation and construction of the rigid pavement section be completed in accordance with the following recommendations:

1. Subgrade areas should be stripped of organics and deleterious materials. The pavement subgrade shall be compacted within 2% of optimum moisture content to at least 95% of maximum standard Proctor dry density (ASTM D 698). Moisture treatment and compaction recommendations also apply where additional fill is necessary.

2. The resulting subgrade shall be checked for uniformity and all soft or yielding materials should be replaced prior to paving. Concrete should not be placed on soft, spongy, frozen, or otherwise unsuitable subgrade.

3. The subgrade shall be kept moist prior to paving.

4. Concrete should not be placed in cold weather or on frozen subgrade

5. Curing procedures should protect the concrete against moisture loss, rapid temperature change, freezing, and mechanical injury for at least 3 days after placement. Traffic should not be allowed on the pavement for at least one week.

6. A white, liquid membrane-curing compound, applied at the rate of 1 gallon per 150 square feet, should be used.

7. Construction joints, including longitudinal joints and transverse joints, should be formed during construction or should be sawed shortly after the concrete has begun to set, but prior to uncontrolled cracking. All joints should be sealed.

8. Construction control and inspection shall be carried out during the subgrade preparation and paving procedures. Concrete shall be carefully monitored for quality control. The additional requirements of City of Montrose, Colorado Specificationsshould apply in areas to be accepted by the municipality.

9. Deicing salts should not be used for the first year after placement.

APPENDIX F

SUPPORTING DOCUMENTS

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

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

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

WATER LEVEL MEASUREMENT SYMBOLS:

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

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

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

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	0 - 1	Very Soft
500 – 1,000	2 - 4	Soft
1,000 – 2,000	5 - 8	Medium Stiff
2,000 – 4,000	9 - 15	Stiff
4,000 – 8,000	16 - 30	Very Stiff
8,000+	> 30	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

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

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

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

PLASTICITY DESCRIPTION

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

FIG. E-1

UNIFIED SOIL CLASSIFICATION SYSTEM

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[Q] PI plots below "A" line.

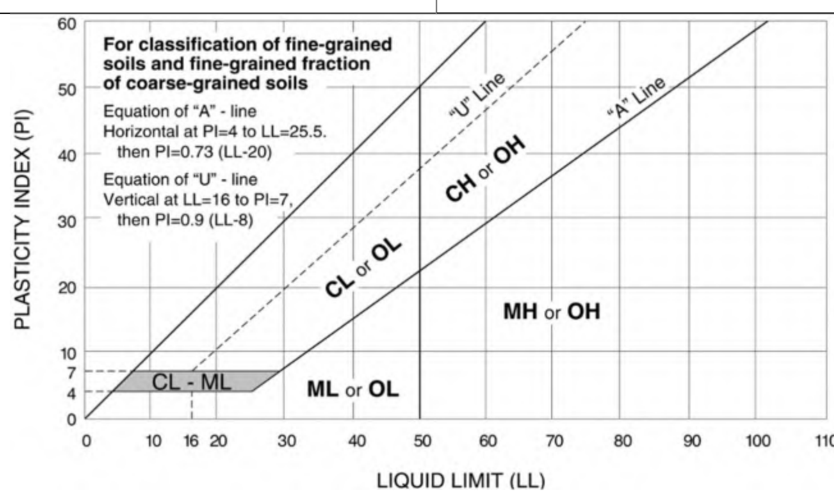
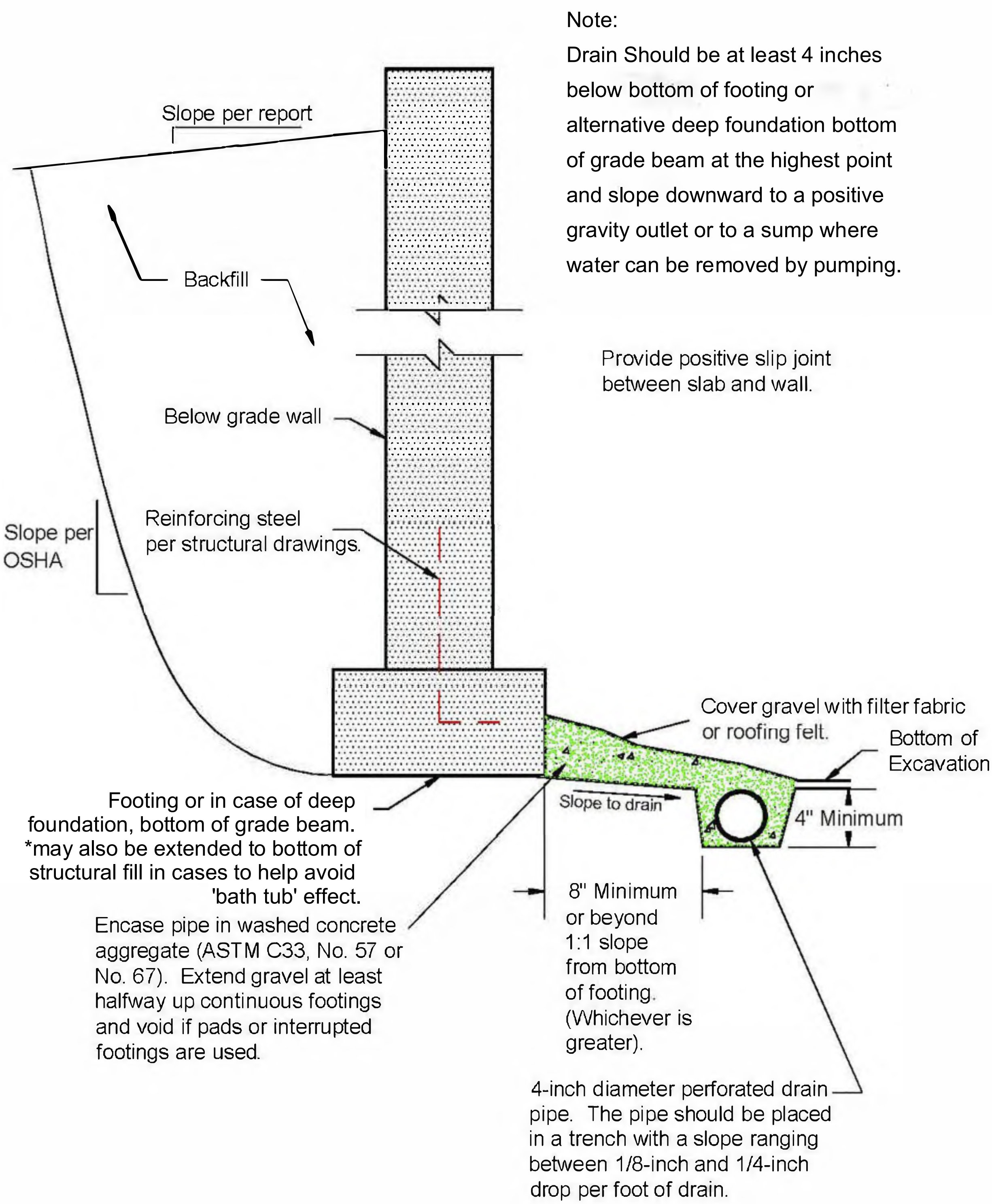
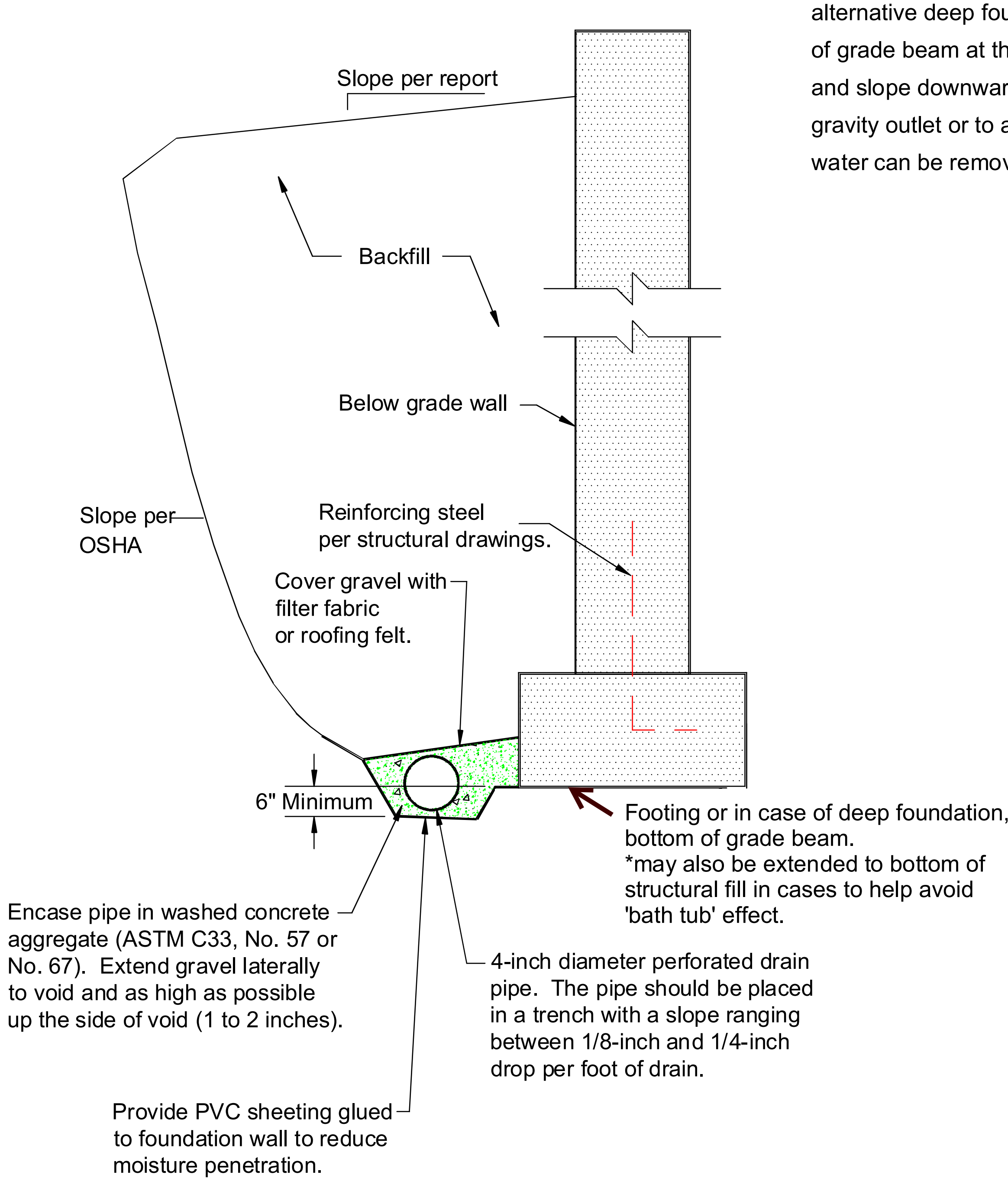


Fig. E-2



Interior Foundation Wall Drain Concept

Note:
Drain should be at least 4 inches below bottom of footing or alternative deep foundation bottom of grade beam at the highest point and slope downward to a positive gravity outlet or to a sump where water can be removed by pumping.



Exterior Foundation Wall Drain Concept

Job No. 4,737

Fig. E-4