September 4, 2019

Jan & Andy Janes
c/o Chandler Deimund
Vertical Arts Architecture
690 Marketplace Plaza, Suite 1
Steamboat Springs, Colorado 80487

Re: Geotechnical Subsurface Exploration
Proposed Janes Residence
Lot 9, Murphy Larson Ranch Subdivision
Routt County, Colorado
WSG Project # 19-1035

Dear Jan and Andy,

Western Slope Geotech, Inc. (WSG) has completed the geotechnical subsurface exploration you requested for your proposed residence to be constructed within Lot 9 of the Murphy Larson Ranch Subdivision in Routt County, Colorado. The results of our subsurface exploration, laboratory testing and pertinent geotechnical engineering recommendations are included with this report.

PURPOSE AND SCOPE OF WORK

The purpose of this exploration and associated reporting is to provide geotechnical design and construction recommendations for the proposed residential structure and other site improvements. WSG's scope of work included field exploration, laboratory testing and the preparation of this report summarizing the data obtained and outlining our recommendations for foundation design and construction. The conclusions and recommendations outlined in this report are based on the results of field exploration, laboratory testing and WSG's experience with subsurface conditions and similar construction in this area.

PROPOSED CONSTRUCTION

Based on the site plan provided and site topography, WSG assumes proposed construction will likely consist of a one to two-story wood framed structure with no basement and with an attached garage. Lower level floor elevation is anticipated to be between 0 and 7 feet

above existing ground surface and garage floor level is anticipated 1-foot above to 3 feet below existing site grades. Concrete slab-on-grade floor systems are assumed to be preferred for at least a portion of the residence lower level and garage.

Site grading to develop finished grades at the site is expected to include unretained cuts and fills up to approximately 7 feet in depth.

Foundation loads for the structure are expected to be relatively light, with continuous wall loads less than 3 kips per lineal foot and individual column pad loads of less than 50 kips. If the assumed construction and loading conditions vary substantially from those assumed, WSG should be contacted to reevaluate the recommendations in this report.

SITE DESCRIPTION

The project site is located off the south side of Hannah's Way in the Murphy Larson Ranch Subdivision, Routt County, Colorado. The proposed building site was vacant, appeared undisturbed at the time of this exploration and was well vegetated with grass, weeds, deciduous brush and scattered aspen trees.

Building site topography appeared variable and generally sloped gently to moderately down to the southeast on the order of 5 to 10 percent. Based on review of the site plan provided, it appears approximately 8 feet of elevation difference exists across the proposed building site.

FIELD EXPLORATION AND SUBSURFACE CONDITIONS

WSG's field exploration program consisted of the drilling of four (4) exploratory test holes at the proposed building and driveway sites. The test holes were advanced to obtain information about the subsurface profile, soils and groundwater conditions and obtain material samples for laboratory testing. Approximate test hole locations are shown on Figure 1.

The subsurface conditions encountered in the test holes were variable and generally consisted of a layer topsoil and organics overlying natural lean to fat clay to the maximum depth explored, 30 feet below existing ground surface. Graphic logs of the exploratory test holes are presented on Figure 2 and the associated legend and notes are presented on Figure 3.

A layer of topsoil and organics was encountered at the ground surface in all test holes and varied from approximately 12 to 30 inches in thickness.

Lean to fat clay was encountered beneath the topsoil in all test holes. The lean to fat clay was slightly sandy to sand and clay with scattered gravel, moderately to highly plastic, stiff to hard, moist to very moist and light brown. Sample of the clay classified as CL, CH and SC-CL-CH soils in accordance with the Unified Soil Classification System (USCS).

Swell-consolidation tests conducted on samples of the lean to fat clay indicates the materials will display a moderate swell potential under wetting and constant (1,000 psf) loading conditions. Swell-consolidation test results are presented on Figures 4 and 5 and are summarized according to risk category on Table A below. Laboratory test results are also summarized on Table 1.

Table A

Slab Performance Risk Category	Representative Percent Swell (500 psf Surcharge)	Representative Percent Swell (1,000 psf Surcharge)	Test Results
			Lean to Fat Clay
Low	0 to <3	0 to <2	
Moderate	3 to <5	2 to <4	2
High	5 to <8	4 to <6	
Very High	>8	>6	
Total			2

Groundwater was not encountered in the test holes at the time of drilling. Groundwater levels will vary seasonally and over time based on weather conditions, site development, irrigation practices and other hydrologic conditions. Perched and/or trapped groundwater conditions may also be encountered at times throughout the year. Perched water is commonly encountered in soils overlying less permeable soil layers and/or bedrock.

ANALYSIS AND RECOMMENDATIONS

General

Based on our understanding of proposed construction, subsurface conditions encountered in the test holes and laboratory test results, WSG recommends a drilled pier foundation be used for structure support due to moderate swell potential for the lean to fat clay.

This type of foundation system extends the foundation elements through expansive materials which are subjected to drying and wetting cycles and places them in materials not as likely to experience significant moisture changes and resulting volume change. Drilled piers also allow for concentration of building dead-loads and resistance to uplift through skin friction between the pier and soils, aiding the resistance of uplift forces caused by expansive materials. An alternate foundation design is also presented with increased risk of differential foundation movement.

Swell-consolidation tests indicate that the lean to fat clay likely to influence slab-on-grade construction will display a moderate swell potential under loading and saturation conditions. WSG estimates total floor slab heave ranging from 1½ to 2 inches could be realized over time if deep wetting of the site occurs. Therefore, a structural floor system is recommended for finished floor areas. Slab-on-grade floor systems are feasible for the garage; however, removal and replacement of expansive materials is recommended to improve performance. Recommendations concerning drilled pier foundation design criteria and floor systems are outlined below.

Foundations

WSG recommends a drilled pier foundation be designed and constructed in accordance with the following criteria:

1. Piers should have a minimum shaft length of 20 feet and a minimum diameter of 12 inches to facilitate proper cleaning and inspection.
2. Piers should be designed using a maximum allowable end bearing value of 3,000 psf and skin friction value of 800 psf. The upper 3 feet of pier penetration should be neglected in skin friction bearing calculations.
3. Piers should be reinforced full length with a minimum of one #5 bar for each 16 inches of pier perimeter.

4. A minimum 4-inch continuous void space should be constructed beneath foundation grade beams and any pier caps to concentrate dead-load on the piers and allow for some movement of the subgrade soils to occur without transmitting stresses to the overlying structure. Voids should be formed using approved methods to prevent soil and debris from entering the void space. Void form material should be collapsible enough such that sufficient loads cannot be transmitted through the void form to mobilize the grade beams.

5. Scattered gravel was encountered in the test borings during this exploration. Based on the subsurface conditions encountered in test holes, we anticipate pier excavations can be completed using conventional augering techniques. The drilling contractor should be informed of the anticipated subsurface conditions and mobilize a drill rig of sufficient size and operating capacity to achieve the minimum depths required in the design.

6. Pier excavations would be expected to remain stable for short periods during construction such that WSG does not anticipate the need for temporary casing. If groundwater is encountered at the time of pier construction, placement of pier concrete using a pump truck or tremie method may be required. A maximum three (3) inch water depth is acceptable at the bottom of pier excavations immediately prior to free fall concrete placement.

7. WSG recommends pier concrete have a slump in the range of 5 to 7 inches and be placed in pier excavations immediately after completion of drilling, cleaning, inspection and placement of reinforcing steel. Care should be taken in forming the upper edges of the pier excavation to avoid "mushrooming" at the top of the drilled pier excavations. The mushroom shape would provide additional area for expansive soil uplift forces. Cylindrical cardboard forms or other approved means may be necessary to maintain a consistent upper shaft diameter.

8. WSG should be retained to conduct observations of pier construction to document pier depth, concrete and steel placement and provide additional recommendations in the event that subsurface conditions vary from those assumed.

WSG estimates long term settlement of the drilled pier foundations designed and constructed as outlined above and resulting from the assumed structural loads would be less than ½ of an inch.

Alternative Foundation Recommendations

If the owner is fully informed and aware of the potential for differential foundation movement and associated damage and/or impact to building performance, then the structure can be supported by a spread footing foundation system placed over structural fill material. Spread footing foundations should be designed and constructed as outlined below. Anticipated differential foundation movement should be within the limits indicated below if foundations are designed and constructed as follows:

1. WSG recommends foundation footings be placed on a minimum of 3 feet of properly compacted structural fill and designed using a maximum net allowable soil bearing pressure of 2,500 psf. As a precaution and to resist uplift forces from expansive soils, we recommend all footings be designed to maintain a minimum dead load pressure of 750 psf.

2. Structural fill should consist of a non-expansive, granular material (CDOT Class 6 Aggregate Base Course) uniformly placed and compacted in 8-inch loose lifts to at least 98% of the maximum standard Proctor density and within 2% of optimum moisture content as determined by ASTM D698. Structural fill should extend out from the edges of footings on a 1(H) to 1(V) or flatter slope.

   The structural fill should be underlain by an underdrainage system to collect and transmit any infiltrated water away from the structural fill zone. The underdrain system should generally consist of 4-inch perforated Sch40 PVC pipe on 10-foot maximum centers and covered with 12 inches of washed rock and filter fabric. The drainage pipe should be graded to drain (1% min.) to a solid PVC daylight pipe (1% min.) protected from animal intrusion and backflow.

3. The excavation should be graded to drain to prevent the accumulation of water beneath the structure and within the backfill zone.

4. Footings exposed to freezing or frost conditions should be designed with adequate soil cover to prevent freezing. A cover depth of 48 inches is recognized by the local building authority as the minimum value for frost protection.

5. Foundation walls and grade beams should be designed to span an unsupported distance of 10 feet or the distance between pads.

6. Foundation resistance to lateral loads can be developed by passive pressure against footings and walls and sliding resistance between footings and floor slabs and the underlying soils. WSG recommends passive pressures be computed using an equivalent fluid pressure value of 250 pcf and friction resistance be calculated using a coefficient of friction of 0.30 times structural dead loads. The recommended passive equivalent fluid pressure value and coefficient of friction do not include a factor of safety.

7. WSG should be retained to observe foundation excavations to verify the subsurface conditions are consistent with those assumed and conduct testing of structural fill during placement to evaluate compliance with project specifications.

WSG estimates total and differential movement of foundations designed and constructed as outlined above and resulting from the assumed structural loads will be 1-inch or less.

Interior and Garage Floor Slabs

To reduce the potential for movement of interior and garage floor slabs subsequent to construction, we recommend the underslab areas be treated similar to the foundation excavation (3 feet of overexcavation and structural backfill). The structural fill and surcharge loads placed on the underlying soils by the structural fill mat would reduce the potential for total and differential movement of the supported slab. The structural fill would also assist in distributing movement in the event that some swelling of the materials underlying the structural fill occurs.

Inherent risks exist when building in areas of expansive soils. The overexcavation/backfill procedures outlined above will reduce, but not eliminate the potential for movement of the floor slab subsequent to construction. The in-place materials below the moisture-conditioned zone can experience volume change with variation in moisture content, causing some floor slab movement. Based upon the variable swell potential of the underlying bedrock, and depending on the actual depth of wetting experienced, we anticipate slab heave on the order of 1-inch, or more could occur over time if deep wetting of the site occurs, even if overexcavation/backfill procedures are performed. If this

amount of movement and cracking of the floor slab cannot be tolerated, a structural flooring system should be employed.

Perimeter and Interior Drainage Systems

WSG recommends a perimeter drainage system be installed at the perimeter foundation of the structure. Properly constructed perimeter drainage systems enhance site drainage, help reduce the potential for development of hydrostatic pressures behind the below-grade walls and reduce the potential for water infiltration beneath footings and into underslab and crawl space areas. In addition, WSG recommends an interior drainage system be constructed within crawl space areas (if used) as a precaution to provide for collection and discharge of any water accumulation within crawl space areas.

A perimeter drainage system should generally consist of a 4-inch diameter perforated PVC drainpipe covered by a minimum of twelve (12) inches of free-draining gravel and covered with filter fabric (Mirafi 140N or equivalent) to prevent intrusion of fines. The high point of the drainpipe should be placed at approximate footing grade around the perimeter foundation footings, constructed with a minimum 1% slope to a daylighted outfall. Multiple outfalls are recommended for larger and more complex structures. Care should be taken during drain installation to avoid disturbing those soils providing support to the footing bearing soils extending down at an approximate 1(H) to 1(V) slope from the bottom edges of the footings. Daylighted outfalls should be protected from small animal intrusion and backflow. Interior crawl space drainage systems should generally consist of 4-inch diameter perforated PVC drainpipe placed at the interior side of the perimeter foundations. Lateral drainpipes connected to the perimeter piping at approximate 10-foot centers should be connected to a sloping central drainpipe leading to a sump and pump system or daylighted outfall if possible.

WSG can provide perimeter and interior crawl space drainage system design and details upon request and after building plans are available.

Lateral Earth Pressures and Backfill

Lateral Earth Pressures: Foundation walls should be designed to resist lateral pressures associated with foundation backfill materials and existing site soils. Materials affecting lateral pressures are located within the area extending from the base of the foundation wall upward at an approximate 1(H) to 1(V) angle. Recommended lateral earth pressure design

values to be used in foundation wall design are provided in Table B shown below. All values presented assume drained conditions (no hydrostatic loads) and sufficient wall deflection is achieved for activation of active earth pressure conditions.

Table B

Design Pressure Condition	Equivalent Fluid Pressure (pcf)
Active	60
At-Rest	70
Passive	250

Variables that affect active lateral earth pressures include but are not limited to the classification and swell potential of the backfill soils, backfill compaction and geometry, wetting of the backfill soils, surcharge loads and point loads developed in the backfill materials. The recommended equivalent fluid pressure values do not include a factor of safety or an allowance for hydrostatic loading. Use of expansive soil backfill, excessive compaction of the wall backfill or surcharge loads placed adjacent to the foundation walls can add to the lateral earth pressures causing the equivalent fluid pressure values used in design to be exceeded.

Backfill placed adjacent to below-grade walls should consist of Low Volume Change (LVC) potential materials, be relatively impervious material free from organic matter, debris and other objectionable materials. Essentially granular materials would be considered LVC. The on-site lean to fat clay are not recommended for foundation wall backfill. Imported LVC soils would also suitable for foundation backfill but should be approved by WSG prior to use. WSG recommends foundation backfill soils be uniformly placed in maximum 9-inch loose lifts, moisture conditioned to within +/-2 percent of optimum moisture content and compacted to at least 95 percent of the maximum standard Proctor dry density (ASTM D698) for imported LVC soils. The upper 2-feet of backfill should consist of a relatively impervious material to reduce the amount of surface water infiltration into the backfill zone. On-site clay could be considered suitable for this purpose.

Foundation wall backfill operations should be conducted only after proper bracing and support is provided. Structural engineer approval is recommended. Excessive lateral stresses resulting in displacement, distress and damage to foundation walls can occur when insufficient bracing is in place or heavy mechanical compaction equipment is used. WSG recommends compaction of unbalanced foundation wall backfill soils be completed using light mechanical or hand compaction equipment.

Exterior Flatwork

Any topsoil/vegetation should be stripped/removed from proposed flatwork areas prior to fill or concrete placement. A minimum of 12-inches of non-expansive granular fill should be provided beneath exterior slabs to reduce the effects of expansive clay subgrade soils. WSG recommends the exposed subgrade be scarified to a depth of 6-inches, moisture conditioned to within -1% to +3% % of optimum moisture content and compacted to at least 95% of the maximum standard Proctor density. WSG recommends fill supporting flatwork consist of approved granular materials or on-site lean clay uniformly placed in 9-inch loose lifts, moisture conditioned and compacted to the values indicated above with a limited risk of post-construction movement. All fill materials should be approved by WSG prior to use.

Subgrade soils expected to receive exterior flatwork concrete should be evaluated closely evaluated immediately prior to concrete placement. If areas of disturbed, wet and softened, or dry subgrade soils are encountered at that time, reworking of those materials or removal/ replacement procedures may be required.

Drainage

Positive drainage is imperative for satisfactory long-term performance of building foundations, floor slabs and associated site improvements. WSG recommends positive drainage be developed away from the structure during construction and maintained throughout the life of the site improvements. Twelve (12) inches of fall in the first 10 feet away from the building is recommended. Flatter slopes could be considered in hardscape areas. In the event that some settlement of the backfill soils occurs adjacent to the residence, the original grade and associated positive drainage outlined above should be immediately restored.

Care should be taken in the planning of landscaping to avoid features which could result in the fluctuation of the moisture content of the foundation bearing and/or flatwork subgrade soils. We recommend watering systems be placed a minimum of 5 feet away from the perimeter of the structure and be designed to discharge away from all site improvements. Gutter systems should be considered to help reduce the potential for water ponding adjacent to the residence, with the gutter downspouts, roof drains or scuppers extended to discharge a minimum of 5 feet away from structural, flatwork and pavement elements. Water which is allowed to pond adjacent to the site improvements can result in unsatisfactory performance of those improvements over time. The use of area drain inlets and subsurface piping is recommended to aid in rapid runoff of surface water from areas of concentrated drainage and/or limited surface runoff capability.

SITE GRADING

WSG has assumed unretained cuts and fills of up to 7 feet in height may be constructed for general site development at the site. Based on our assumptions of proposed construction, WSG recommends the following:

1. Unretained cuts and fills should be constructed to a 2(H) to 1(V) or flatter slope configuration. Flatter slopes are often desirable to help facilitate revegetation efforts.

2. Areas to receive fills should be stripped of organics prior to fill placement, scarified to at least 12 inches, moisture conditioned and uniformly compacted prior to fill placement.

   Fill materials supporting driveways or other settlement-sensitive landscaping features should consist of approved materials. These fills should be uniformly placed and compacted in 9-inch loose lifts to at least 95% of the maximum standard Proctor density within +/-2% of optimum moisture content for on-site materials and +/-2% for LVC or granular imported materials (ASTM D698).

3. Proper drainage should be provided and maintained around all cuts, fills, buildings, and driveway surfaces. Special attention should be given to channeling or routing drainage around and away from site fills and retaining structures. Excessive or uncontrolled surface and subsurface drainage could lead to erosion and poor site fill performance and/or slope failure.

4. All disturbed areas should be protected from erosion by revegetation or other appropriate methods. Areas of concentrated drainage should be protected by use of rip rap or other appropriate methods.

5. Construction safety is the sole responsibility of the contractor. The contractor is responsible for determining the appropriate OSHA slope criteria for the soil and bedrock conditions encountered and implementing it during construction. The contractor shall be responsible for all means, methods, techniques, sequencing, and operations during construction. All excavation activities should meet minimum OSHA, state or local trenching and excavation safety standards.

GENERAL COMMENTS

This report was prepared based upon the data obtained from the completed site exploration, engineering analysis and WSG's experience with similar construction in this area. The subsurface conditions encountered during this investigation provide an indication of subsurface conditions at the test hole locations only. Variations in subsurface conditions can occur in relatively short distances away. This report does not reflect any variations which may occur across the site or away from the test hole locations. If variations in the subsurface conditions anticipated become evident, the geotechnical engineer should be notified immediately so that further evaluation can be completed and when warranted, alternative recommendations provided.

The scope of services for this project does not include either specifically or by implication any biological or environmental assessment of the site or identification or prevention of pollutants or hazardous materials or conditions. Other studies should be completed if concerns over the potential of such contamination or pollution exist.

WSG should be retained to review the plans and specifications so that comments can be made regarding the interpretation and implementation of our geotechnical recommendations in the design and specifications. WSG should also be retained to provide testing and observation services during construction to help evaluate compliance with project plans and specifications.

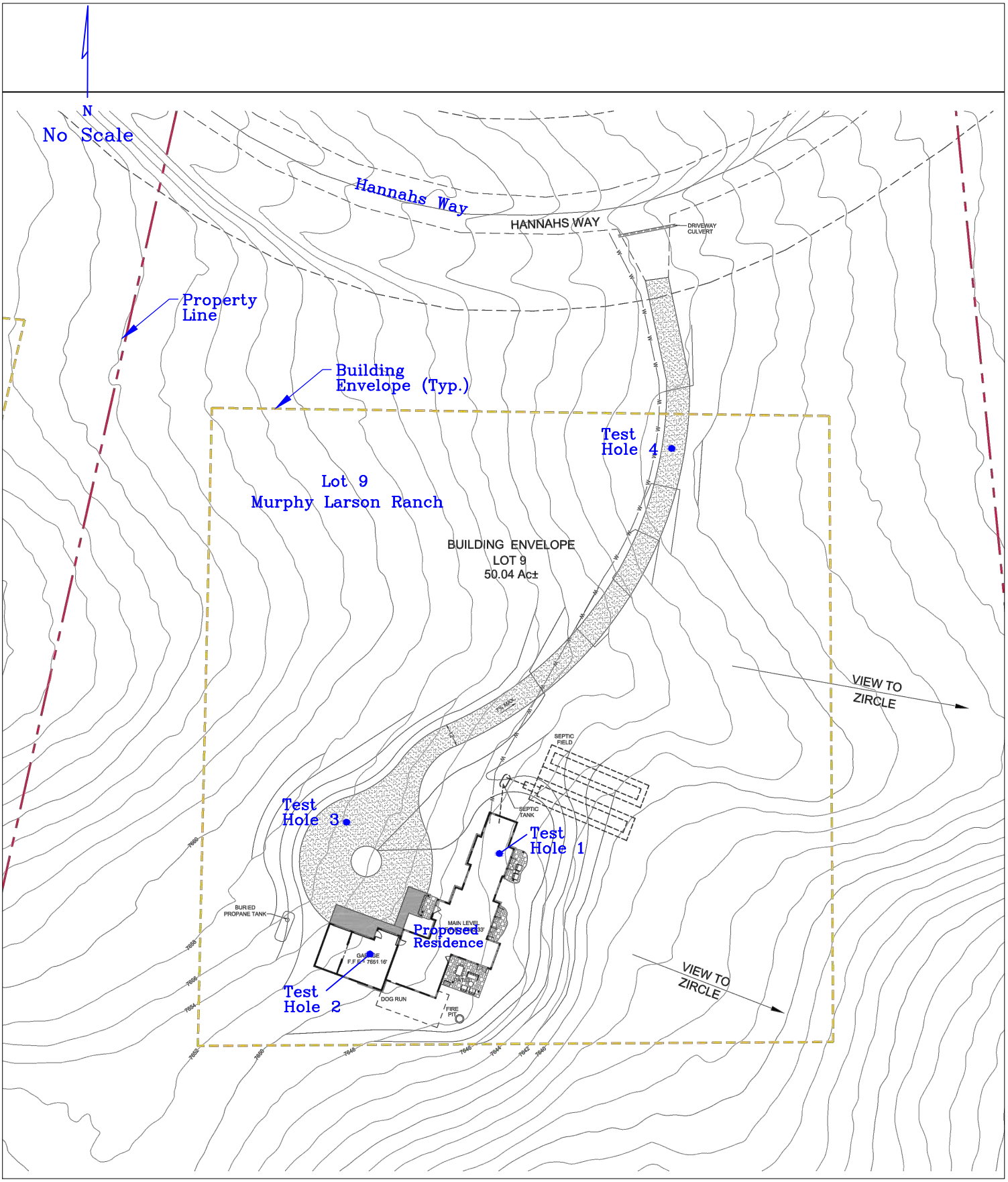
This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with the generally accepted standard of care for the profession. No warranties express or implied, are made. The

conclusions and recommendations contained in this report should not be considered valid in the event that any changes in the nature, design or location of the project as outlined in this report are planned, unless those changes are reviewed, and the conclusions of this report modified and verified in writing by the geotechnical engineer.

WSG appreciates the opportunity to be of service to you on this project. If you have any questions concerning the enclosed information or if we can be of further service to you in any way, please do not hesitate to contact us.

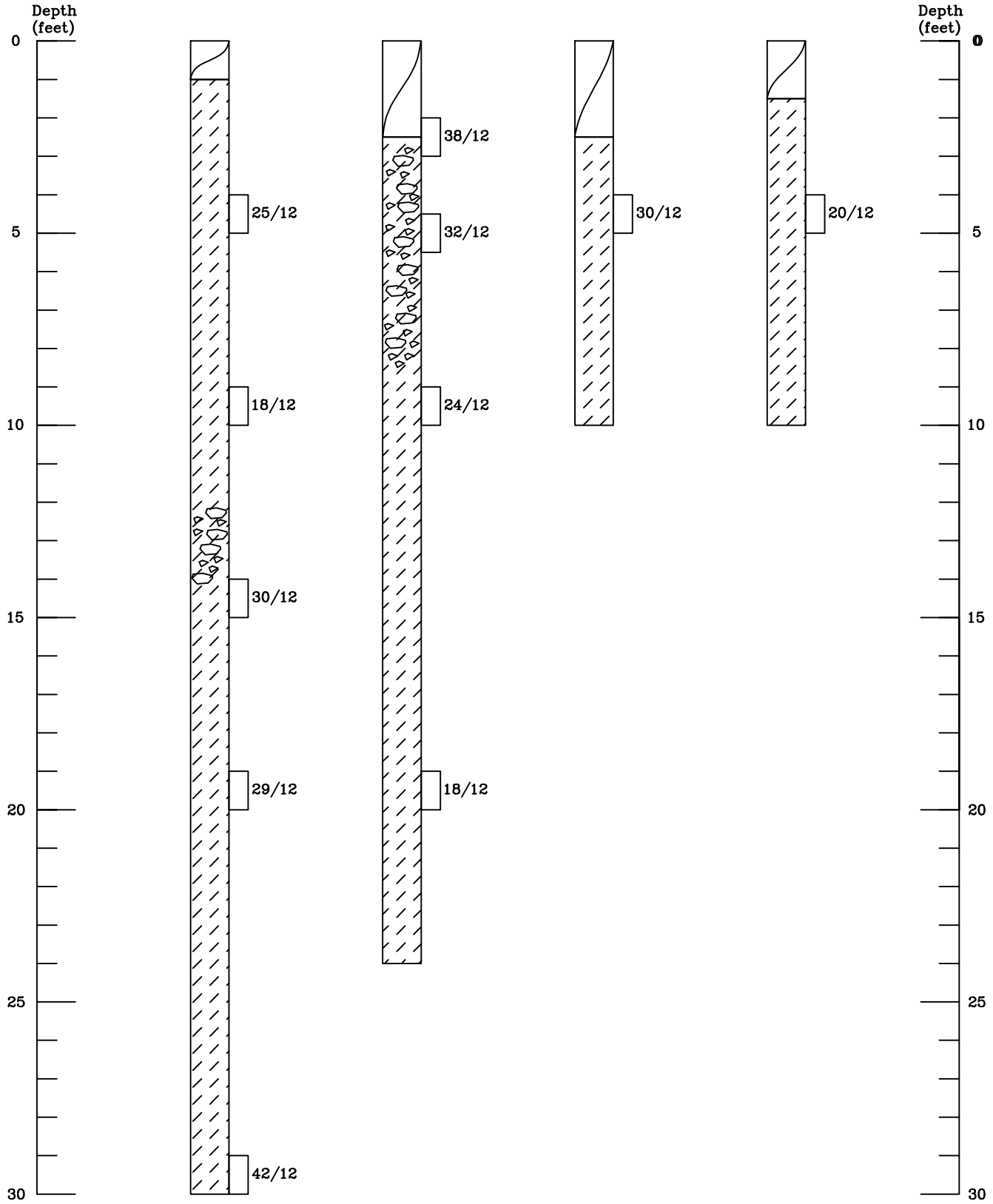
Very Truly Yours,
Western Slope Geotech, Inc.

Harold Schlicht, P.E.
Principal Engineer



SITE PLAN/LOCATION OF TEST HOLES

Project Name: Proposed Janes Residence	WESTERN SLOPE GEOTECH STEAMBOAT SPRINGS COLORADO
Location: Lot 9, Murphy Larson Ranch, Routt County, CO	Project No.: 19-1035 | Drawn/Checked:HS
	Date: 8/28/19 | Figure No.: 1



LOGS OF EXPLORATORY TEST HOLES

Project Name: Proposed Janes Residence

Location: Lot 9, Murphy Larson Ranch, Routt County, CO

WESTERN SLOPE GEOTECH
STEAMBOAT SPRINGS COLORADO

Project No.: 19-1035	Drawn/Checked:HS/HS
Date: 8/28/19	Figure No. 2

Legend

TOPSOIL & ORGANICS.

LEAN TO FAT CLAY: Slightly sandy to sand and clay with scattered gravel, moderately to highly plastic, stiff to hard, moist to very moist and light brown.

Drive Sample – California barrel sampler.

25/12 Drive sample blow count. Indicates 25 blows from a 140–pound hammer falling 30–inches was required to drive the sampler 12 inches.

Notes

1) Test holes were drilled on August 19, 2019 with an ATV mounted CME 45 drill rig using 4–inch diameter augers.

2) Test hole locations were determined by taping from existing building envelope corners, building corners staked in the field and as shown on the site plan provided.

3) Test hole elevations were determined by interpolation between contours shown on the site plan provided.

4) Lines between materials types indicated on the test hole logs are approximate and transitions may be gradual.

LEGEND & NOTES

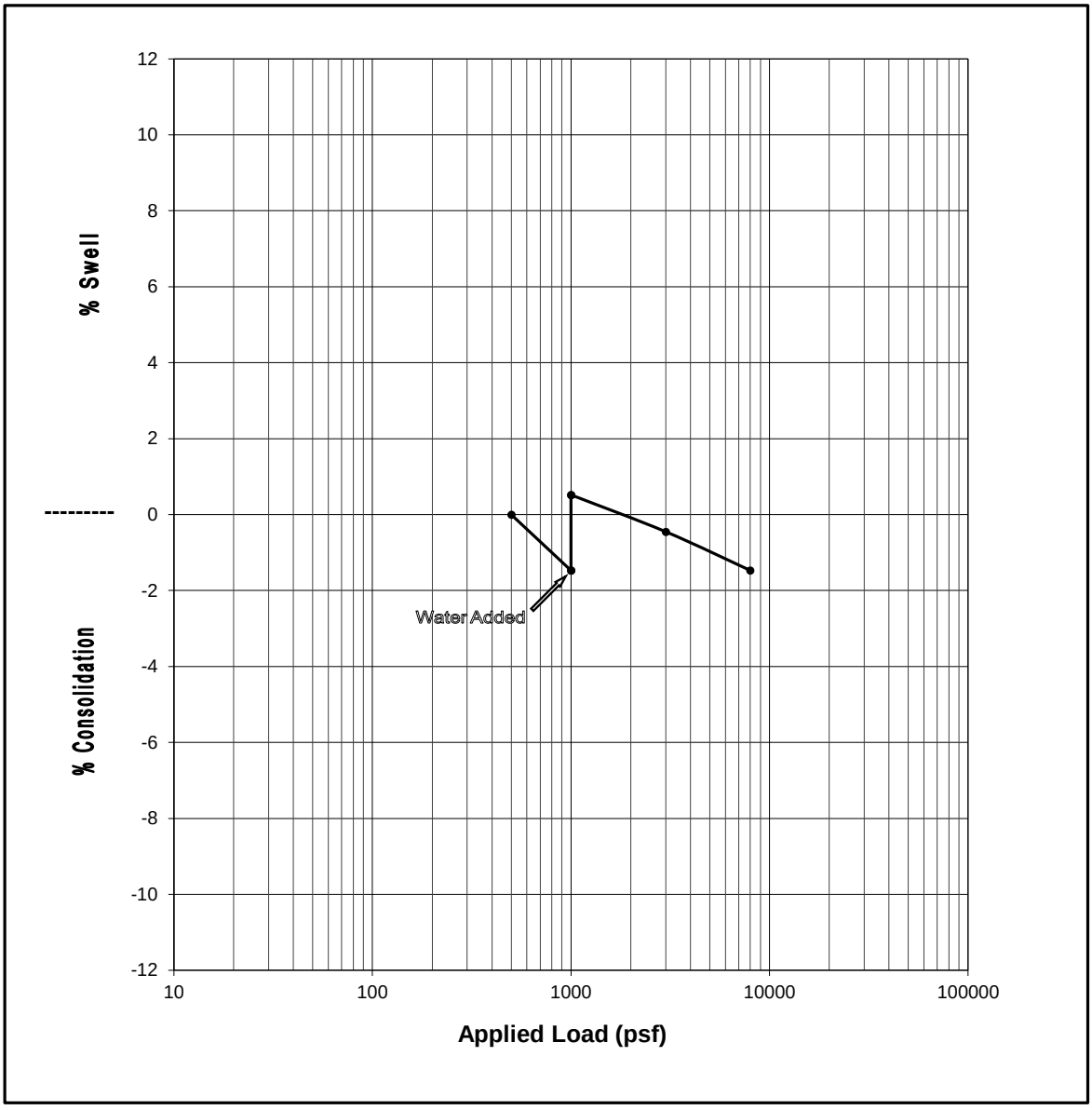
Project Name: Proposed Janes Residence

Location: Lot 9, Murphy Larson Ranch, Routt County, CO

WESTERN SLOPE GEOTECH STEAMBOAT SPRINGS COLORADO

Project No.: 19–1035	Drawn/Checked:HS/HS
Date: 8/28/19	Figure No. 3

SWELL/CONSOLIDATION TEST SUMMARY

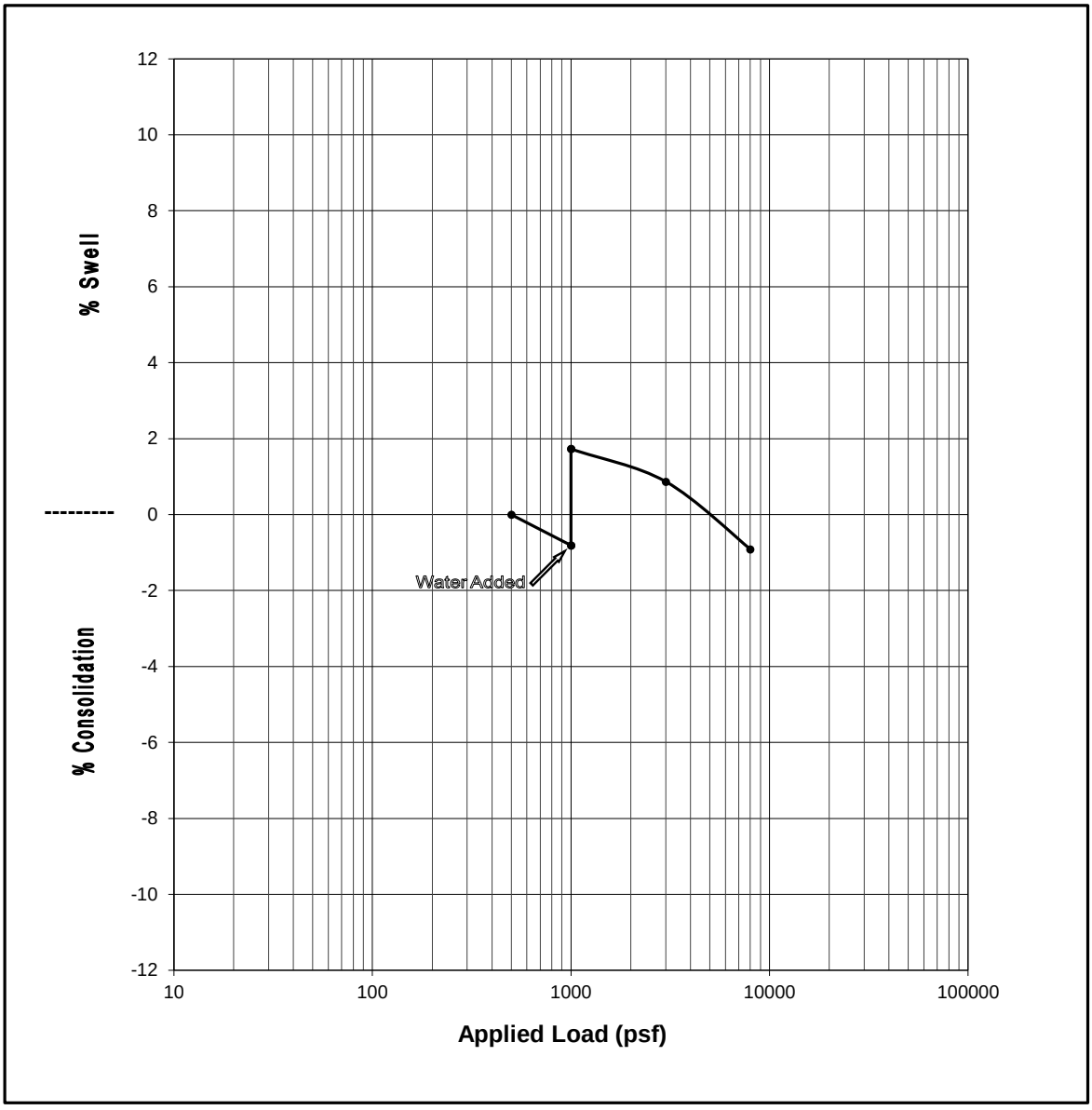


Sample ID: TH-1 @ 9'			
Sample Description: Very Sandy Fat Clay (CH)			
Initial Moisture	27.0%	Liquid Limit	55
Final Moisture	30.0%	Plasticity Index	30
% Swell @ 1,000 psf	2.0%	% Passing #200	57.8%
Swell Pressure	7,000 psf	Dry Density	91.3 pcf

Project Name: Proposed Janes Residence	Project No.: 19-1035
Location: Lot 9, Murphy Larson Ranch, Routt County, CO	Date: 8/28/19
Drawn/Checked: HS/HS	Figure No. : 4

WESTERN SLOPE GEOTECH
STEAMBOAT SPRINGS COLORADO

SWELL/CONSOLIDATION TEST SUMMARY



Sample ID: TH-2 @ 4'			
Sample Description: Sand & Lean Clay (SC-CL)			
Initial Moisture	13.7%	Liquid Limit	40
Final Moisture	16.6%	Plasticity Index	23
% Swell @ 1,000 psf	2.6%	% Passing #200	50.8%
Swell Pressure	6,500 psf	Dry Density	110.4 pcf

Project Name: Proposed Janes Residence	Project No.: 19-1035
Location: Lot 9, Murphy Larson Ranch, Routt County, CO	Date: 8/28/19
Drawn/Checked: HS/HS	Figure No. : 5

WESTERN SLOPE GEOTECH
STEAMBOAT SPRINGS COLORADO

WESTERN SLOPE GEOTECH STEAMBOAT SPRINGS COLORADO

Project No.: 19-1035

Table 1
Summary of Laboratory Test Results

Test Hole/ Pit	Depth (ft)	Natural Moisture Content (%)	Dry Density (pcf)	Grain Size Analysis			Atterberg Limits		Swell Test Data		Soil or Bedrock Type	USCS Classification	AASHTO Classification
				Gravel (%)	Sand (%)	Silt/ Clay (%)	LL (%)	PI (%)	Swell(+) Consol.(-)	Swell Pressure (psf)			
TH-1	9	27.0	91.3	0	42	58	55	30	2.0	7000	Very Sandy Fat Clay	CH	
TH-1	19	17.9	106.8	0	44	56	–	–			Very Sandy Clay		
TH-2	4	16.6	110.4	12	37	51	40	27	2.6	6500	Gravelly, Very Sandy Lean Clay	CL	
TP-2	9	18.8	106.0	1	10	89	–	–			Slightly Sandy Clay		