NorthWest Colorado Consultants, Inc.
Geotechnical / Environmental Engineering • Materials Testing

Reviewed for Code Compliance

08/11/2023

November 18, 2022

Bill Uhl
626 Franklin Street
Denver, CO 80218

Job Number: 22-12786

Subject: Subsoil and Foundation Investigation, Uhl Property, 40343 County Road 68, Routt County, Colorado.

Bob,

This report presents the results of the Subsoil and Foundation Investigation for the proposed barn/residence and cabins to be constructed at 40343 County Road 68 in Routt County, Colorado. The approximate location of the project site is shown in Figure #1.

NWCC, Inc. (NWCC) scope of our work included obtaining data from cursory observations made at the site, the logging of three test pits, the sampling of the probable foundation soils and the laboratory testing of the obtained samples. This report presents recommendations for economically feasible and safe type foundations, as well as allowable soil pressures and other design and construction considerations that are advisable, but not necessarily routine to quality design and building practices.

Proposed Construction: NWCC understands that a residence, barn with living unit and three cabins will be constructed at the site. We assume the lower levels of the residence, barn and cabins will be constructed with concrete slab-on-grade floor systems or crawlspaces placed from 1 foot above to 4 feet below the existing ground surface.

For design purposes, we have assumed that the building loads will be light to moderate typical of this type of residential construction. If loadings or conditions are significantly different from those above, we should be notified to reevaluate the recommendations in this report.

Site Conditions: The building site is situated along the west side County Road 68 in Routt County, Colorado. The building sites are primarily located in a meadow where the primary vegetation consists of hay grasses. To the north and south, vegetation consists of aspen trees, deciduous bushes and sage brush. The building sites slope strongly to moderately down to the southeast, east and northeast.

Subsurface Conditions: To investigate the subsurface conditions at the site, three test pits were advanced in October 2022 with a Cat rubber-tired backhoe provide Bud's Backhoe.

The approximate test pit locations are shown in Figure #2.

The subsurface conditions encountered were somewhat variable and generally consisted of a layer of topsoil and organic materials overlying clays or highly weathered claystone bedrock materials to the maximum depth investigated, 7 feet below the existing ground surface (bgs). Graphic logs of the exploratory test pits, along with the associated Legend and Notes, are presented in Figure #3.

A layer of topsoil and organic materials was encountered at the ground surface in all of the test pits and was approximately 2 ½ to 6 feet in thickness. Clays were encountered beneath the topsoil and organic materials in Test Pits 1 and 3 and extended to 7 feet bgs. Clays were very sandy to silty, low to moderately plastic, blocky, stiff slightly moist to very moist and dark brown to brown in color. A sample of the clays classified as a CL soil in accordance with the Unified Soil Classification System.

Highly weathered claystone bedrock materials were encountered beneath the topsoil and organic materials in Test Pit 2 and extended to 6 feet bgs. Highly weathered claystone bedrock materials were low plastic, fine to coarse grained with cobble-sized bedrock fragments, moist and tan to light brown in color.

Swell-consolidation testing conducted on a sample of the clays indicates the materials tested exhibited a low swell potential when wetted under a constant load. The swell-consolidation test results are presented in Figure #4, and other laboratory test results are summarized in the attached Table 1.

Based on anticipated geologic site conditions, NWCC recommends a **Site Class C** designation be used in structural design calculations in accordance with Table 20.3-1 in Chapter 20 of ASCE 7-10.

Groundwater was not encountered in the test pits at the time of excavation. It should be noted that the groundwater conditions at the site can be expected to fluctuate with changes in precipitation and runoff.

Foundation Recommendations: Based on the results of the field and laboratory investigations and our experience with similar projects, NWCC believes a safe and economical foundation system will consist of spread or continuous footings placed directly on the clays, weathered bedrock materials or on properly compacted structural fill materials placed over the natural clays or bedrock materials.

The design and construction details presented below should be observed if a shallow foundation system is opted for. The precautions and recommendations itemized below will not prevent movement of the foundations if the underlying clays or bedrock materials become wetted and swell. However, they should reduce amount of differential movement beneath the foundation system. Differential movements on the order of 1 to 2 inches could still occur if the clays or bedrock materials undergo moisture changes. The owner must be willing to accept the risk of foundation movement associated with placing shallow foundations on expansive soils/bedrock materials.

1) Footings placed on undisturbed, natural clays or bedrock materials or properly compacted structural fill materials placed over the natural clays or bedrock materials should be designed using an

allowable soil bearing pressure of 2,500 psf. We also recommend a minimum dead load pressure of at least 600 psf be used to reduce the risk of foundation movement associated with the expansive clays/bedrock materials.

2) Footings or pad sizes should be computed using the above soil pressure and placed on the natural undisturbed clays, bedrock materials or on properly compacted structural fill materials after all of the existing topsoil and organic materials and any existing fill materials are removed.

3) Any topsoil and organic materials, loose or soft natural soils encountered within the foundation excavations, should be removed and the excavations extended to competent natural clays or bedrock materials prior to concrete or structural fill placement. Any fill materials placed beneath the footings should be a non-expansive granular soil approved by NWCC prior to placement. The fill materials placed under the footings should be uniformly placed and compacted in 6 to 8-inch loose lifts and compacted to at least 100% of the maximum standard Proctor density and within 2% of the optimum moisture content determined in accordance with ASTM D-698, or to at least 80% of the maximum relative density in accordance with ASTM D4253/4254 if free draining gravels are used as structural fill. The structural fill materials should extend out from the edge of the footings on a 1(horizontal) to 1(vertical) or flatter slope.

4) Foundation walls should be designed and reinforced to span an unsupported distance of 10 feet or the length between pads, whichever is greater.

5) Footings or pads should be placed well enough below final backfill grades to protect them from frost heave. Forty-eight (48) inches is typical for this location considering normal snow cover and other winter factors.

6) Based on experience, we estimate the total settlement for footings and pads designed and constructed as discussed in this section will be approximately 1 inch. Additional bearing capacity values along with the associated settlements are presented in Figure #5.

7) We strongly recommend the client retain our firm to observe the foundation excavations when they are near completion to identify the bearing soils and confirm the recommendations in this report, as well as test compaction of structural fill materials.

Floor Slabs: NWCC assumes the lower levels of the buildings will be constructed with concrete slab-on-grade floor systems. The on-site soils, apart from the topsoil and organic materials, are capable of supporting slab-on-grade construction. However, floor slabs present a difficult problem where swelling materials are present near floor slab elevation because sufficient dead load cannot be imposed on them to resist the uplift pressure generated when the materials are wetted and expand. Based on the moisture-volume change characteristics of the clays and bedrock materials encountered at this site, we believe slab-on-grade construction may be used, provided the risk of distress resulting from slab movement is recognized and special design precautions are followed.

The following measures should be taken to reduce the damage, which could result from movement should the underslab clays or bedrock materials be subjected to moisture changes.

1) Floor slabs should be separated from all bearing walls, columns and their foundation supports with a positive slip joint. We recommend the use of ½-inch thick cellotex or impregnated felt.

2) Interior non-bearing partition walls resting on the floor slabs should be provided with a slip joint, preferably at the bottom, so that in the event the floor slab moves, this movement is not transmitted to the upper structure. This detail is also important for wallboard and doorframes and is shown in Figure #6.

3) A minimum 6-inch gravel layer should be provided beneath all floor slabs to act as a capillary break and to help distribute pressures. Prior to placing the gravel, the excavation should be shaped so that if water does get under the slab, it will flow to the low point of the excavation. In addition, all the existing fill materials should be removed prior to placement of the underslab gravels or new fill materials.

4) Floor slabs should be provided with control joints placed a maximum of 10 to 12 feet on center in each direction, depending on slab configuration, to help control shrinkage cracking. The location of the joints should be carefully checked to assure that the natural, unavoidable cracking will be controlled. The depth of the control joints should be a minimum of ¼ of the thickness of the slab.

5) Underslab soils should be kept as close as possible to their in-situ moisture content. Excessive wetting or drying of these soils prior to placement of the floor slab could result in differential movement after the slabs are constructed.

6) It has been NWCC's experience that the risk of floor slab movement can be reduced by removing at least 2 feet of the expansive materials and replacing them with a well compacted, non-expansive fill. If this is done or if fills are required to bring underslab areas to the desired grade, the fill should consist of non-expansive, granular materials. Fill should be uniformly placed and compacted in 6 to 8-inch lifts to at least 95% of the maximum standard Proctor density at or near the optimum moisture content, as determined by ASTM D-698.

The above precautions and recommendations will not prevent floor slab movement in the event the clays/ bedrock materials beneath the floor slabs undergo moisture changes. However, they should reduce the amount of damage if such movement occurs. The only way to eliminate the risk of all floor slab movement is to construct a structural floor over a well-vented crawl space or void form materials.

Underdrain System: Any floor levels or crawl space areas constructed below the existing or finished ground surfaces and foundations should be protected by an underdrain system to help reduce the problems associated with surface and subsurface drainage during high runoff periods. Localized perched water or runoff can infiltrate the lower levels of the structure at the foundation levels. This water can be one of the primary causes of differential foundation and slab movement, especially where expansive soils and bedrock materials

are encountered. Excessive moisture in crawl space areas or lower levels can also lead to rotting and mildewing of wooden structural members and the formation of mold and mold spores. The formation of mold and mold spores could have detrimental effects on the air quality in these areas, which in turn can lead to potential adverse health effects.

The drains should be located around the entire perimeter of the lower levels and be placed and at least 12 inches below any floor slab or crawl space level and at least 6 inches below the foundation voids and bottom of the footings. We recommend the use of perforated PVC pipe for the drainpipe, which meets ASTM D-3034/SDR 35 requirements, to minimize the potential for crushing the pipe during backfill operations. The holes in the drainpipe should be oriented down between 4 o'clock and 8 o'clock to promote rapid runoff of the water. The drainpipe should be surrounded with at least 12 inches of free draining gravel and should be protected from contamination by a filter covering of Mirafi 140N subsurface drainage fabric or an equivalent product. The drains should have a minimum slope of 1/8 inch per foot and should be daylighted at a positive outfall protected from freezing, or be led to a sump from which the water can be pumped. Due to the size of the proposed structure, we recommend the use of multiple daylights for the underdrain system. Caution should be taken when backfilling so as not to damage or disturb the installed underdrain. We recommend the drainage system include cleanouts, be protected against intrusion by animals at the outfalls and be tested prior to backfilling. We also recommend that the client retain this firm to observe the underdrain system during construction to verify that it is being installed in accordance with our recommendations and observe a flow test prior to backfilling the system.

In addition, we recommend that an impervious barrier be constructed to keep water from infiltrating through the voided areas and/or under the footings. The barrier should be constructed of an impervious material, which is approved by this office and placed below the perimeter drain and up against the sides of the foundation walls. A typical perimeter/underdrain detail is shown in Figure #7. The placement of the impervious membrane and properly compacted clays in the crawl space areas to the top of the footings or at least 12 inches above the top of the foundation voids or bottom of the foundation walls will help reduce the moisture problems in these areas.

Foundation Walls and Retaining Structures: Foundation walls and retaining structures, which are laterally supported and can be expected to undergo only a moderate amount of deflection, may be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of 45 pcf for imported, free draining granular backfill and 60 pcf for the on-site soils and bedrock materials.

Cantilevered retaining structures on the site can be expected to deflect sufficiently to mobilize the full active earth pressure condition. Therefore, cantilevered structures may be designed for a lateral earth pressure computed based on an equivalent fluid unit weight of 35 pcf for imported, free draining granular backfill and 50 pcf for the on-site soils and bedrock materials.

Foundation walls and retaining structures should be designed for appropriate hydrostatic and surcharge pressures such as adjacent buildings, traffic and construction materials. An upward sloping backfill and/or natural slope will also significantly increase the earth pressures on foundation walls and retaining structures and the structural engineer should carefully evaluate these additional lateral loads when designing the foundation and retaining walls.

Lateral resistance of retaining wall foundations placed on undisturbed natural soils at the site will be a combination of the sliding resistance of the footings on the foundation materials and the passive pressure against the sides of the footings. Sliding friction can be taken as 0.4 times the vertical dead load. Passive pressure against the sides of the footing can be calculated using an equivalent fluid pressure of 250 pcf. The fill placed against the sides of the footings to resist lateral loads should be compacted to at least 100% of the maximum standard Proctor density and near the optimum moisture content.

We recommend imported granular soils for backfilling foundation walls and retaining structures because their use results in lower lateral earth pressures. The imported granular materials should be placed to within 2 to 3 feet of the ground surface. Imported granular soils should be free draining and have less than 5 percent passing the No. 200 sieve. The granular soils behind foundation and retaining walls should be sloped from the base of the wall at an angle of at least 45 degrees from the vertical. The upper 2 to 3 feet of fill should be a relatively impervious soil or pavement structure to prevent surface water infiltration into the backfill.

Wall backfill should be carefully placed in uniform lifts and compacted to at least 95 percent of the maximum standard Proctor density and near the optimum moisture content. Care should be taken not to overcompact the backfill since this could cause excessive lateral pressure on the walls. Some settlement of deep foundation wall backfill materials will occur even if the material is placed correctly.

Surface Drainage: Proper surface drainage at this site is of paramount importance for minimizing the infiltration of surface drainage into the wall backfill and bearing soils, which could result in increased wall pressures, differential foundation and slab movement. The following drainage precautions should be observed during construction and at all times after the structures have been completed:

1) Ground surface surrounding the structures should be sloped (minimum of 1.0 inch per foot) to drain away from the structures in all directions to a minimum of 10 feet. Ponding must be avoided. If necessary, raising the top of foundation walls to achieve a better surface grade is advisable.

2) Non-structural backfill placed around the structures should be compacted to at least 95% of the maximum standard Proctor density at or near the optimum moisture content in order to minimize future settlement of the fill. The backfill should be placed immediately after the braced foundation walls are able to structurally support the fill. Puddling or sluicing must be avoided.

3) Top 2 to 3 feet of soil placed within 10 feet of the foundations should be impervious in nature to minimize infiltration of surface water into the wall backfill.

4) Roof downspouts and drains should discharge well beyond the limits of all backfill. Roof overhangs, which project two to three feet beyond the foundations, should be considered if gutters are not used.

5) Landscaping, which requires excessive watering and lawn sprinkler heads, should be located a minimum of 10 feet from the foundation walls of the structures.

6) Plastic membranes should not be used to cover the ground surface adjacent to foundation walls.

Site Grading: Slopes on which the structures and driveways are proposed could become unstable as a result of proposed construction. Design and construction considerations must be addressed to avoid and/or limit the potential for slope instability at the site. Although a detailed slope stability analysis is beyond the scope of this report, some general guidelines are provided below for initial planning and design. Our office should review the construction plans as they are being prepared so that we can verify that our recommendations are being properly incorporated into the plans.

1) Slopes greater than 25 percent should be avoided whenever possible for construction of permanent roads and structures.

2) Temporary cuts for foundation construction should be constructed to OSHA standards for temporary excavations. Permanent, unretained cuts for driveways or building sites should be kept as shallow as possible and should not exceed a 3(Horizontal) to 1(Vertical) configuration for topsoil and organic materials and a 2(Horizontal) to 1(Vertical) configuration for clays. We recommend these cuts be limited to 10 feet in height or less unless stable bedrock is encountered. The risk of slope instability will be significantly increased if groundwater seepage is encountered in the cuts. NWCC office should be notified immediately to evaluate the site if seepage is encountered or deeper cuts are planned and assess whether additional investigations and/or stabilization measures are warranted.

3) Excavating during periods of low runoff at the site can reduce potential slope instability during excavation. Excavations should not be attempted during the spring or early summer when seasonal runoff and groundwater levels are typically high.

4) Fills up to 10 feet in height can be constructed at the site and should be constructed to a 2(Horizontal) to 1(Vertical) or flatter configuration. The fill areas should be prepared by stripping any existing fill materials and topsoil and organics, scarification and compaction to at least 95% of the maximum standard Proctor density and within 2% of optimum moisture content as determined by ASTM D698. The fills should be properly benched/keyed into the natural hillsides after the natural topsoil and organic materials have been removed. The fill materials should consist of the on-site soils (exclusive of topsoil, organics or silts) and be uniformly placed and compacted in 6 to 8-inch loose lifts to the minimum density value and moisture content range indicated above.

5) Proper surface drainage features should be provided around all permanent cuts and fills and steep natural slopes to direct surface runoff away from these areas. Cuts, fills and other stripped areas should be protected against erosion by revegetation or other methods. Areas of concentrated drainage should be avoided and may require the use of riprap for erosion control. NWCC recommends that a maximum of 4 inches of topsoil be placed over the new cut and fill slopes. It should be noted that the newly placed topsoil materials may slough/slide off the slopes during the spring runoff seasons until the root zone in the vegetated cover establishes.

6) A qualified engineer experienced in this area should prepare site grading and drainage plans. The contractor must provide a construction sequencing plan for excavation, wall construction and bracing and backfilling for the steeper and more sensitive portions of the site prior to starting the excavations or construction.

Limitations: The recommendations provided in this report are based on the soils encountered at this site and our understanding of the proposed construction. We believe that this information gives a high degree of reliability for anticipating the behavior of the proposed structures; however, our recommendations are professional opinions and cannot control nature, nor can they assure the soils profiles beneath those or adjacent to those observed. No warranties expressed or implied are given on the content of this report.

Expansive soils and bedrock materials were encountered at this site. These soils are stable at their natural moisture content but can shrink or swell with changes in moisture and loading. The behavior of expansive soils and bedrock materials is not fully understood. The swell and/or consolidation potential of any particular site can change erratically both in lateral and vertical extent. Moisture changes also occur erratically, resulting in conditions, which cannot always be predicted. The recommendations presented in this report are based on the current state of the art for foundations and floor slabs on swelling/consolidating soils and bedrock materials. The owner should be aware that there is a risk in construction on these types of soils and bedrock materials. Performance of the structures will depend on following the recommendations and in proper maintenance after construction is complete. As water is the main cause for volume change in the soils and bedrock materials, it is necessary that the changes in moisture content be kept to a minimum. This requires judicious irrigation and providing positive surface drainage away from the structures. Any distress noted in the structures should be brought to the attention of this office.

This report is based on the investigation at the described site and on the specific anticipated construction as stated herein. If either of these conditions is changed, the results would also most likely change. Therefore, NWCC strongly recommends that our firm be contacted prior to finalizing the construction plans so that we can verify that our recommendations are being properly incorporated into the construction plans. Man-made or natural changes in the conditions of a property can also occur over a period of time. In addition, changes in requirements due to state of the art knowledge and/or legislation do from time to time occur. As a result, the findings of this report may become invalid due to these changes. Therefore, this report is subject to review and not considered valid after a period of 3 years or if conditions as stated above are altered.

It is the responsibility of the owner or his representative to ensure that the information in this report is incorporated into the plans and/or specifications and construction of the project. It is advisable that a contractor familiar with construction details typically used to dealing with the local subsoils and climatic conditions be retained to build the structures.

If you have any questions regarding this report or if we may be of further service, please do not hesitate to contact us.

Sincerely,
NWCC, INC.

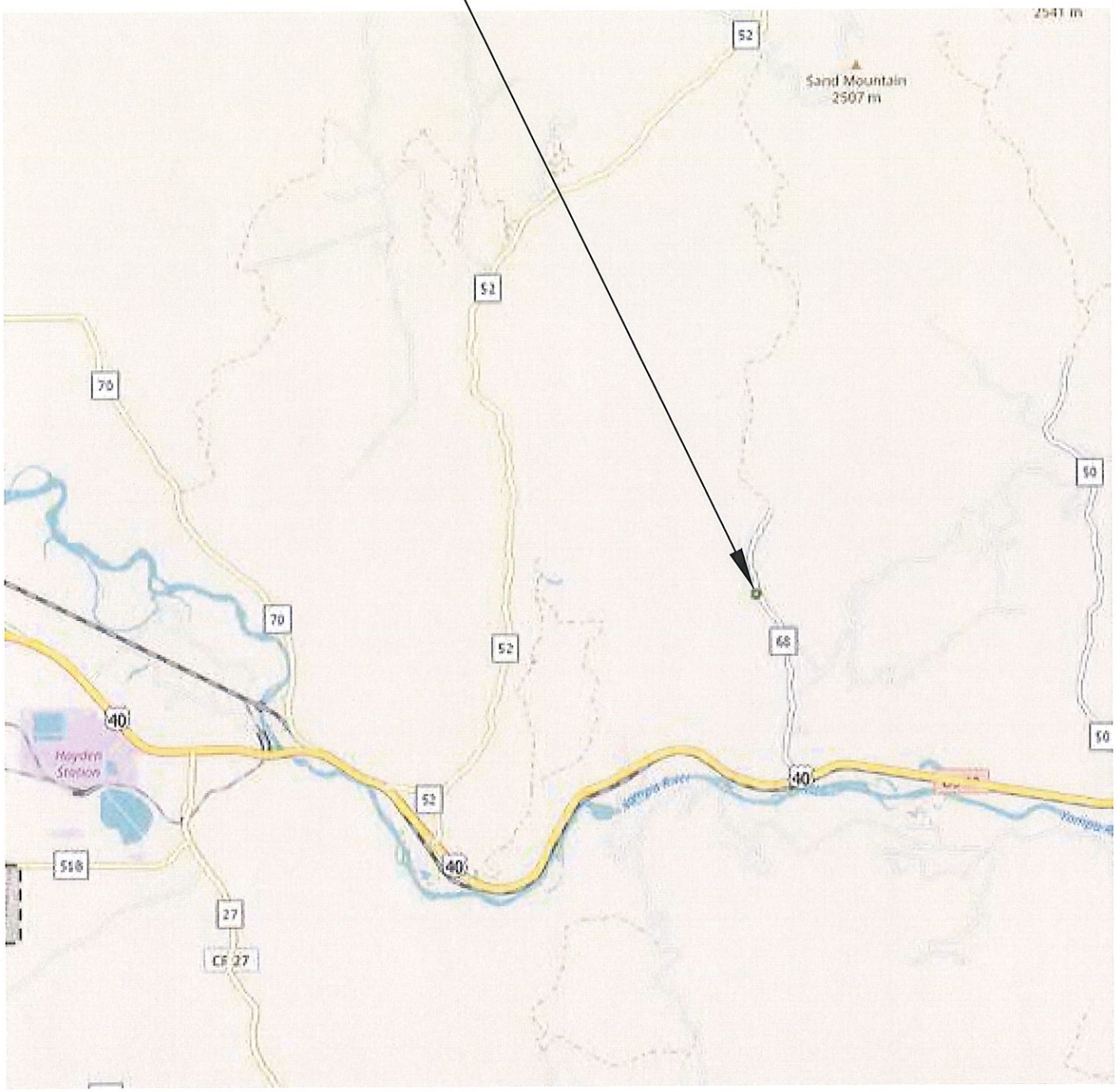
Erika K. Hill, P.E.
Project Engineer

Reviewed by Brian D. Lee, P.E.
Principal Engineer

N

NOT TO SCALE

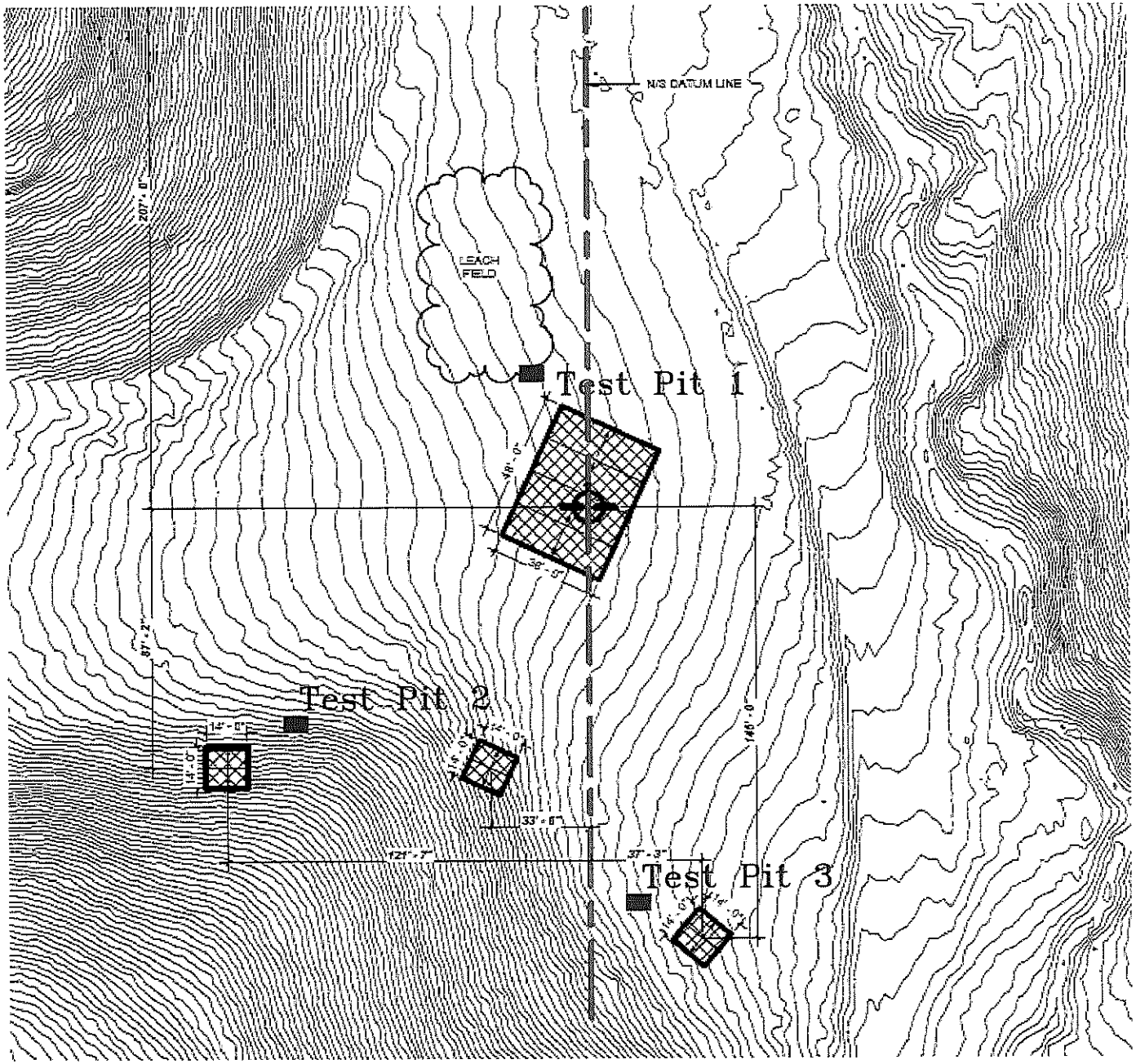
PROJECT SITE



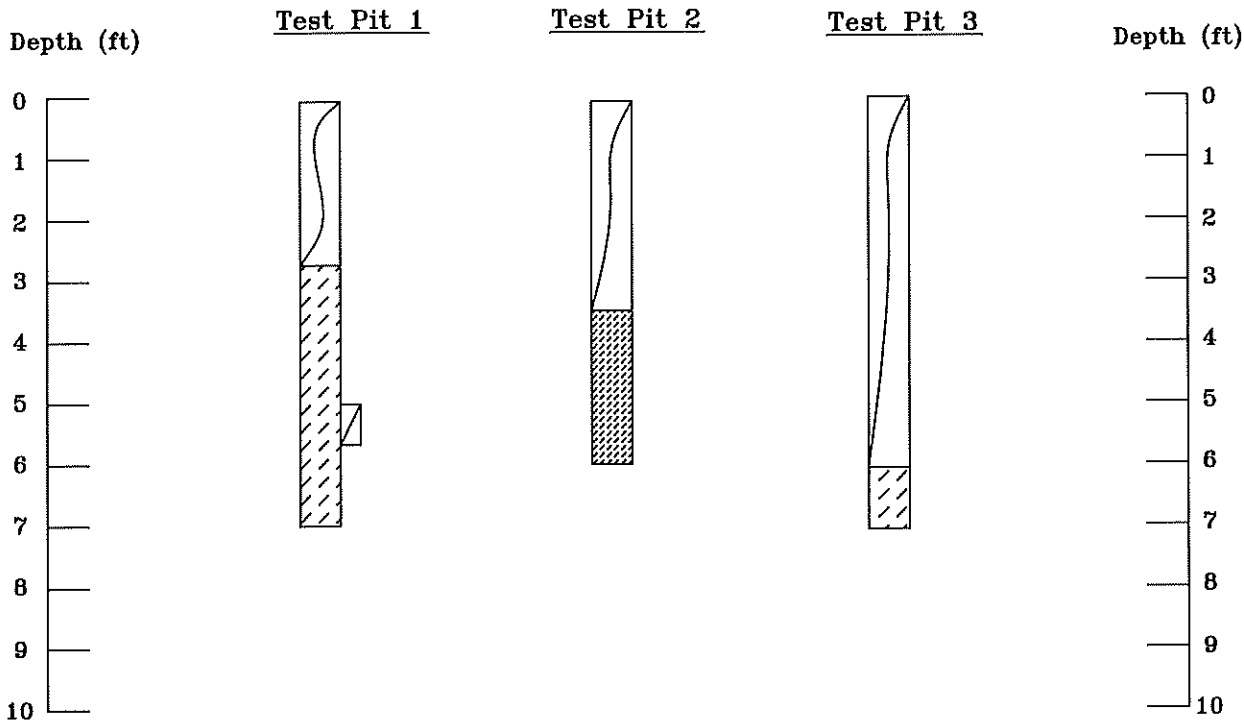
Title: VICINITY MAP	**Date:** 11/17/22	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing
Job Name: Uhl Property	**Job No.** 22-12786	(970)879-7888- Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: 40343 County Road 68, Routt County, Colorado	**Figure** #1	

N

NOT TO SCALE



Title: SITE PLAN/LOCATION OF TEST PITS		**Date:** 11/17/22	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing
Job Name: Uhl Property		**Job No.** 22-12786	(970)879-7888- Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
LOCATION: 40343 County Road 68, Routt County, Colorado		**Figure** #2	



LEGEND:

TOPSOIL AND ORGANICS

CLAYS: Very sandy to silty, low to moderately plastic, blocky, , stiff. slightly moist to very moist and dark brown to brown.

HIGHLY WEATHERED CLAYSTONE BEDROCK: Low plastic, fine to coarse grained with cobble-sized bedrock fragments, moist and tan to light brown.

Hand Drive Sample-California Liner.

NOTES:

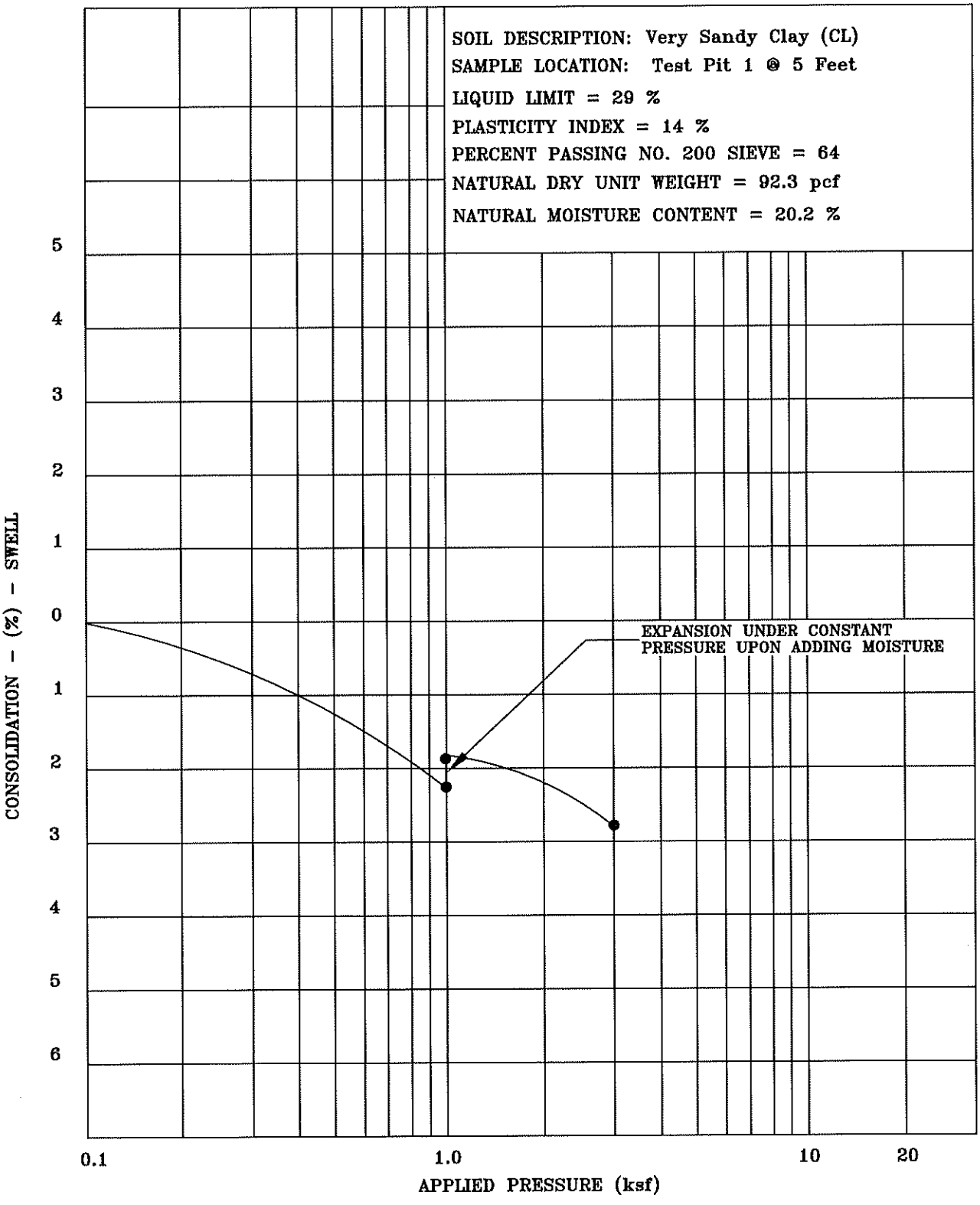
1) Test pits were excavated in October, 2022 with a rubber tired backhoe.

2) Test pit locations were determined by pacing from topographic features at the site.

3) Elevations of the test pits were not measured and the logs are drawn to the depths investigated.

4) The lines between materials shown on the test pit log represent the approximate boundaries between material types and transitions may be gradual.

Title: LOGS, LEGEND AND NOTES	Date: 11/17/22	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing
Job Name: Uhl Property	Job No. 22-12786	(970)879-7888 Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: 40343 County Road 68, Routt County, Colorado	Figure #3	



Title: SWELL–CONSOLIDATION TEST RESULTS		Date: 11/17/22
Job Name: Uhl Property		Job No. 22–12786
Location: 40343 County Road 68, Routt County, Colorado		Figure #4

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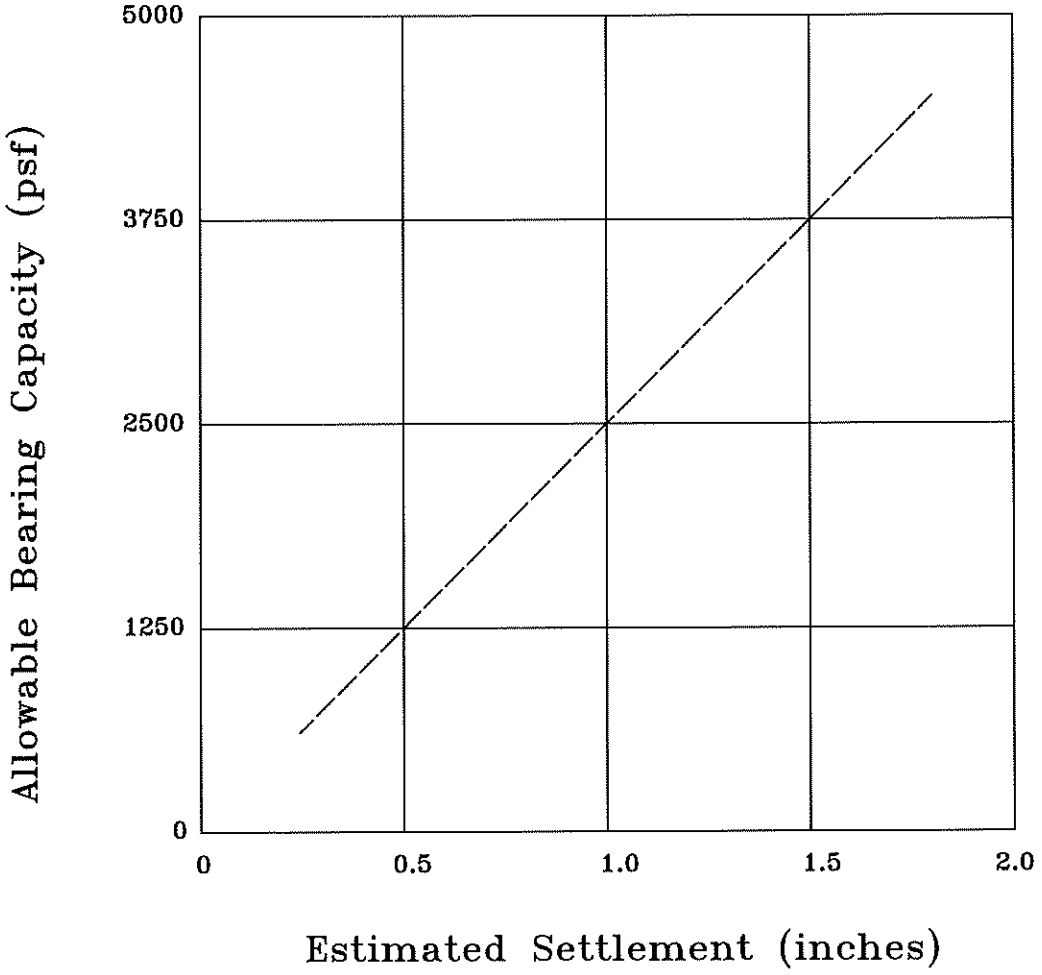

Note: These values are based on footing widths of 1 to 4 feet. If the footing width is to be greater than 4 feet in width, then we should be notified to re-evaluate these recommendations.

Title: BEARING CAPACITY CHART	Date: 11/17/22
Job Name: Uhl Property	Job No. 22-12786
Location: 40343 County Road 68, Routt County, Colorado	Figure #5

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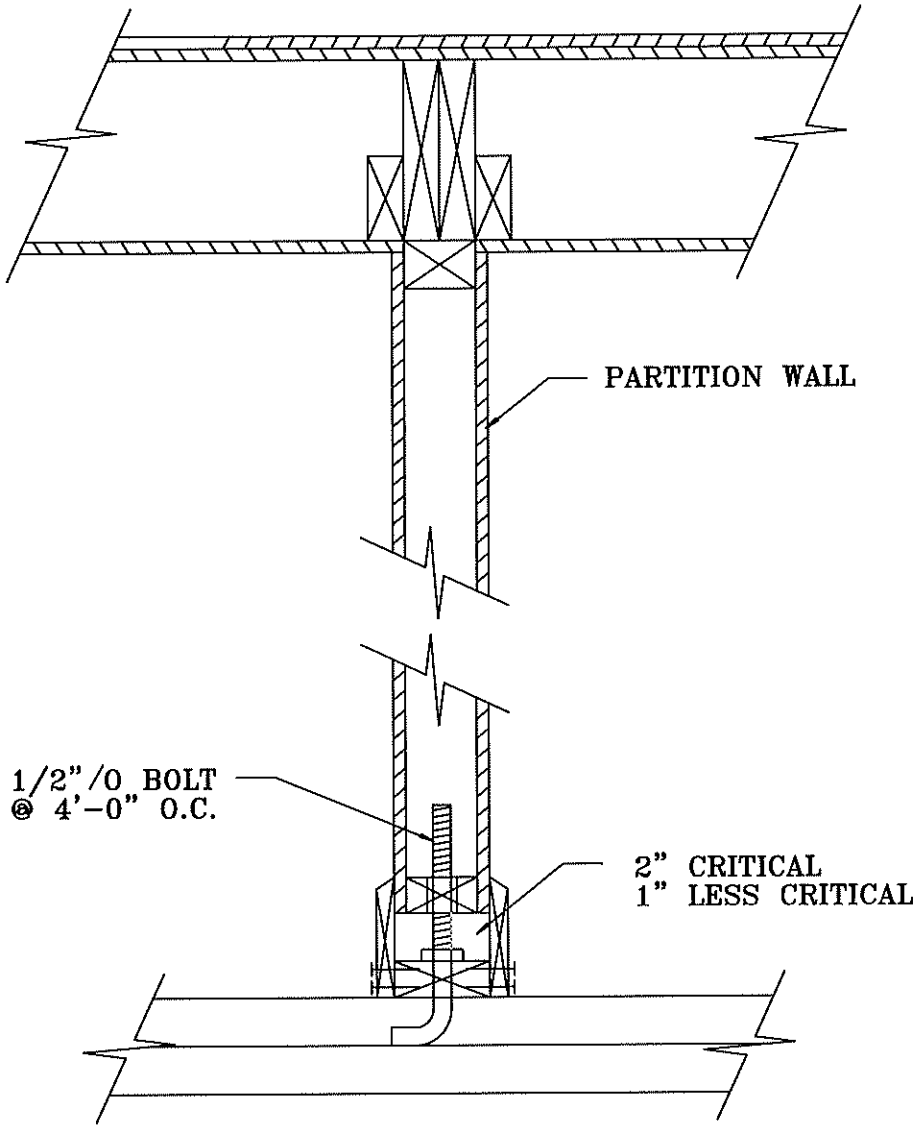
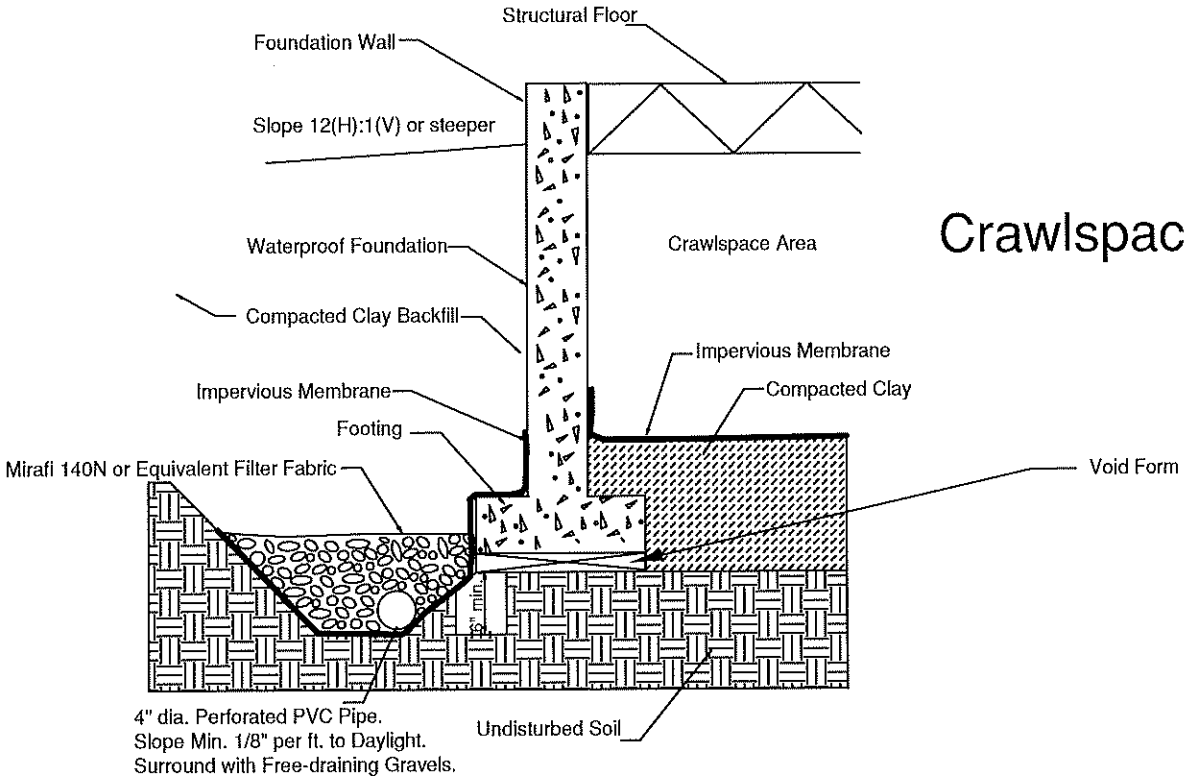
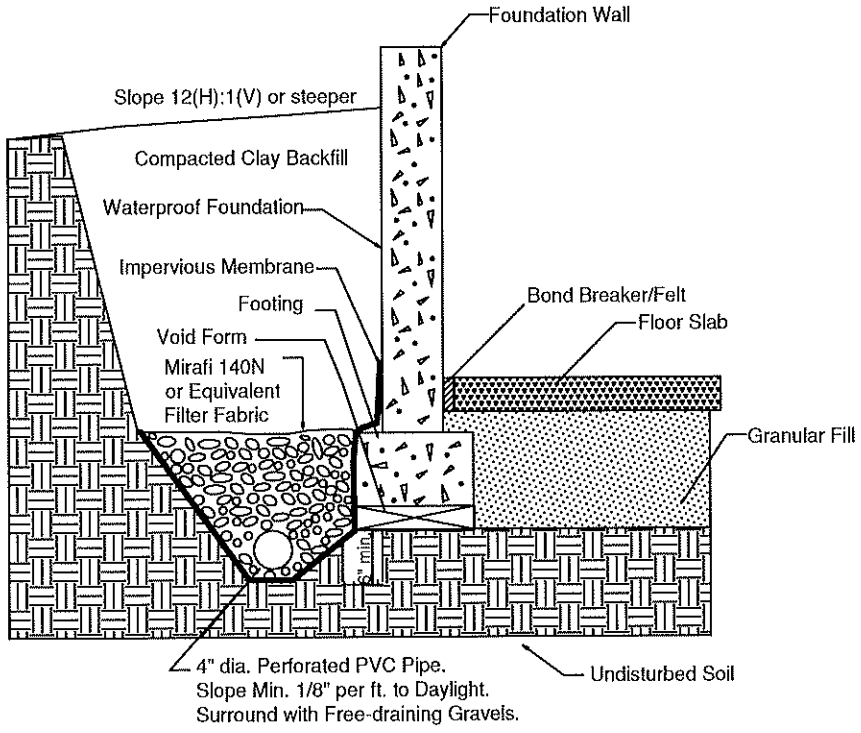


Title: HUNG PARTITION WALL DETAIL	Date: 11/17/22	NWCC North West Colorado Consultants Inc Geotechnical / Environmental Engineering · Materials Testing (970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Job Name: Uhl Property	Job No. 22-12786	
Location: 40343 County Road 68, Routt County, Colorado	Figure #6	



Crawlspace Area



Floor Slab

Title: PERIMETER/UNDERDRAIN DETAIL	**Date:** 11/17/22	NWCC Northwest Colorado Consultants Inc. Geotechnical / Environmental Engineering · Materials Testing
Job Name: Uhl Property	**Job No.** 22-12786	(970)879-7688 · Fax (970)879-7691 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: 40343 County Road 68, Routt County, Colorado	**Figure** #7	

NWCC, Inc.

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	ATTERBERG LIMITS		GRADATION		PERCENT PASSING No. 200 SIEVE	UNCONFINED COMPRESSIVE STRENGTH (psf)	SOIL or BEDROCK DESCRIPTION	UNIFIED SOIL CLASS.
TEST PIT	DEPTH (feet)			LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)				
1	5	20.2	92.3	29	14	0	36	64		Very Sandy Clay	CL

JOB NUMBER: 22-12786