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

December 20, 2022

East West Partners Steamboat
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1815 Central Park Drive, #10
Steamboat Springs, CO 80487

Job Number: 21-12448

Subject: Supplemental Subsoil and Foundation Investigation, The Amble – Steamboat Grand Phase II, Steamboat Springs, Colorado.

Nikki,

This report presents the results of the Supplemental Subsoil and Foundation Investigation (SSFI) for the proposed Amble building to be constructed as Phase II of the Steamboat Grand in Steamboat Springs, Colorado. The approximate location of the project site is shown in Figure #1. The original SFI report was dated December 1, 2021. Results of the original SFI report are included in this supplemental report.

NWCC, Inc.'s (NWCC) scope of work included obtaining data from cursory observations made at the site, drilling and logging of two additional test holes, sampling of the probable foundation soils and laboratory testing of the samples obtained. In the previous investigation, eight foundation test holes and three pavement test holes were drilled at the site. 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 the project will consist of the construction of a five-story multi-family structure with 31+ condo units, underground parking structure and associated roadways and utilities at the site. The building configuration, as well as the access road location, has changed since the previous SFI. NWCC understands that cuts of approximately 20 to 25 feet will be required at the site to accommodate the lower level parking garage.

For design purposes, NWCC has assumed that building loads will be moderate to heavy, typical of this type of multi-story construction. If loadings or conditions are significantly different from those above, NWCC should be notified to reevaluate recommendations in this report.

Site Conditions: The proposed Amble Building will be located south of the existing Steamboat Grand Building. Extensive regrading has been done in this area. Existing roads/pathways run through the otherwise vacant site. Vegetation in the proposed building area consists primarily of grasses and weeds with occasional small aspen trees and shrubs. A pond is located directly to the north northeast of the northern part of the building. Topography of the site is variable and consists of a hill in the approximate center of the proposed building area that slopes moderately down in all directions. An elevation difference of approximately 15 to 25 feet exists across the proposed building site.

Subsurface Conditions: To investigate the subsurface conditions at the site, eight foundation test holes and three pavement test holes were drilled at the site on October 27 and 28, 2021 with a track-mounted drill rig using 4-inch diameter continuous flight augers for the original investigation. On November 22, 2022, two additional test holes were drilled with a truck-mounted CME 55 drill rig using 4-inch diameter continuous flight augers. A site plan showing existing features along with the approximate test hole locations is presented in Figure #2.

Subsurface conditions encountered were variable and generally consisted of fill materials or topsoil and organic materials overlying natural clays and claystone bedrock to the maximum depth investigated, 30 feet below the existing ground surface (bgs). A layer of sands and gravels was encountered beneath the clays and above the bedrock materials in Test Hole 9. Apart from the gravel layer and high groundwater encountered in Test Hole 9, subsurface conditions encountered in the additional test holes were consistent with the previous investigation. Graphic logs of the foundation test holes are presented in Figures #3 and #4; logs of pavement test holes are presented in Figure #5; logs of the additional test holes are presented in Figure #6 and associated Legend and Notes are presented in Figure #7.

Fill materials were encountered at the ground surface in all foundation test holes and pavement test holes apart from Pavement Hole P3 and extended to depths ranging from 1 to 14 ½ feet bgs. Fill materials consisted of sandy gravelly clays with occasional organics that were low plastic, fine to coarse grained, medium stiff to very stiff, slightly moist to moist and light brown to brown to dark brown in color. Samples of the fill materials encountered classified as CL soils in accordance with the Unified Soil Classification System (USCS).

A layer of natural topsoil and organic materials, approximately 12 inches in thickness, was encountered at the ground surface in Pavement Hole 3.

Natural clays were encountered below the topsoil and organic materials in Pavement Hole P3 and beneath the fill materials in Test Holes 1, 2 and 6. Natural clays extended to approximately 3 feet bgs in Pavement Hole P3; 17 feet bgs in Test Hole 1; 3 feet bgs in Test Hole 2; and 11 ½ feet bgs in Test Hole 6. The clays were nil to very sandy, moderately to highly plastic, fine to coarse grained with occasional gravels, stiff to very stiff, slightly moist to moist and brown to light brown to reddish brown in color. Samples of the natural clays classified as CL soils in accordance with the USCS.

Claystone to sandstone bedrock of the Browns Park Formation was encountered beneath the clays in Test Holes 1, 2 and 6, and Pavement Hole P3; beneath the sands and gravels in Test Hole 9; and beneath fill materials in all other test holes. Bedrock materials extended to the maximum depths investigated in each test hole. The bedrock materials were primarily sandy to very sandy claystone with sandstone interbeds, low to moderately plastic, fine to coarse grained, hard to very hard, moist to dry and light brown to reddish brown in color. Samples of the bedrock materials classified as CL to SC soils in accordance with the USCS.

Swell-consolidation tests conducted on samples of the natural clays, fill materials and bedrock materials indicate the materials tested will exhibit a low to moderate swell potential when wetted under a constant load. The swell-consolidation test results are presented in Figures #7 through #18, and all other laboratory test results are summarized in the attached Table 1. Standard Proctor test results indicate the clay fill materials encountered in the proposed roadway area will have a maximum dry density of 122.3 pcf at 16.2% optimum moisture content. Standard Proctor test results are shown in Figure #19.

Water soluble sulfate (WSS), chloride content, resistivity and pH testing was conducted on a bulk sample obtained from Test Hole 2 at 2 to 14 feet bgs to evaluate corrosivity of the soils to metal and cement. Resistivity and corrosivity and test results, including WSS, chloride content and pH testing, are included in the attached Table 2. Soil resistivity test results indicate the materials tested exhibited values between approximately 1,100 and 1,800 ohm-cm (moderately corrosive).

Groundwater was encountered in Test Hole 9 at the time of drilling. Groundwater was not encountered in any other test holes at the time of drilling. Groundwater encountered in Test Hole 9 appeared to be perched and may be associated with seepage from the nearby pond. It should be noted that the groundwater conditions at the site can be expected to fluctuate with seasonal changes in precipitation and runoff.

Foundation Recommendations: Based on the subsurface conditions encountered in the test holes, the results of the field and laboratory investigations and our understanding of the proposed construction, NWCC believes an economically feasible and safe type of foundation system for the Amble building would consist of straight-shaft skin friction/end bearing piers drilled into the natural bedrock materials. Foundation movement less than ½ inch should be within tolerable limits if the following design and construction precautions are observed.

1) A minimum pier diameter of 16 inches and a minimum pier length of 20 feet are recommended with a minimum bedrock penetration of 5 feet. A maximum pier length to diameter ratio of 25 is also recommended.

2) Piers should be designed using an allowable skin friction value of 900 psf for the portion of the pier penetrating the natural clays and 4,000 psf for the portion of the pier penetrating the bedrock materials. The upper 5 feet of penetration should be neglected in the skin friction calculations. A drill rig of sufficient size, type and operating condition should be used so bottom of the piers can be cleaned out properly and minimum length requirements can be met. If bottom of piers are properly cleaned and approved by an engineer from this office, then an allowable end bearing pressure of 40,000 psf for bedrock materials may be used in the design.

3) Piers should be reinforced their full length with at least one #5 reinforcing rod for each 16 inches of pier perimeter.

4) Piers should be properly cleaned and dewatered prior to steel and concrete placement. If groundwater is encountered, dewatering equipment will most likely be required to reduce water infiltration into the piers constructed at this site. The concrete should not be placed in more than 3 inches of water unless the tremie or pump methods are used.

5) A 4-inch void should be provided beneath grade beams to prevent swelling soils from exerting uplift forces on grade beams and to concentrate pier loadings. A void should also be provided beneath necessary pier caps.

6) A representative of NWCC must observe pier drilling operations.

L-Pile Parameters: Table B below outlines our recommendations for soil parameters to be used in the LPILE design program.

TABLE B
PARAMETERS FOR LPILE DESIGN

SOIL TYPE	LPILE SOIL TYPE	YOUNG'S MODULUS (x 10E6 psi)	EFFECTIVE UNIT WEIGHT (pci)	COHESIVE STRENGTH (psi)	Φ' (deg.)	E_{50}
Bedrock	Weak Rock	0.10	0.075	14.0	30	0.005

Alternate Deep Foundation Recommendations: An alternative foundation system to the drilled piers would be a helical pile or micropile foundation system advanced into the underlying bedrock materials. The helical screw pile or micropile foundation system should be designed by a qualified engineer, using industry standards and be installed by a licensed/certified installer. If pile groups are required, we recommend a minimum pile spacing of 3 times the largest helix or pile diameter to achieve the maximum capacity of each individual pile. Lateral loads should be resisted using battered piles or tiebacks or through passive soil pressures against foundation walls or grade beams. Refusal in fill materials will NOT be acceptable.

We strongly recommend that at least three test helical piles be advanced at the site so that the torque versus depth relationships can be established and the proper shaft and helix size and type can be determined. In addition, load testing of the helical screw piles is strongly recommended to verify the design capacity of the piles. A representative of this office should observe the test piles, load test and helical screw pile installations.

NWCC also recommends the following:

- Minimum 6-inch diameter helix for helical piles;
- Minimum penetration of 8 feet between upper helix and ground surface for helical piles;
- Minimum micropile length of 20 feet;
- Minimum installation torque of 4,000 ft-lbs. for helical piles;
- Full-time installation observation by a qualified special inspector;
- Review of the Contractor's quality control plan regarding instrumentation calibration and testing, materials QC, and pile installation procedures;

Alternate Shallow Foundation Recommendations: If the owner is aware of the risks associated with placing shallow foundations on expansive soils and bedrock materials, and can tolerate and/or design for differential movements that could result if the natural clays become wetted and swell, the foundations may be supported by spread footings founded on undisturbed 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 underlying clays and 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 clays and 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 and bedrock materials.

1) Footing excavations should be extended below existing fill materials and any topsoil and organic materials down to natural clays or bedrock materials.

2) Footings placed on the natural clays or bedrock materials or footings placed on less than 2 feet of properly compacted structural fill materials should be designed using an allowable soil bearing pressure of 3,500 psf. Footings placed on the natural clays or bedrock materials should also be designed using a minimum dead load pressure of at least 800 psf.

3) Footings or pad sizes should be computed using the above soil pressures and placed on the natural clays or bedrock materials encountered below the topsoil and organic materials and fill materials.

4) Any topsoil and organic materials, existing fill materials or soft natural soils found beneath the footings when excavations are opened should be removed and footings extended down to competent natural clays or bedrock materials prior to concrete placement. Footings placed on the clays and bedrock materials may have to be narrow or interrupted to maintain the minimum dead load. Foundation design should be closely checked to assure that it distributes loads per the allowable pressures given.

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

6) 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.

7) Structural fill materials should consist of a non-expansive granular soil approved by NWCC. If groundwater is encountered in the footing excavations, NWCC recommends that clean gravel fill materials meeting the gradation specifications for Colorado Department of Transportation (CDOT) Class A or Class B Filter Materials be used. 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. Structural fill materials should extend out from the edge of the footings or mats on a 1(horizontal) to 1(vertical) or flatter slope.

8) Based on experience, NWCC estimates 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 #20.

9) NWCC must be retained by the client to observe the foundation excavations when they are near completion to identify bearing soils and bedrock materials, and confirm the recommendations in this report, as well as test the structural fill materials placed beneath the footings for compaction.

Retaining Structures and Foundation Wall Recommendations: Foundation walls and retaining structures that are laterally supported and can be expected to undergo only a moderate amount of deflection, may be designed for a lateral earth pressured calculated based on 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 can be expected to deflect sufficiently to mobilize the full active earth pressure condition. Therefore, the 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.

The retaining structures should also 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 retaining walls.

The lateral resistance of retaining wall foundations placed on undisturbed clays and bedrock materials 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.

NWCC recommends 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.

The 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.

Floor Slabs: On-site soils and bedrock materials, apart from existing fill and topsoil and organic materials, are capable of supporting slab-on-grade construction. However, floor slabs present a very 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 natural clays and bedrock materials encountered at this site, NWCC believes 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 must be taken to reduce damage, which could result from movement should the underslab clays and bedrock materials be subjected to moisture changes.

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

2) Interior non-bearing partition walls resting on the floor slabs must be provided with a slip joint, preferably at the bottom, so 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 #21.

3) A minimum 6-inch gravel layer must be provided beneath all floor slabs to act as a capillary break and to help distribute pressures. Prior to placing the gravel, 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 topsoil and organic materials and existing fill materials should be removed prior to placement of the underslab gravels or new structural fill materials.

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

5) Underslab soils and bedrock materials must be kept as close as possible to their in-situ moisture content. Excessive wetting or drying of these soils prior to placement of floor slab could result in differential movement after 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.

Following the above precautions and recommendations will not prevent floor slab movement in the event the clays and 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 that are constructed below the existing or finished ground surfaces and the foundations should be protected by underdrain systems 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 structures 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.

Drains should be located around entire perimeter of the lower levels and be placed and at least 12 inches below any floor slab or crawl space levels and at least 6 inches below the foundation voids and bottom of the foundation walls or footings. NWCC recommends the use of perforated PVC pipe for the drainpipe, which meets or exceeds ASTM D-3034/SDR 35 requirements, to minimize potential for pipe crushing during backfill operations. Holes in the drainpipe should be oriented down between 4 o'clock and 8 o'clock to promote rapid runoff of water. 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. Drains should have a minimum slope of 1/8 inch per foot and be daylighted at positive outfalls protected from freezing or be led to sumps from which water can be pumped.

The use of interior laterals, multiple daylights or sumps will likely be required for the proposed structure. Caution should be taken when backfilling so as not to damage or disturb the installed underdrain. NWCC recommends the drainage system include a cleanout every 100 feet, be protected against intrusion by animals at outfalls and be tested prior to backfilling. NWCC also recommends the client retain our firm to observe the underdrain systems during construction to verify that they are being installed in accordance with recommendations provided in this report and observe a flow test prior to backfilling the system.

In addition, NWCC recommends an impervious barrier be constructed to keep water from infiltrating through the voided areas and/or under footings and/or foundation walls. 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. Typical perimeter/underdrain details are shown in Figure #22.

Surface Drainage: Proper surface drainage at this site is of paramount importance for minimizing infiltration of surface drainage into 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 structures should be sloped (minimum of 1.0 inch per foot) to drain away from structures in all directions to a minimum of 10 feet. Ponding must be avoided. If necessary, raising top of foundation walls to achieve a better surface grade is advisable.

2) Non-structural backfill placed around structures should be compacted to at least 95% of the maximum standard Proctor density at or near the optimum moisture content to minimize future settlement of the fill. 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 foundations should be impervious in nature to minimize infiltration of surface water into wall backfill.

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

Site Grading: The slopes on which the proposed structures are proposed could become unstable due to the 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. Additional recommendations and/or investigations may be warranted to provide additional information for the design and construction of temporary or permanent shoring and slope stabilization structures. Slope reinforcement should be designed and constructed by engineers and contractors experienced in earth retention systems.

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 should be kept as shallow as possible and should not exceed a 3(Horizontal) to 1(Vertical) configuration for the topsoil and organic materials and existing fill materials; and a 2(Horizontal) to 1(Vertical) configuration for the clays and bedrock materials.

   We recommend permanent, unretained cuts be limited to 20 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 determine if additional investigations and/or stabilization measures are warranted.

3) Due to the hard bedrock encountered at the site, larger excavation equipment with ripper teeth will most likely be required for foundation and utility trench excavations. It is possible that isolated areas of hard bedrock may require blasting or other rock breaking techniques in confined areas.

4) 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 very heavy.

5) Fills up to 20 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 existing fill materials, natural topsoil and organic materials, and sands and silts have been removed. The fill materials should consist of the on-site soils (exclusive of topsoil, organics, or sands and 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.

6) 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.

7) 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.

Pavement Recommendations: Pavement section alternatives presented below are based on field and laboratory investigations, assumed traffic loadings indicated below, pavement design procedures presented in the AASHTO Guide for Design of Pavement Structures, and our experience with similar sites and conditions in this part of Steamboat Springs. AASHTO pavement design procedures have been adopted and are used by the Colorado Department of Transportation (CDOT).

Based on the results of the original field and laboratory investigations and our understanding of the proposed construction, it appears the materials to be encountered at proposed pavement subgrade elevations will most likely consist of existing clay fill materials, natural clays or claystone bedrock. It should be noted that the pavement hole locations for the previous investigation are no longer in the area of the proposed access road. However, NWCC does not anticipate a high degree of variation in likely subgrade materials from the previous proposed access road and the new proposed access road location. These materials generally classified as CL soils in accordance with the Unified Soil classification system and as A-6 to A-7 soils in accordance with the AASHTO classification system. These materials are generally considered to provide poor support for pavement structures.

NWCC recommends the pavement areas subjected to both automobile and truck traffic be constructed with a composite pavement section consisting of at least 4 inches of hot mix asphalt (HMA) placed over 4 inches of CDOT Class 6 aggregate base course (ABC) and 8 inches of subbase materials consisting of CDOT Class 2 aggregates. Pavements for areas subjected to automobile traffic only, such as automobile parking spaces, should be constructed with a composite pavement section consisting of at least 3 inches of HMA placed over 4 inches of Class 6 ABC and 8 inches of subbase aggregates.

NWCC recommends the areas subjected to heavy truck traffic turning movements, such as in the apron areas in front of the trash dumpster approach areas, be paved with a rigid pavement section consisting of at least 7 inches of Portland cement concrete (PCC). Sidewalks subjected to pedestrian traffic should be paved using at least 4 inches of PCC. Areas where occasional emergency or snow removal vehicle traffic is anticipated should be paved using at least 5 inches of PCC.

Prior to placement of subbase materials, any topsoil and organics materials and topsoil fill materials should be removed. NWCC recommends the exposed subgrade soils be uniformly mixed, moisture treated to within 2 % of the optimum moisture content and then be recompacted to at least 95 % of the maximum standard Proctor density. Depending on the time of year when subgrade preparation is considered, moisture conditioning including drying and/or moistening of subgrade materials will most likely be required in order to attain uniform compaction. NWCC also recommends that the properly moisture conditioned and recompacted subgrade soils be proofrolled with a loaded tandem dump truck or water truck prior to placing the subbase gravels. Areas exhibiting deflection and rutting will most likely require deeper stabilization. The depth and type of stabilization should be determined at the time of construction.

NWCC recommends the HMA materials consist of an approved “Superpave” mix designed by a qualified, registered engineer. The mix design should be designed using the SX gradation and mixed with PG 58-28 oil or other performance graded asphaltic materials. The mix should be produced and placed by a qualified contractor and should be compacted to between 92 and 96 percent of the maximum theoretical (Rice) density. Quality control activities should be conducted on paving materials at the time of placement.

ABC materials should consist of a well-graded aggregate base course materials that meet CDOT Class 6 ABC grading and durability requirements. Base course and subbase materials (Class 2 Subbase) should be uniformly placed and compacted in 4 to 6-inch loose lifts to at least 95 % of the maximum modified Proctor density and within +/- 2 % of the optimum moisture content as determined by ASTM D1557.

Concrete pavement materials shall be based on a mix design established by a qualified engineer. Concrete should have a minimum 28-day compressive strength of 4,500 psi, be air entrained with approximately 6 percent air and have a maximum water/cement ratio of 0.42. Concrete should have a maximum slump of 4 inches and should contain control joints not greater than 12 feet on centers. The depth of the control joints should be at least ¼ of the slab thickness.

The collection and diversion of surface and subsurface drainage away from the paved areas is extremely important to satisfactory performance of the pavement. The design of the surface and subsurface drainage features should be carefully considered to remove all water from paved areas and to prevent ponding of water on and adjacent to paved areas. NWCC recommends subgrade areas be graded to drain if feasible so that surface runoff is not allowed to pond on the subgrade surface.

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

Swelling soils and bedrock materials were encountered at this site. These soils/bedrock materials are stable at their natural moisture content but can shrink or swell with changes in moisture. The behavior of swelling soils and bedrock materials is not fully understood. The swell or consolidation potential of a site can change erratically both in lateral and vertical extent. Moisture changes also occur erratically, resulting in conditions, which cannot always be predicted. Recommendations presented in this report are based on the current state of the art for foundations and floor slabs on swelling soils and bedrock materials. As noted previously, the owner must be made aware there is a risk in construction on these types of soil 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 NWCC.

This report is based on the investigation at the described site and on 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 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 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.

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

Sincerely,
NWCC, INC.

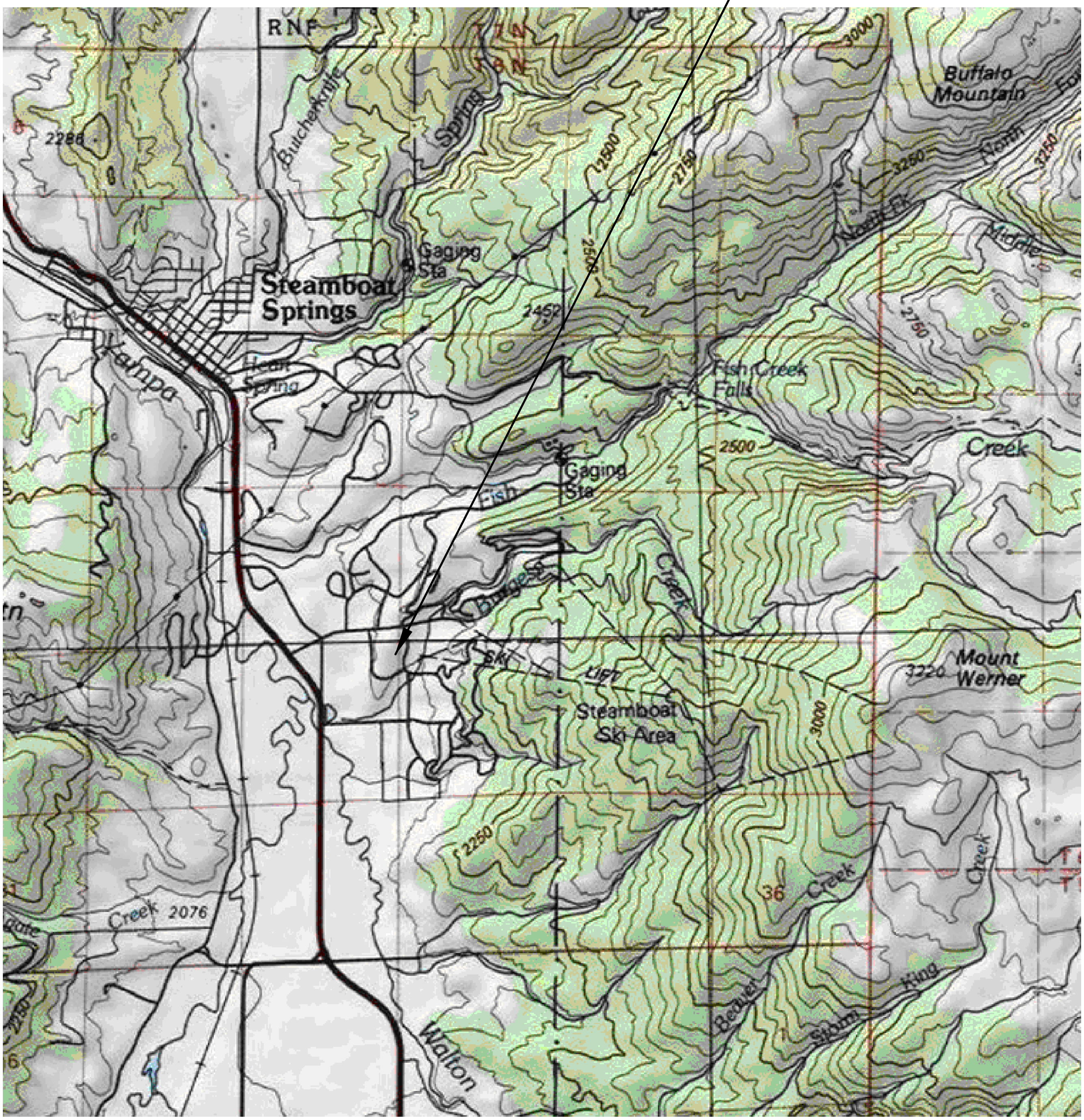
Erika K. Hill, P.E., P.G.
Project Engineer

Reviewed by Brian D. Len, P.E.
Principal Engineer 12-21-2022

N

NOT TO SCALE

PROJECT SITE



Title: VICINITY MAP	Date: 11/23/21
Job Name: The Amble-Steamboat Grand Phase II	Job No. 21-12448
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #1

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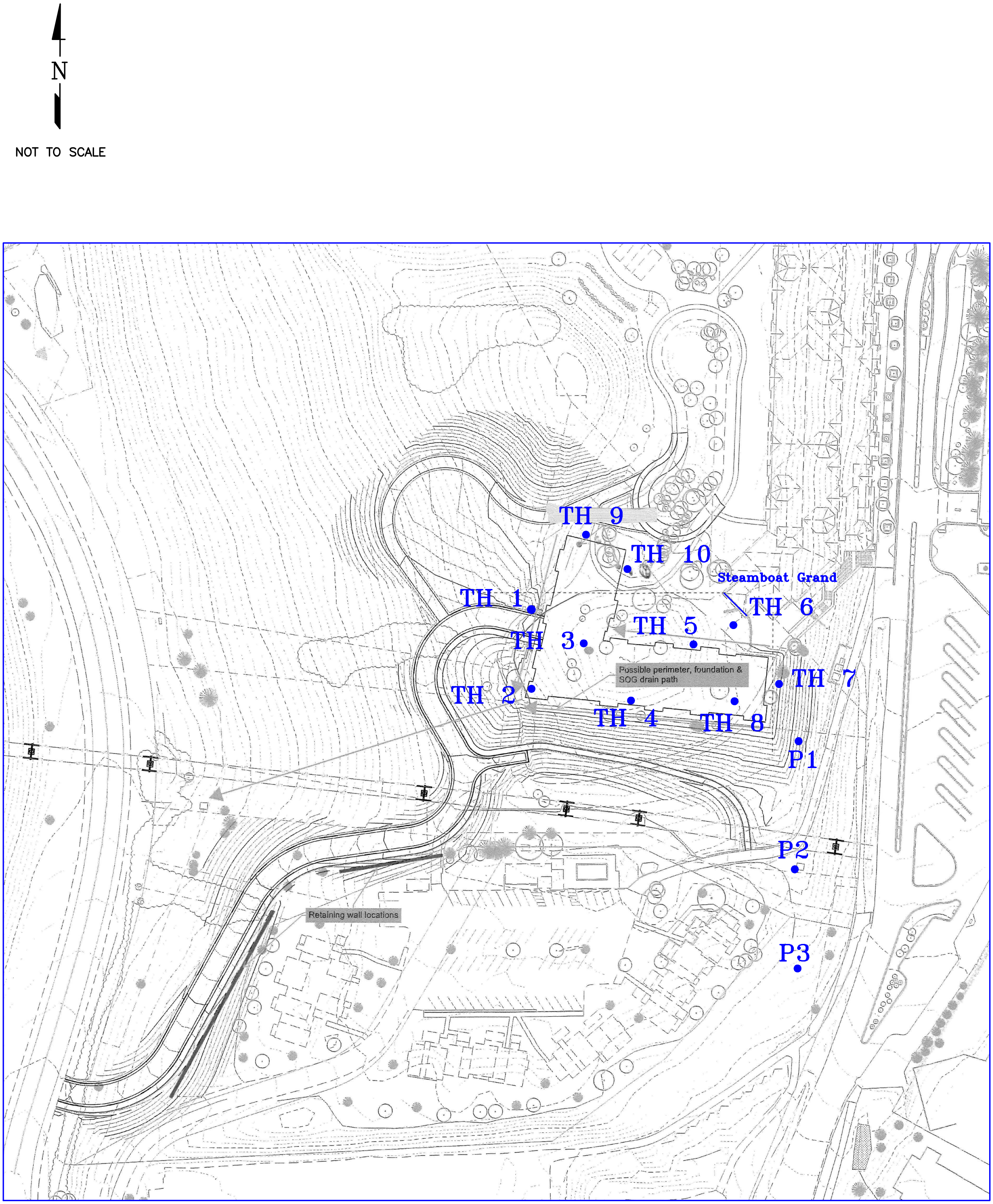
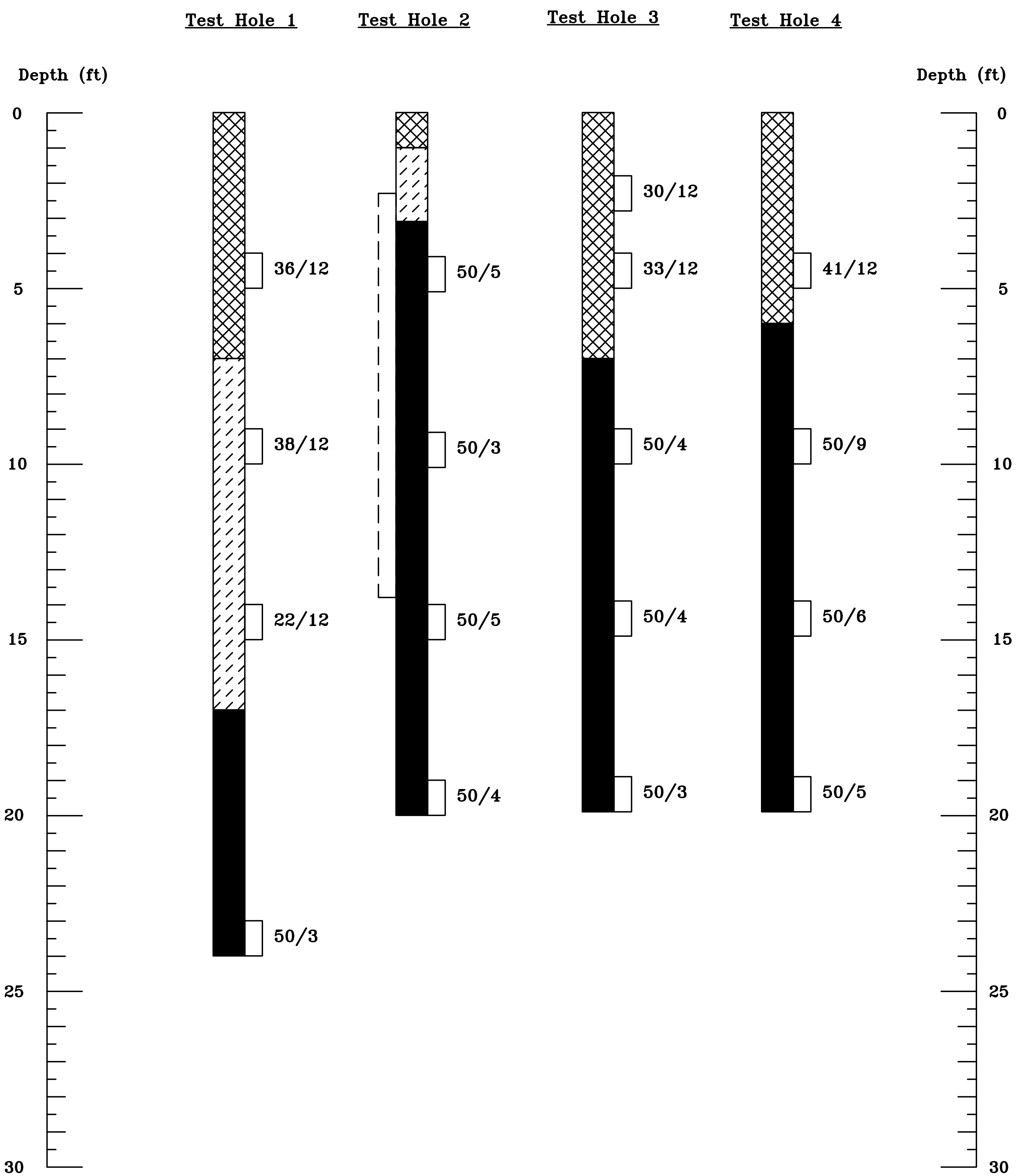
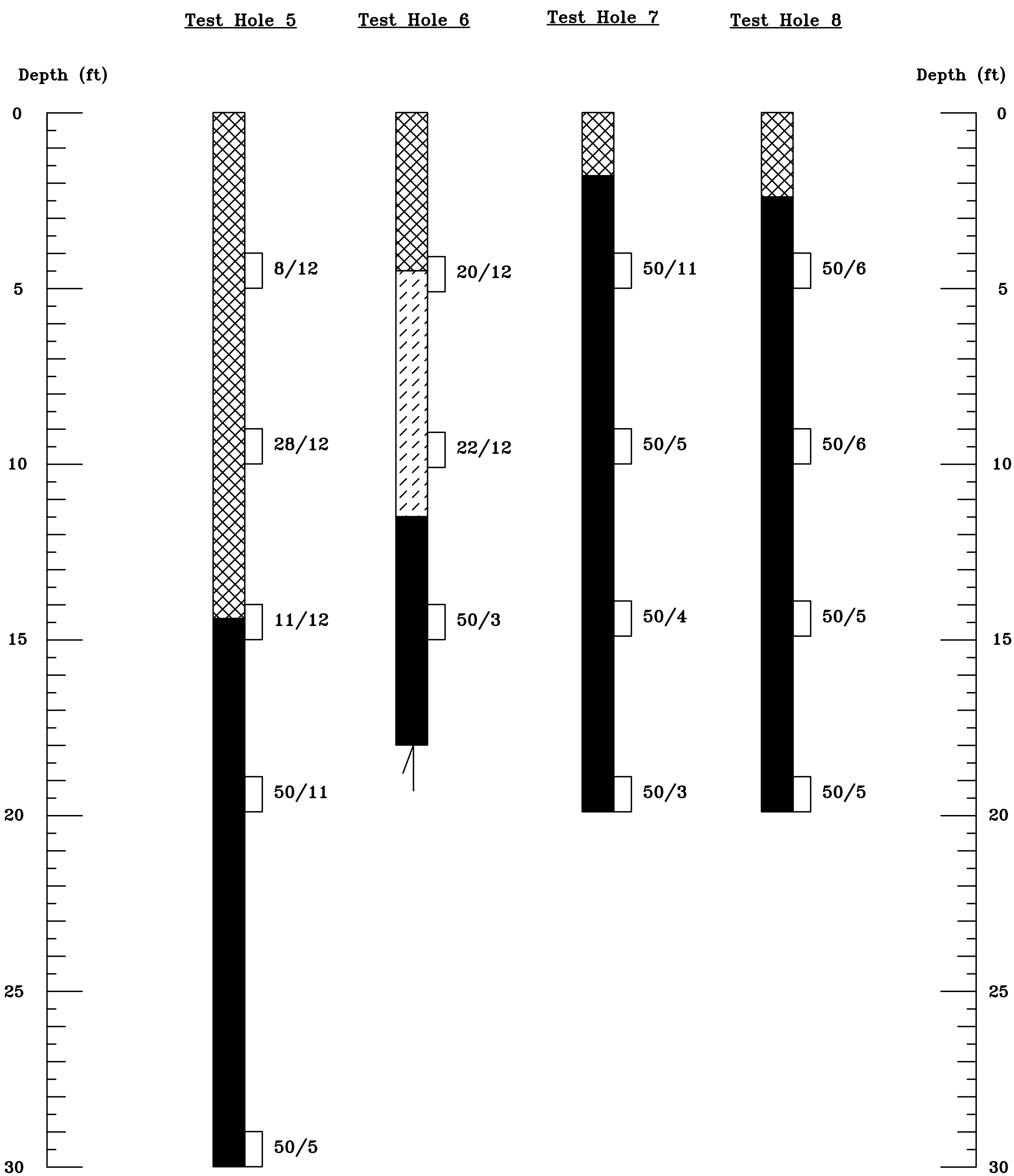


Title: SITE PLAN–LOCATION OF TEST HOLES	Date: 11/23/21	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering • Materials Testing
Job Name: The Amble–Steamboat Grand Phase II	Job No. 21–12448	(970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #2	



Title:	LOGS OF EXPLORATORY TEST HOLES	Date:	11/23/21	NWCC North West Colorado Consultants, Inc.
Job Name:	The Amble-Steamboat Grand Phase II	Job No.	21-12448	Geotechnical / Environmental Engineering • Materials Testing
Location:	Steamboat Grand, Steamboat Springs, Colorado	Figure	#3	(970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive • P.O. Box 775226 Steamboat Springs, Colorado 80477



Title: LOGS OF EXPLORATORY TEST HOLES	Date: 11/23/21		
Job Name: The Amble-Steamboat Grand Phase II	Job No. 21-12448		
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #4		

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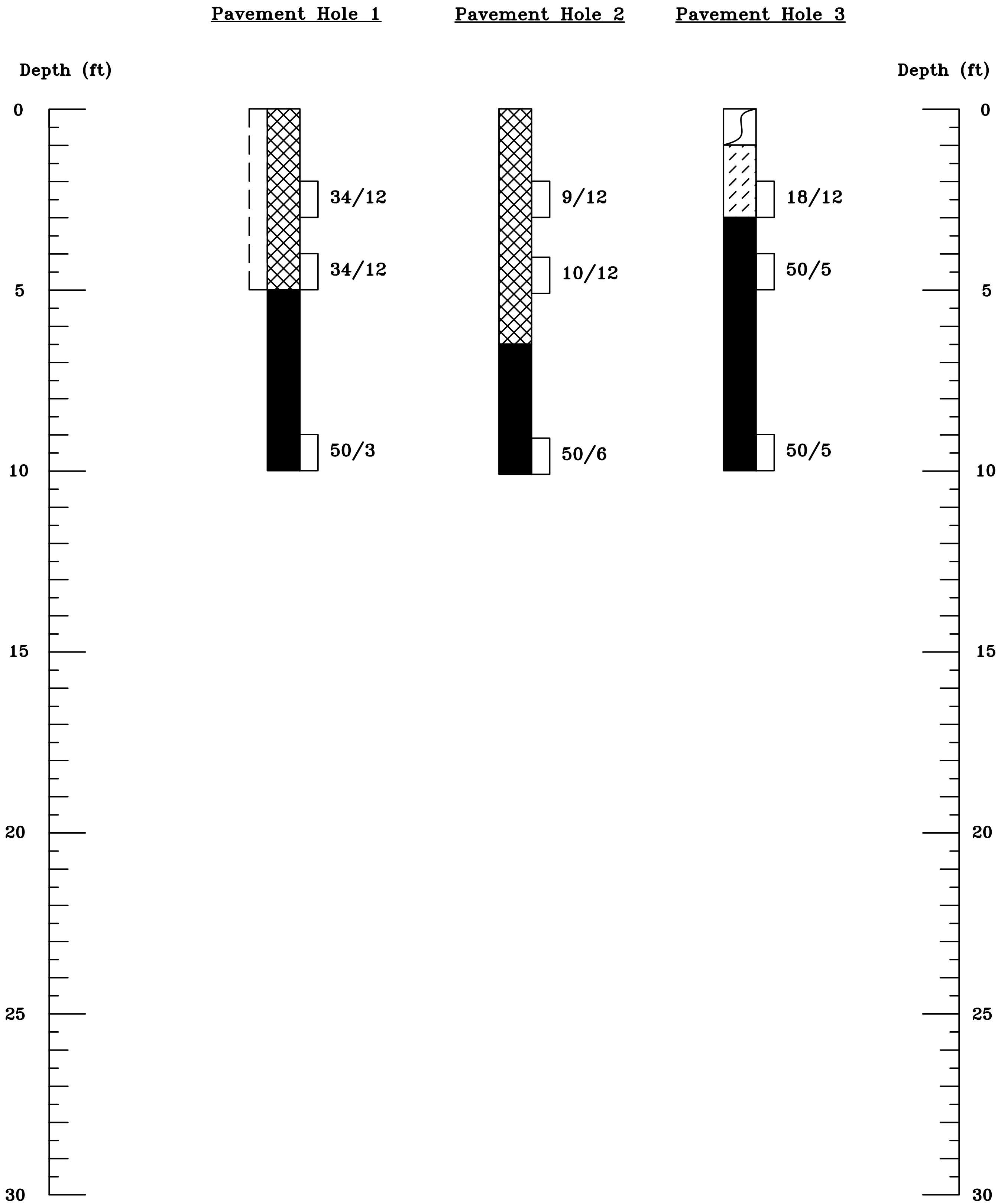
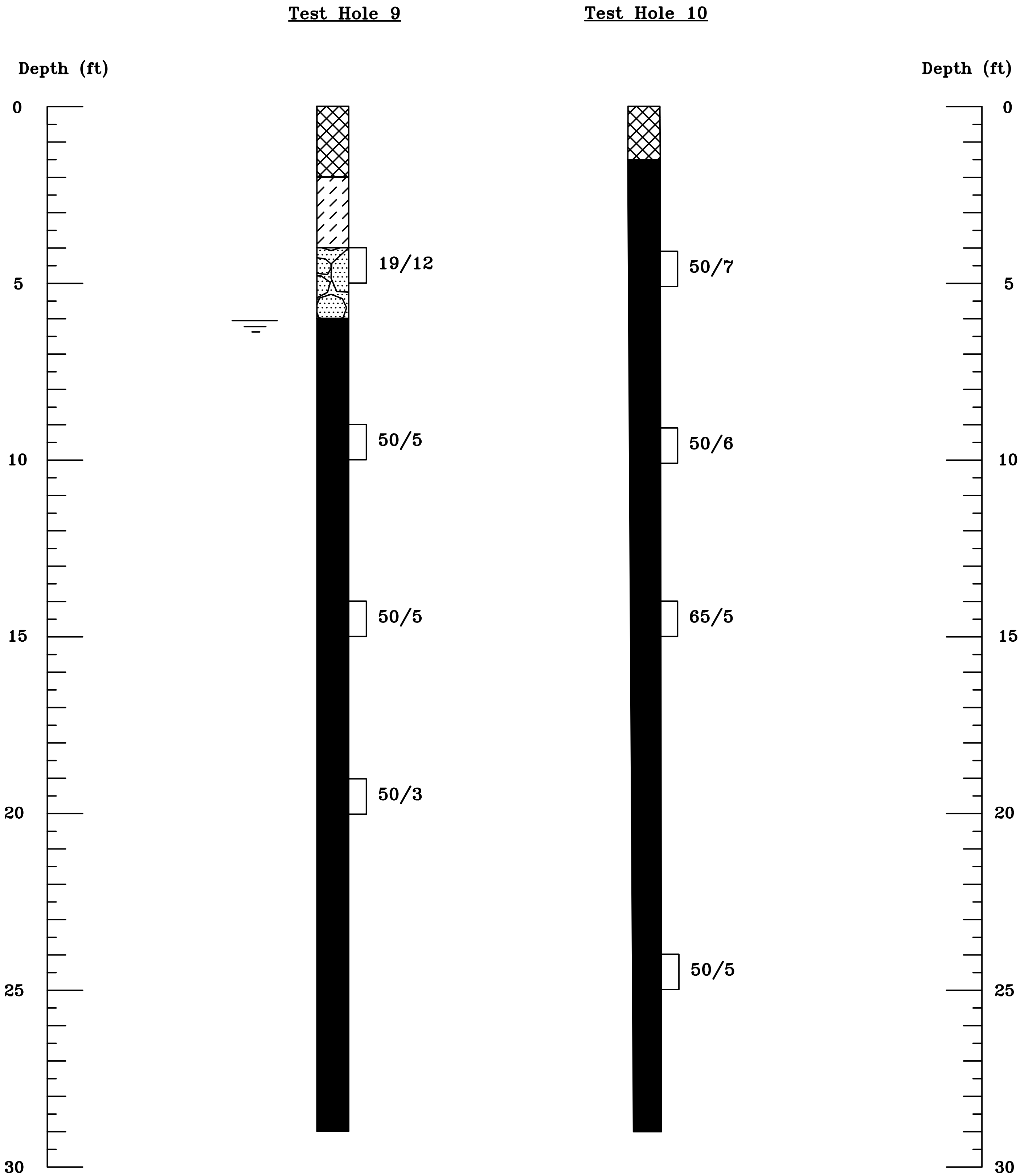


Title: LOGS OF EXPLORATORY TEST HOLES		Date: 11/23/21	North West Colorado Consultants, Inc.
Job Name: The Amble-Steamboat Grand Phase II		Job No. 21-12448	Geotechnical / Environmental Engineering • Materials Testing
Location: Steamboat Grand, Steamboat Springs, Colorado		Figure #5	(970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive • P.O. Box 775226 Steamboat Springs, Colorado 80477



Title: LOGS OF EXPLORATORY TEST HOLES	Date: 12/14/22
Job Name: The Amble-Steamboat Grand Phase II	Job No. 21-12448
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #6

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LEGEND:

FILL: Sandy gravelly clays with occasional organics, low plastic, fine to coarse grained, medium stiff to very stiff, slightly moist to moist and light brown to brown to dark brown.

TOPSOIL AND ORGANIC MATERIALS

CLAYS: Nil to very sandy, moderately to highly plastic, fine to coarse grained with occasional gravels, stiff to very stiff, moist and light brown to brown to reddish brown.

SANDS AND GRAVELS: Clayey to clean, low to non plastic, fine to coarse grained, moist to wet and brown.

CLAYSTONE/SANDSTONE BEDROCK: Browns Park Formation, sandy to very sandy claystone with sandstone interbeds, low to moderately plastic, fine to coarse grained, hard to very hard, moist to dry and light brown to reddish brown.

Drive Sample, 2-inch I.D. California Liner Sampler.

Large disturbed bulk sample

19/12 Drive Sample Blow Count, indicates 19 blows of a 140-pound hammer falling 30 inches were required to drive the sampler 12 inches.

Indicates depth at which groundwater was encountered at the time of drilling.

NOTES:

1) Test holes 1 through 8 and P1 through P3 were drilled on October 27 and 28, 2021 with an all terrain drill rig using 4-inch diameter continuous flight augers. Test holes 9 and 10 were drilled on November 22, 2022 with a truck-mounted CME55 rig using 4-inch diameter continuous flight augers.

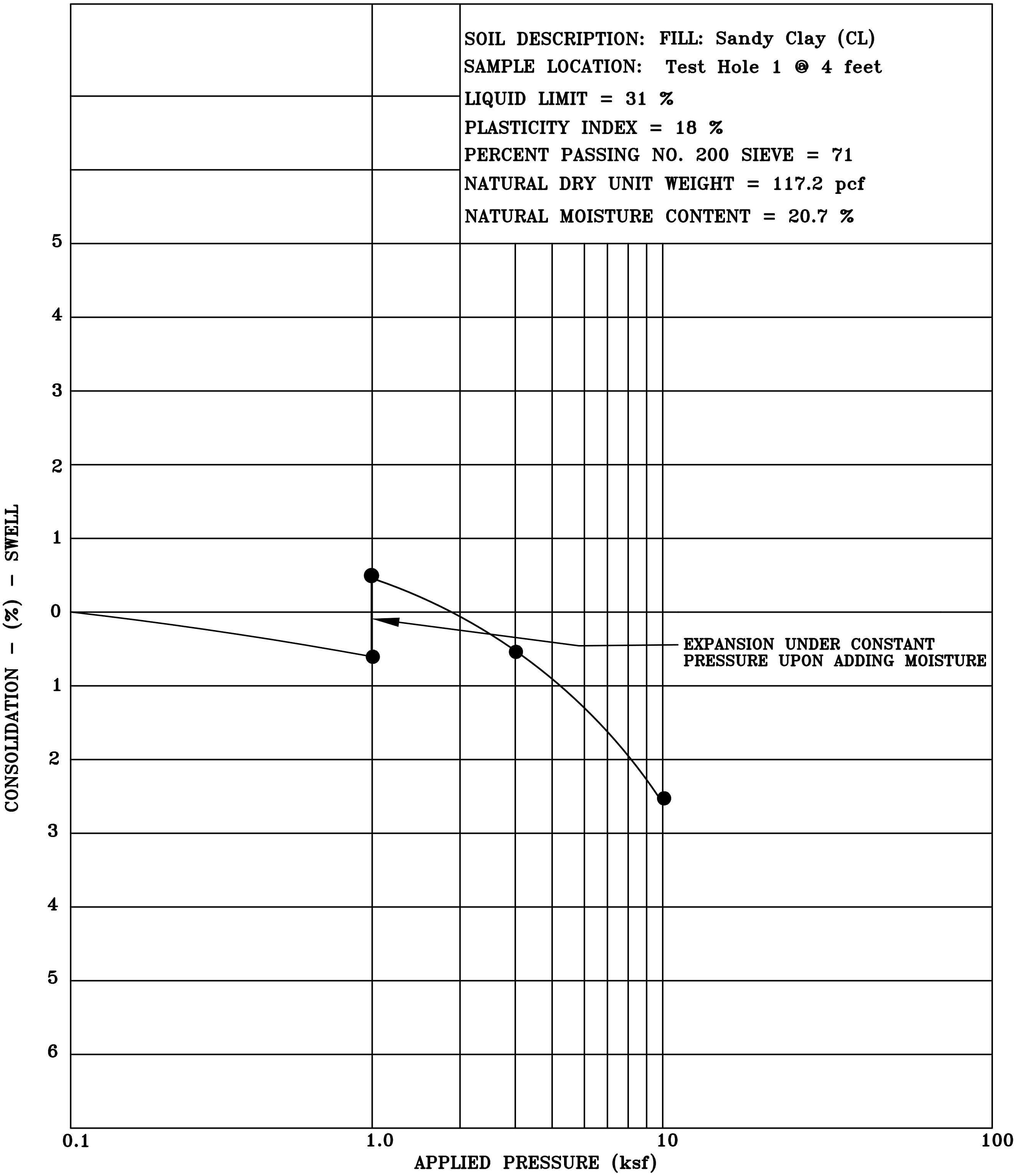
2) Locations of the test holes were determined in the field by pacing from existing features at the site.

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

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

5) The water level readings shown on the logs were made at the time of the investigation and under the conditions indicated. Fluctuations in the water levels will likely occur with time.

Title: LEGEND AND NOTES	Date: 12/14/22	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering • Materials Testing
Job Name: The Amble-Steamboat Grand Phase II	Job No. 21-12448	(970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive • P.O. Box 775226 Steamboat Springs, Colorado 80477
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #7	



Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 11/23/21
Job Name: The Amble–Steamboat Grand Phase II	Job No. 21–12448
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #8

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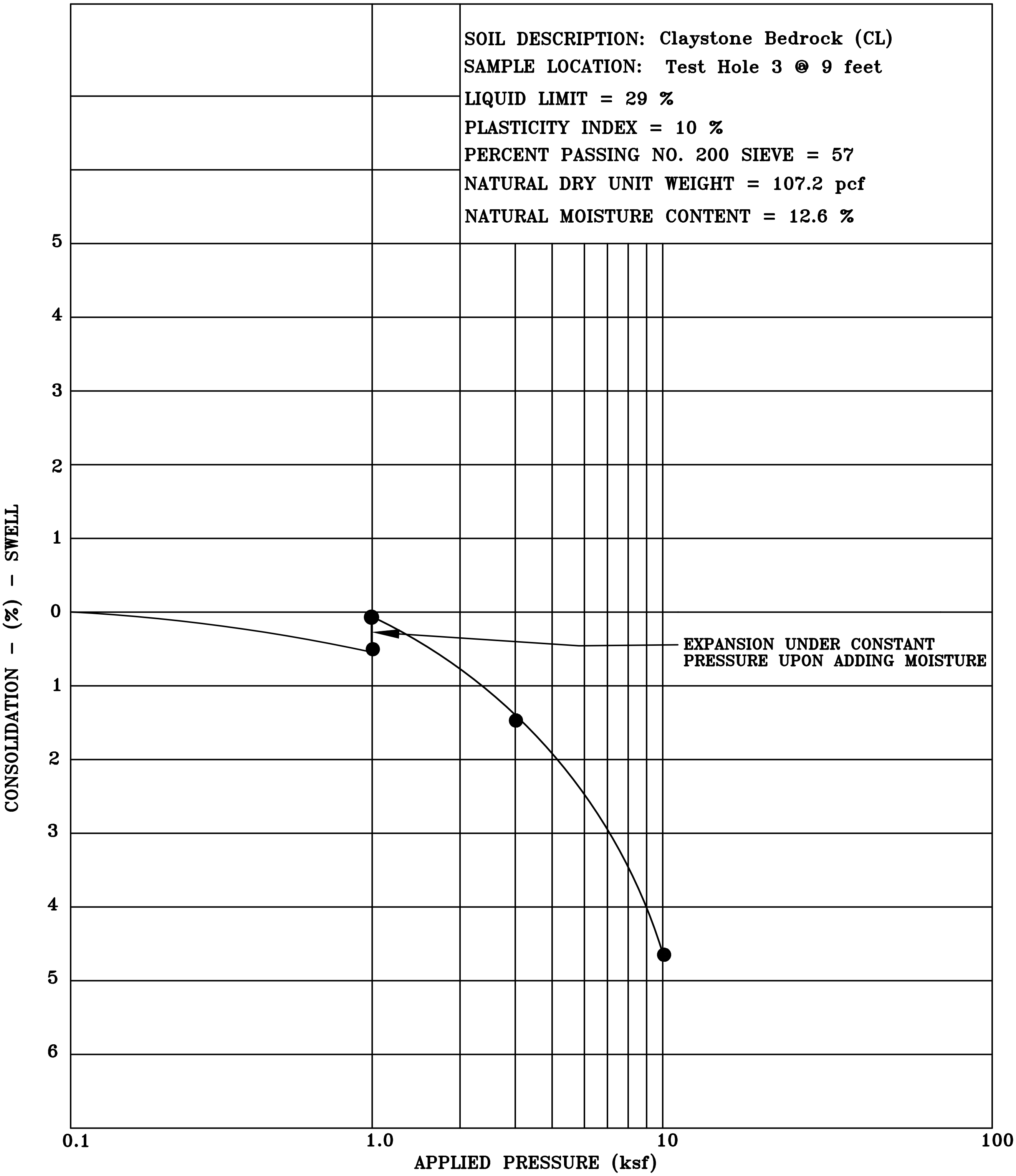
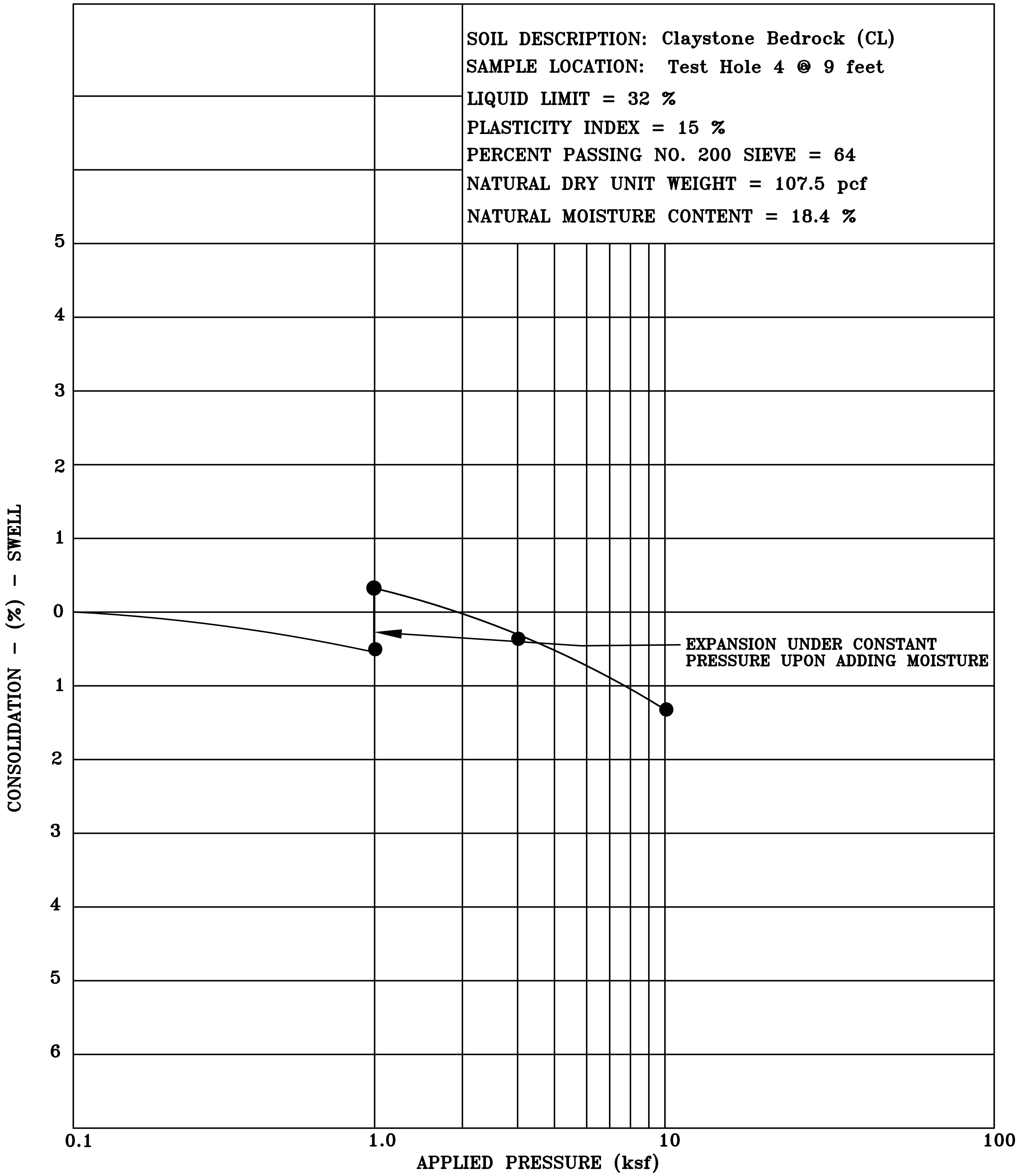


Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 11/23/21	NWCC North West Colorado Consultants, Inc.
Job Name: The Amble–Steamboat Grand Phase II	Job No. 21–12448	Geotechnical / Environmental Engineering • Materials Testing
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #9	(970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487



Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 11/23/21
Job Name: The Amble–Steamboat Grand Phase II	Job No. 21–12448
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #10

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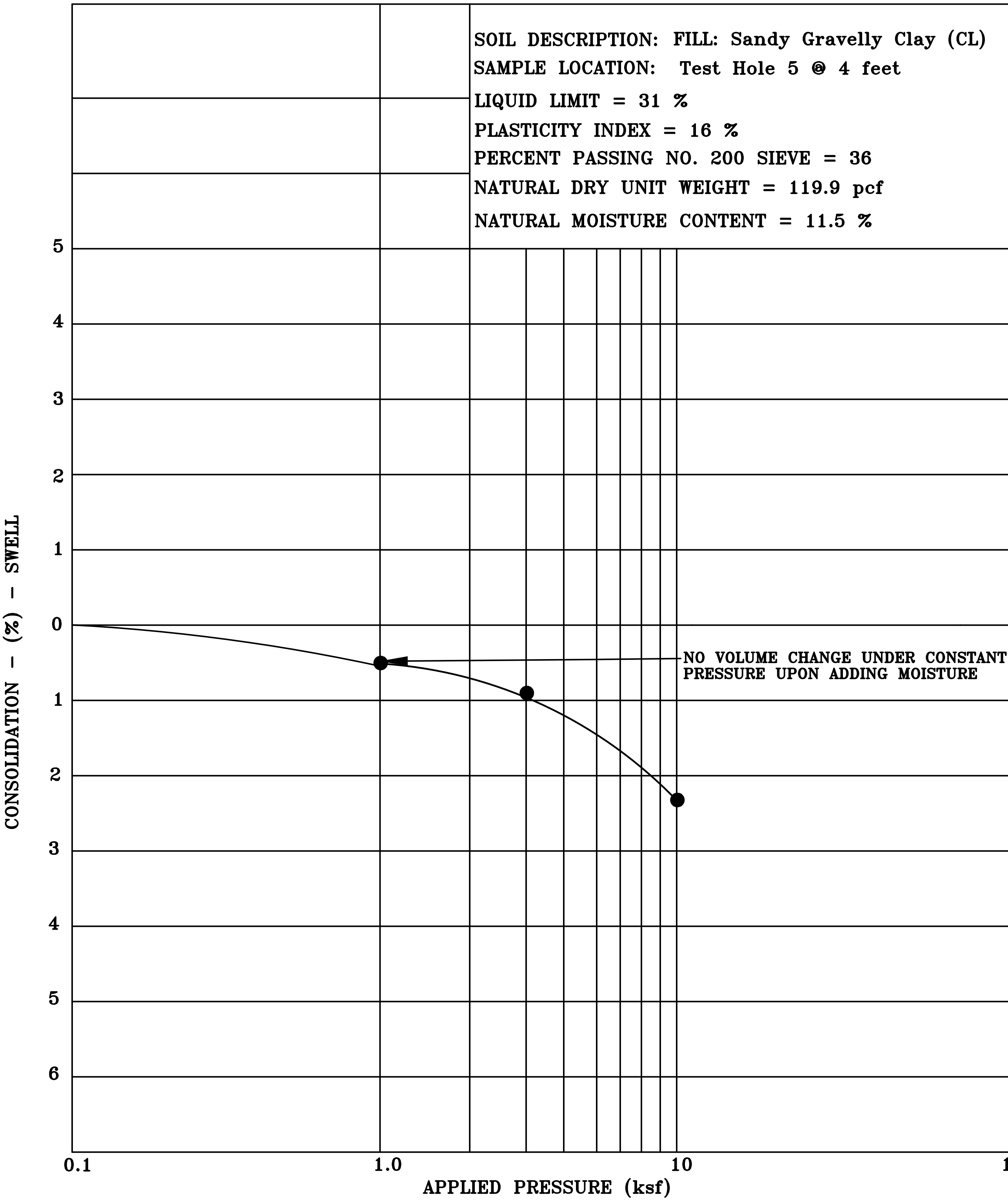

Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 11/23/21
Job Name: The Amble–Steamboat Grand Phase II	Job No. 21–12448
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #11

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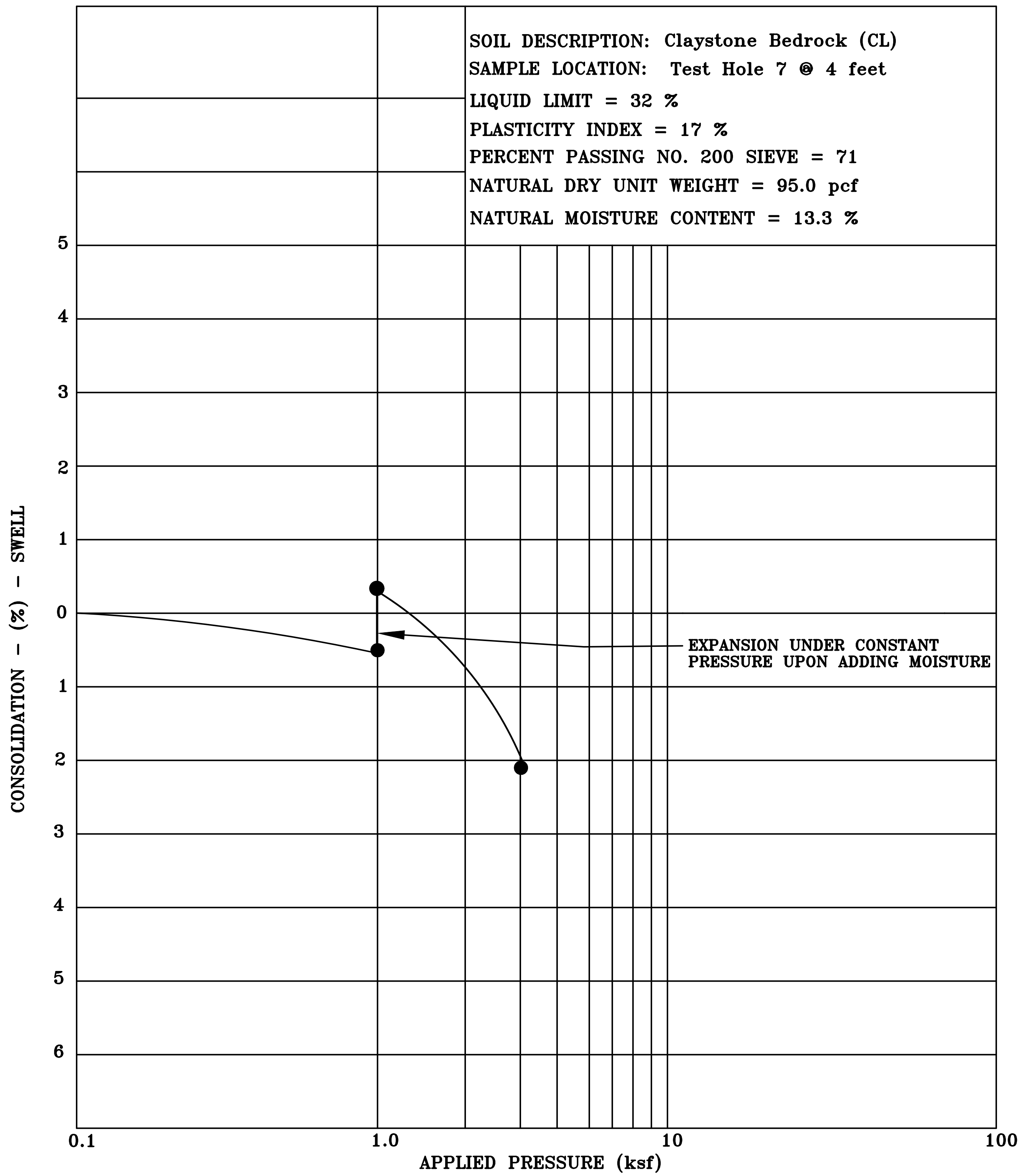

Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 11/23/21
Job Name: The Amble–Steamboat Grand Phase II	Job No. 21–12448
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #12

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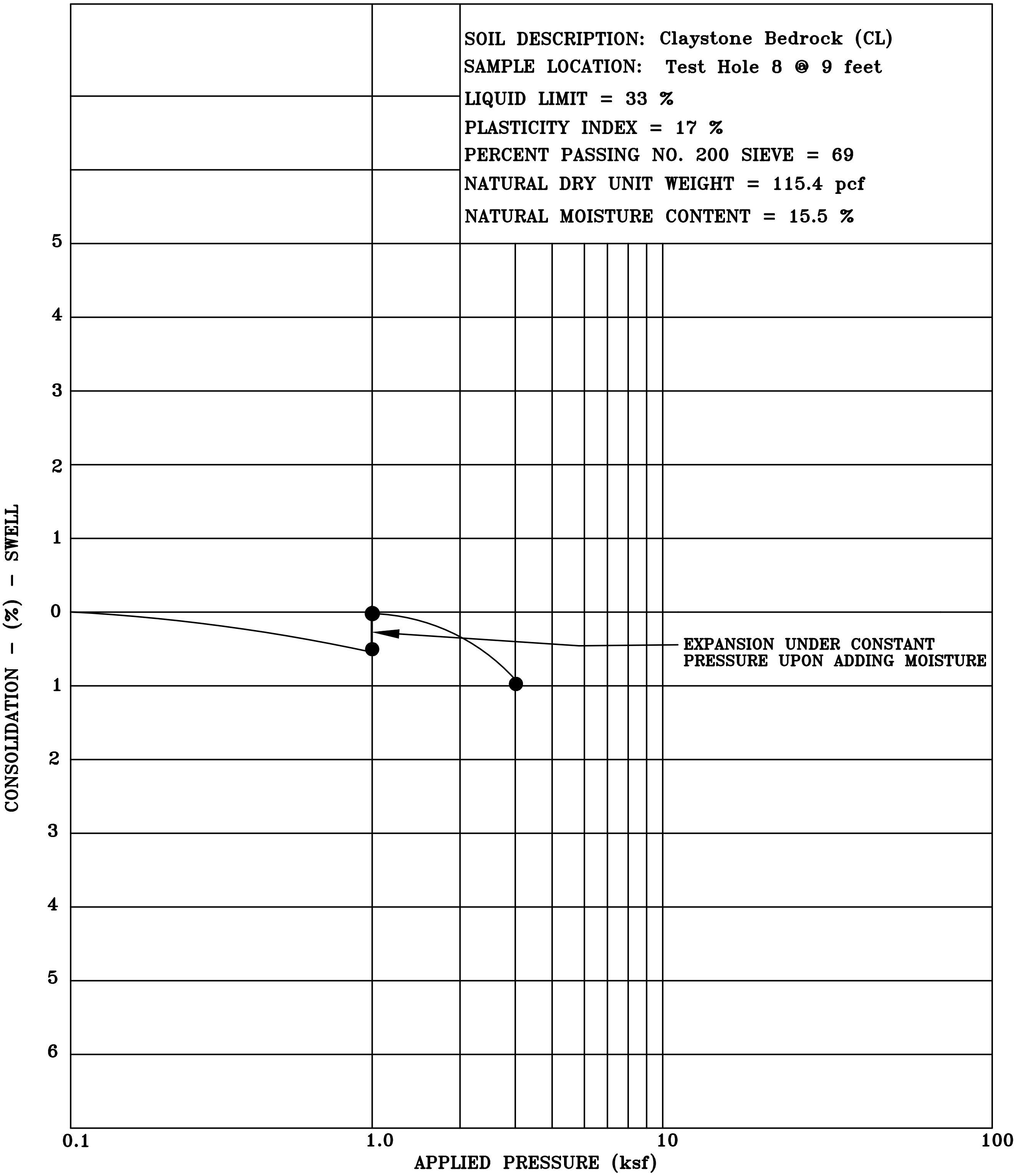

Title: SWELL−CONSOLIDATION TEST RESULTS	Date: 11/23/21		
Job Name: The Amble−Steamboat Grand Phase II	Job No. 21−12448		
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #13		

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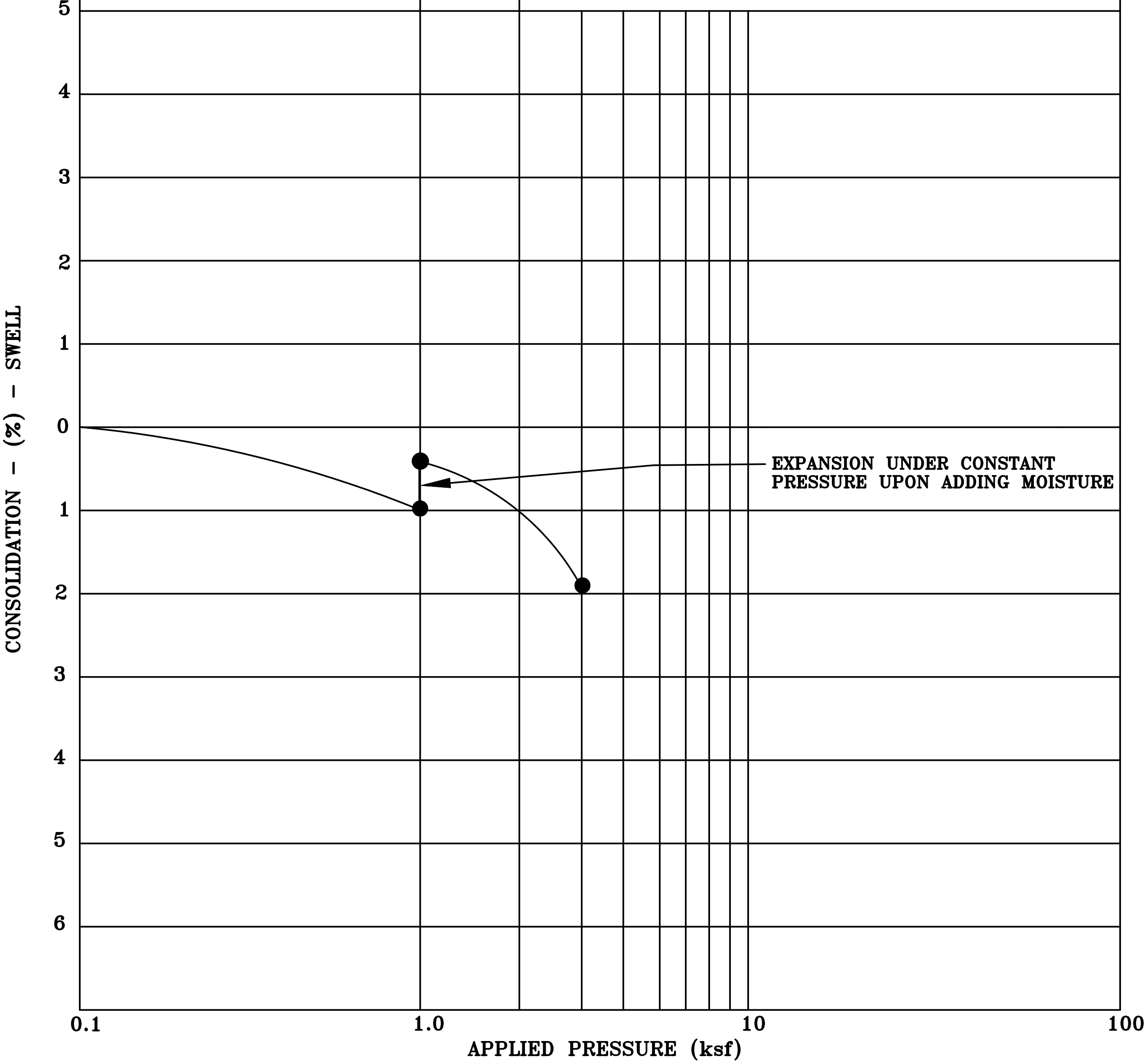
SOIL DESCRIPTION: Sandstone Bedrock (SC)
SAMPLE LOCATION: Test Hole 9 @ 9 feet
LIQUID LIMIT = 36 %
PLASTICITY INDEX = 19 %
PERCENT PASSING NO. 200 SIEVE = 45
NATURAL DRY UNIT WEIGHT = 112.9 pcf
NATURAL MOISTURE CONTENT = 15.6 %



Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 12/19/22		
Job Name: The Amble–Steamboat Grand Phase II	Job No. 21–12448		
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #14		

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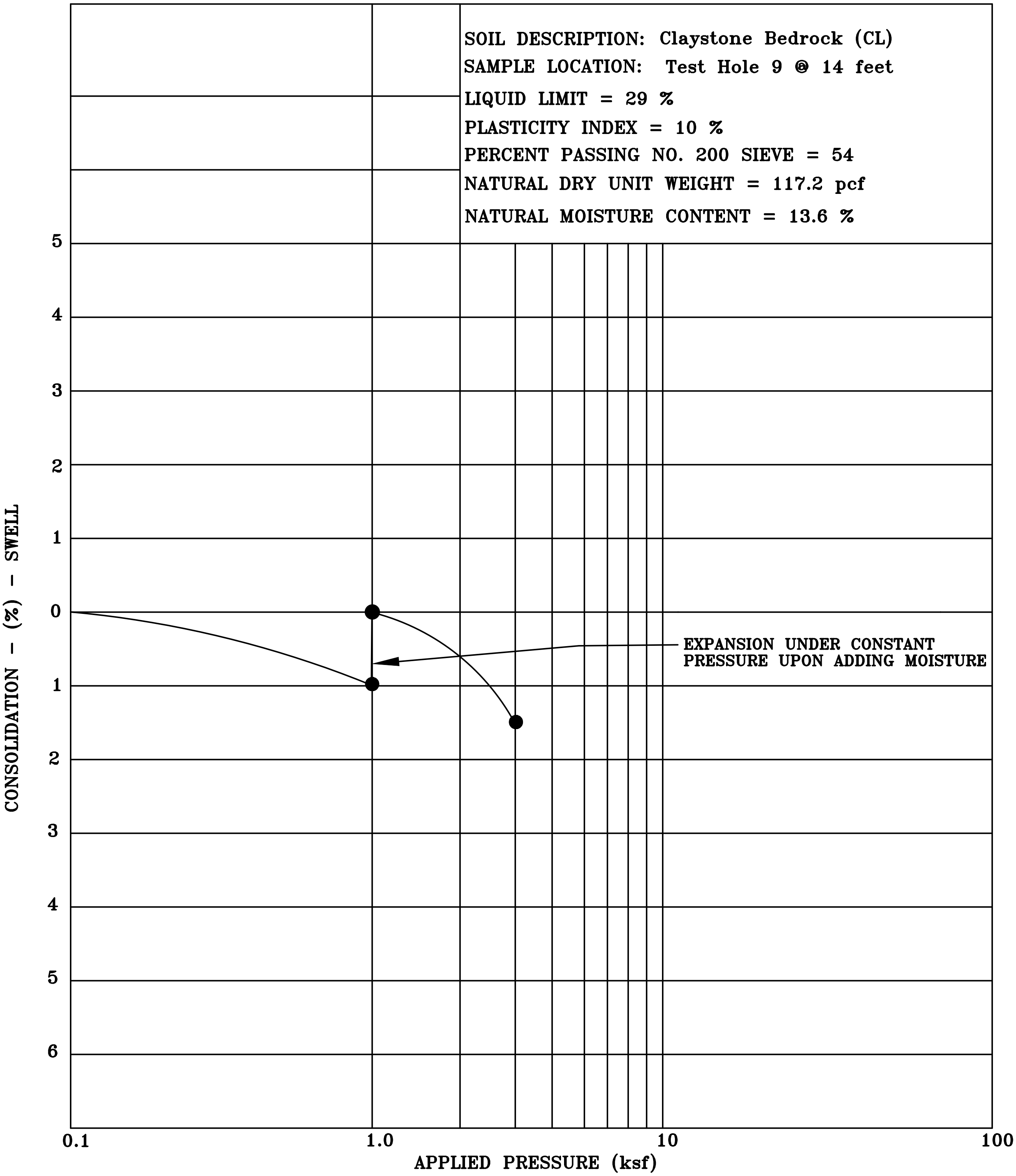
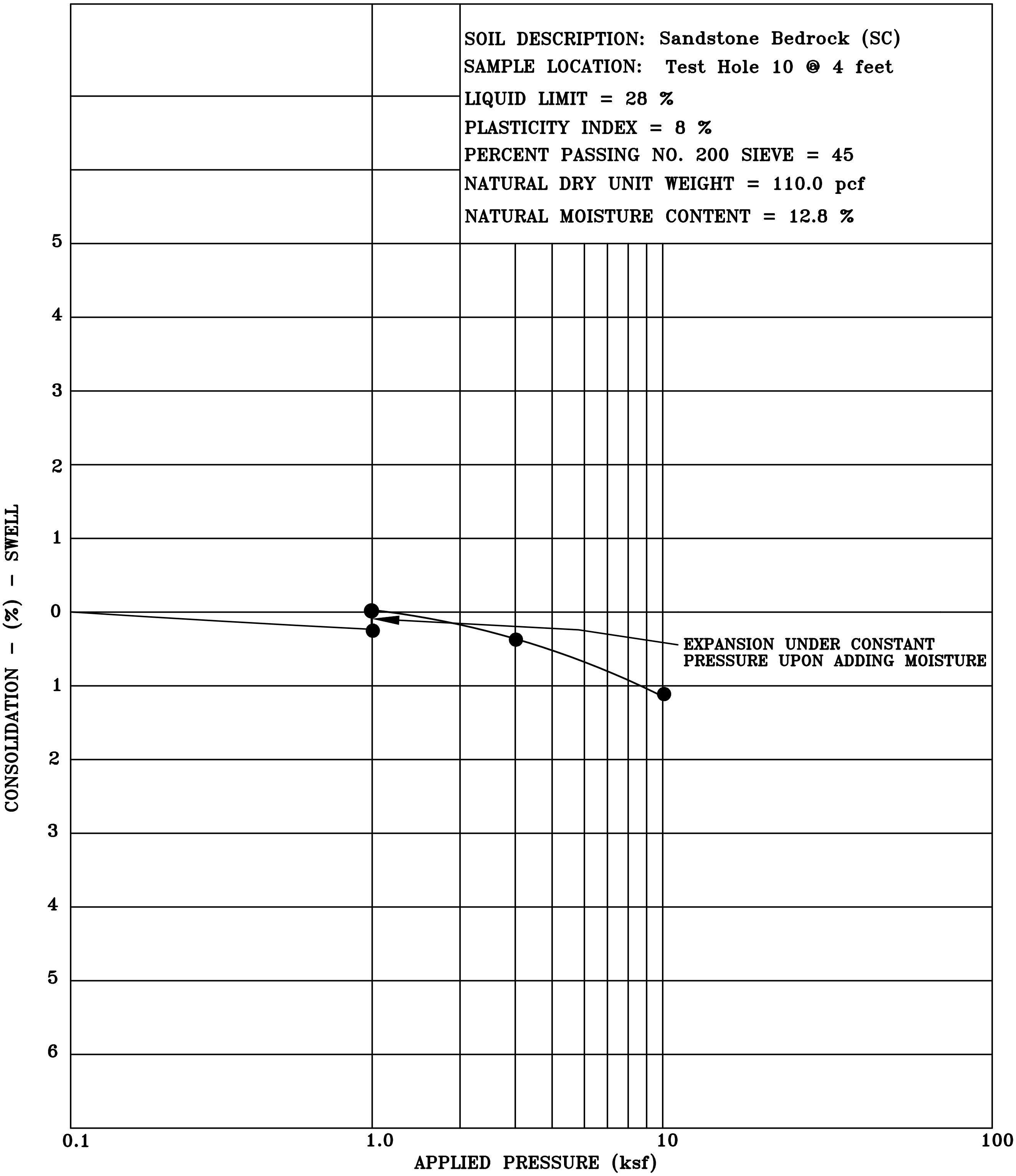


Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 12/19/22	NWCC North West Colorado Consultants, Inc.
Job Name: The Amble–Steamboat Grand Phase II	Job No. 21–12448	Geotechnical / Environmental Engineering • Materials Testing
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #15	(970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487



Title: SWELL-CONSOLIDATION TEST RESULTS	Date: 12/19/22
Job Name: The Amble-Steamboat Grand Phase II	Job No. 21-12448
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #16

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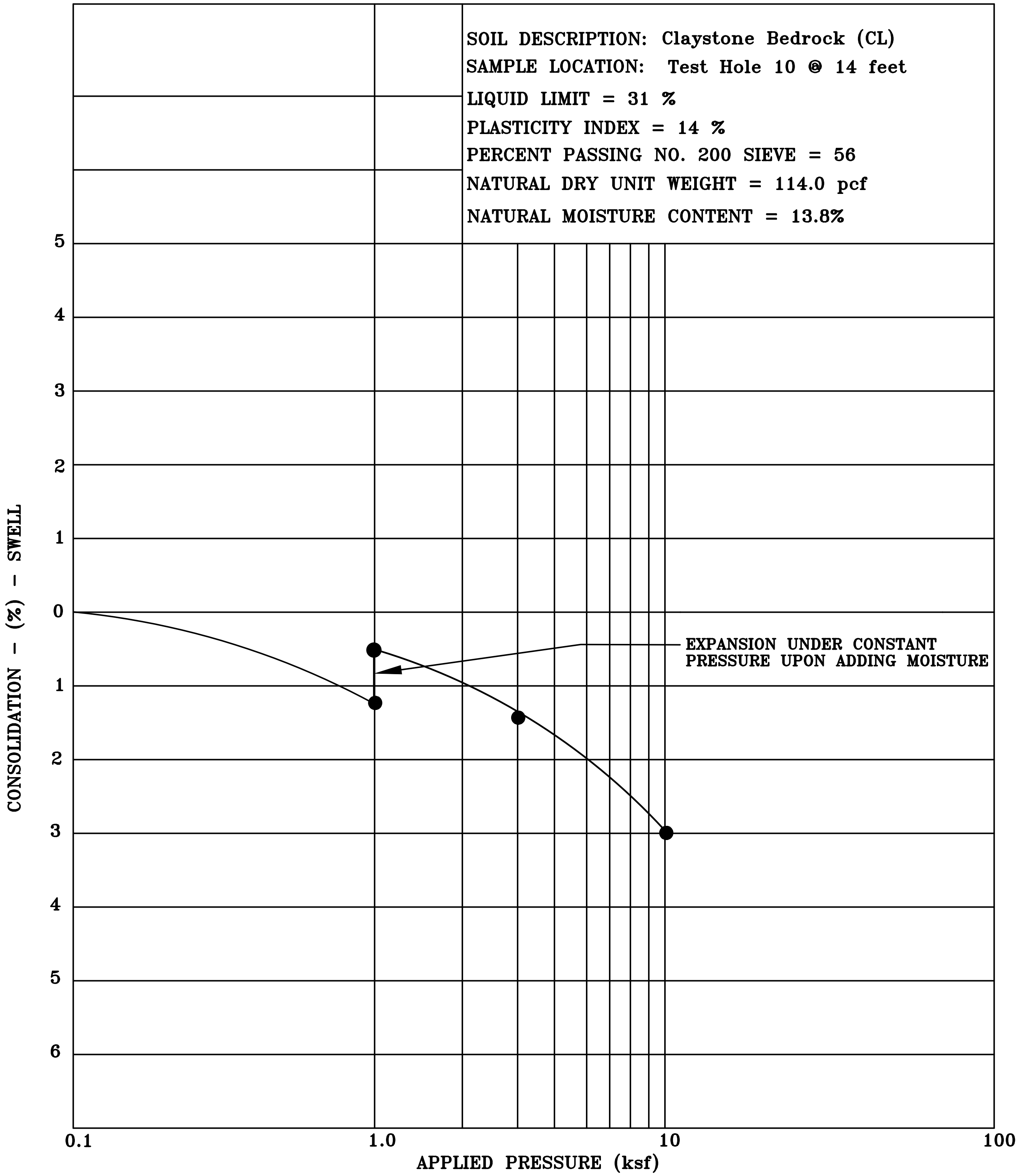
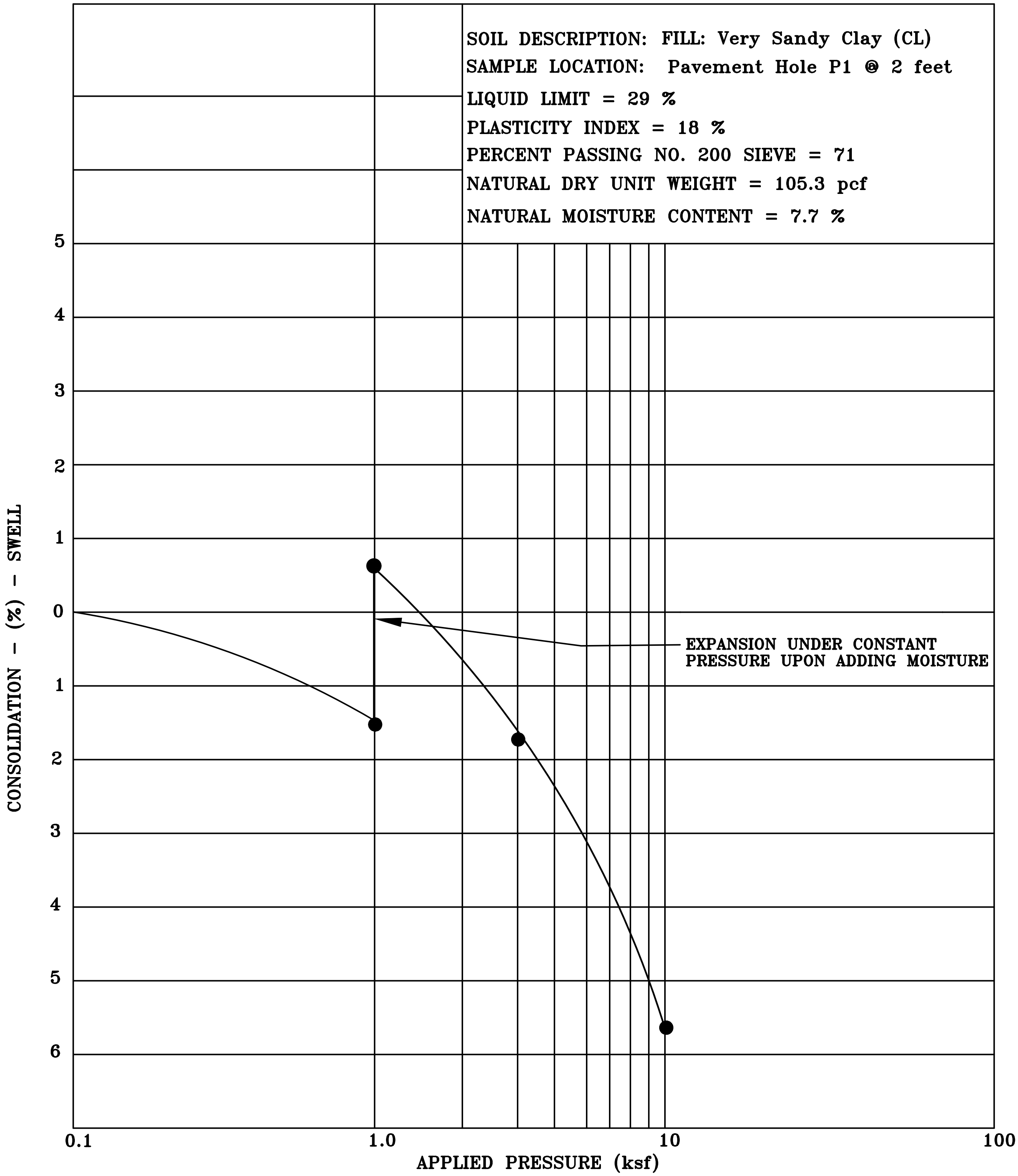


Title: SWELL-CONSOLIDATION TEST RESULTS	Date: 12/19/22	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering • Materials Testing (970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Job Name: The Amble-Steamboat Grand Phase II	Job No. 21-12448	
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #17	



Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 11/23/21		
Job Name: The Amble–Steamboat Grand Phase II	Job No. 21–12448		
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #18		

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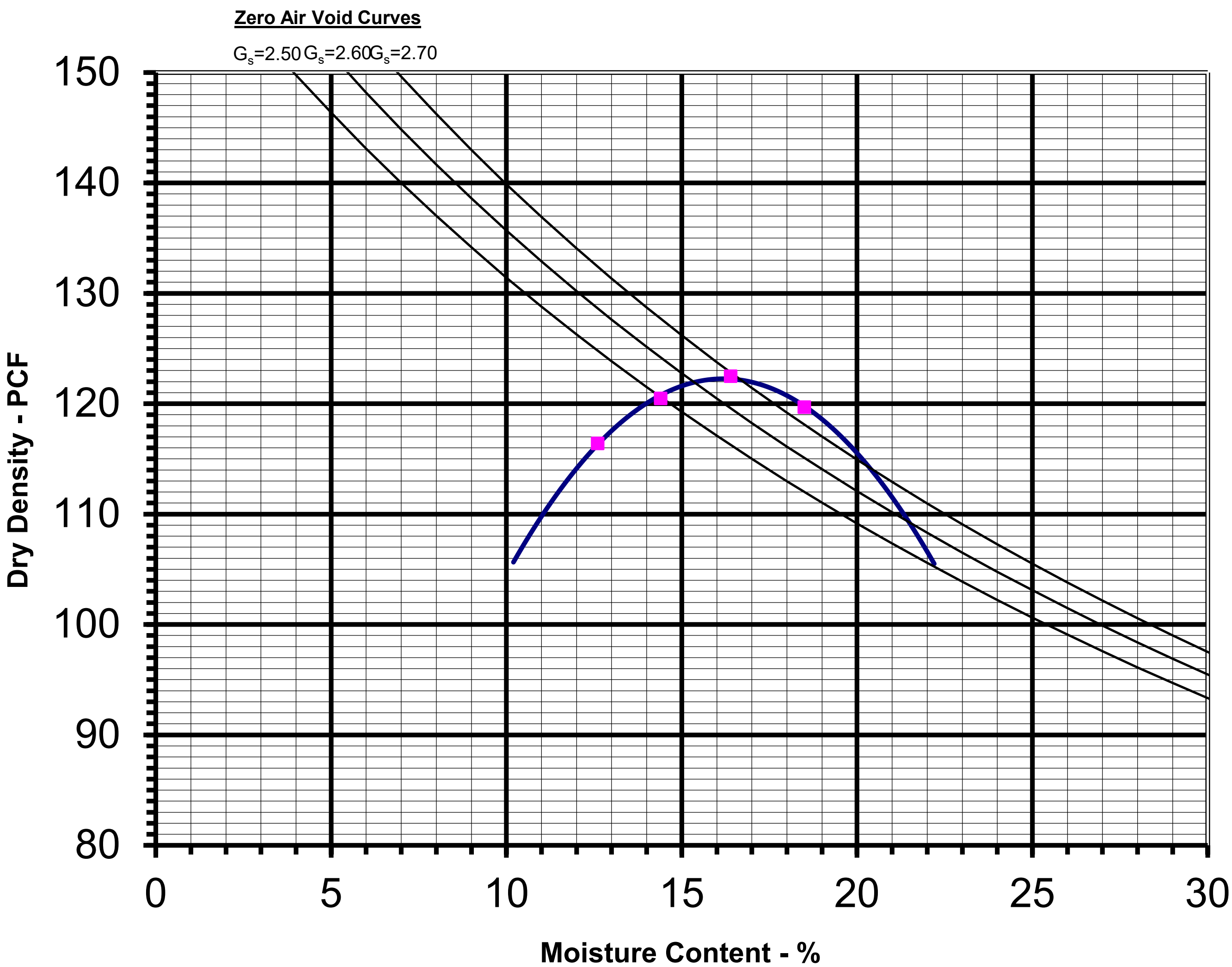

Job Name: The Amble						**PROCTOR TEST RESULTS**	
Sample Location: P1 Bulk							
Soil Description: Sandy Clay						**Figure**	#19
Maximum Dry Density:	122.3 pcf	**Opt. Moisture Content**:	16.2 %			**Procedure**:	ASTM D698
Liquid Limit: 32 **%**		**Plasticity Index**:	19			**Date**:	11/10/2021
Gravel: 0 **%**	**Sand**: 25 **%**	**Silt & Clay (-200)**:	75 %			**Job No**: 21-12448	**Tech**: RE

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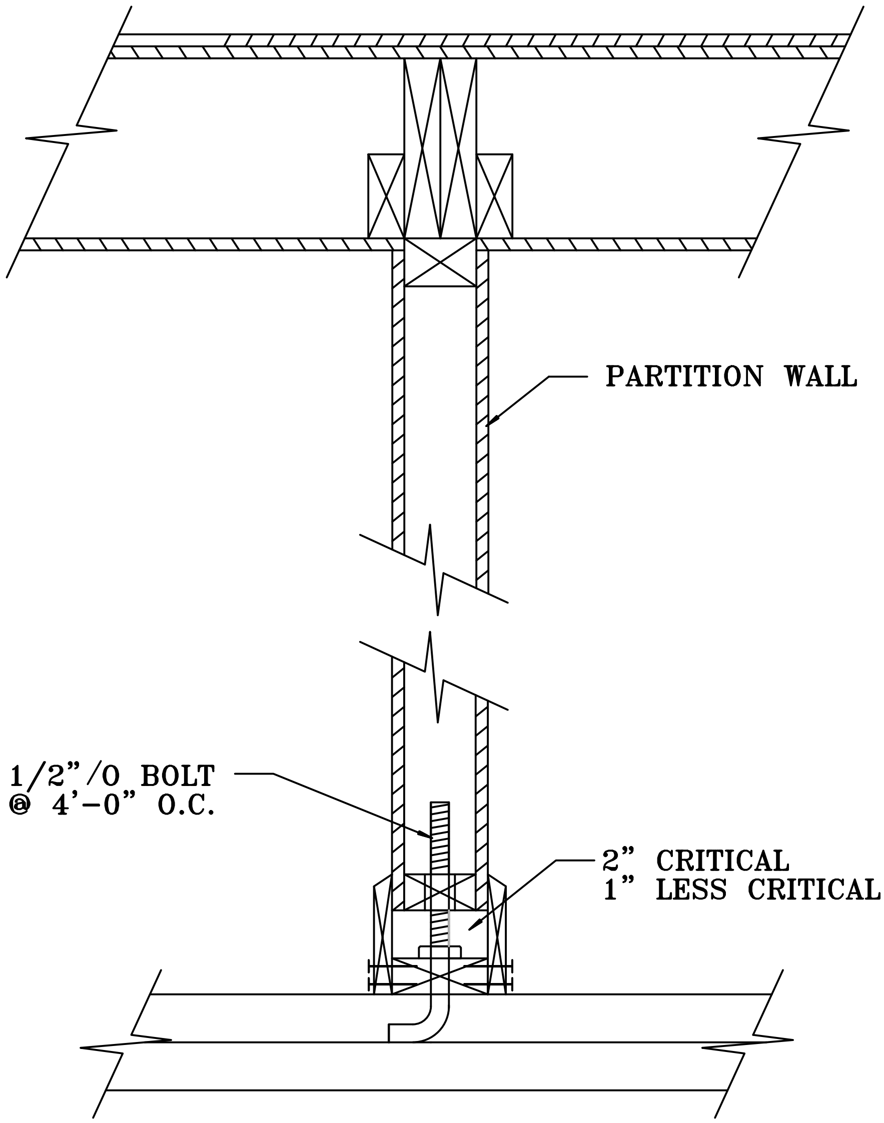
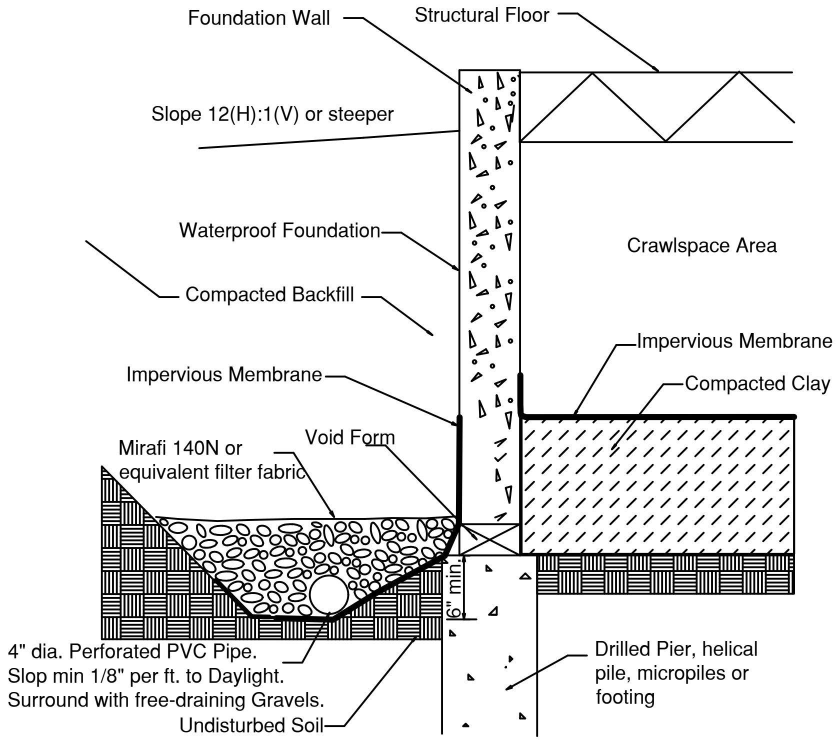
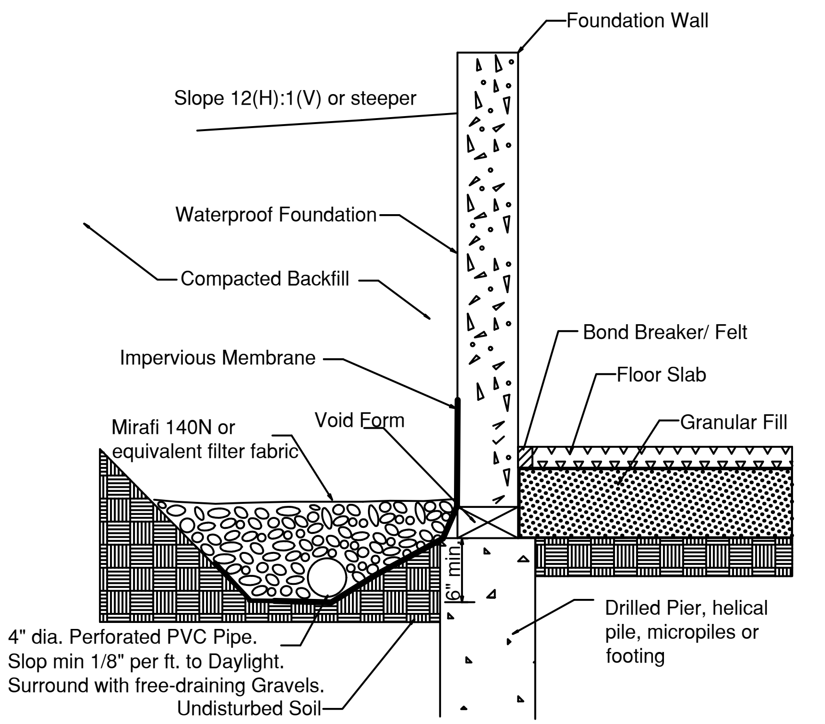


Title: HUNG PARTITION WALL DETAIL	Date: 12/19/22	NWCC North West Colorado Consultants, Inc.
Job Name: The Amble-Steamboat Grand Phase II	Job No. 21-12448	Geotechnical / Environmental Engineering • Materials Testing
Location: Steamboat Grand, Steamboat Springs, Colorado	Figure #21	(970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487



Crawlspace Area



Lower Level with
Floor Slab

Title: PERIMETER/UNDERDRAIN DETAIL	**Date:** 12/19/22
Job Name: The Amble–Steamboat Grand Phase II	**Job No.** 21–12448
Location: Steamboat Grand, Steamboat Springs, Colorado	**Figure** #22

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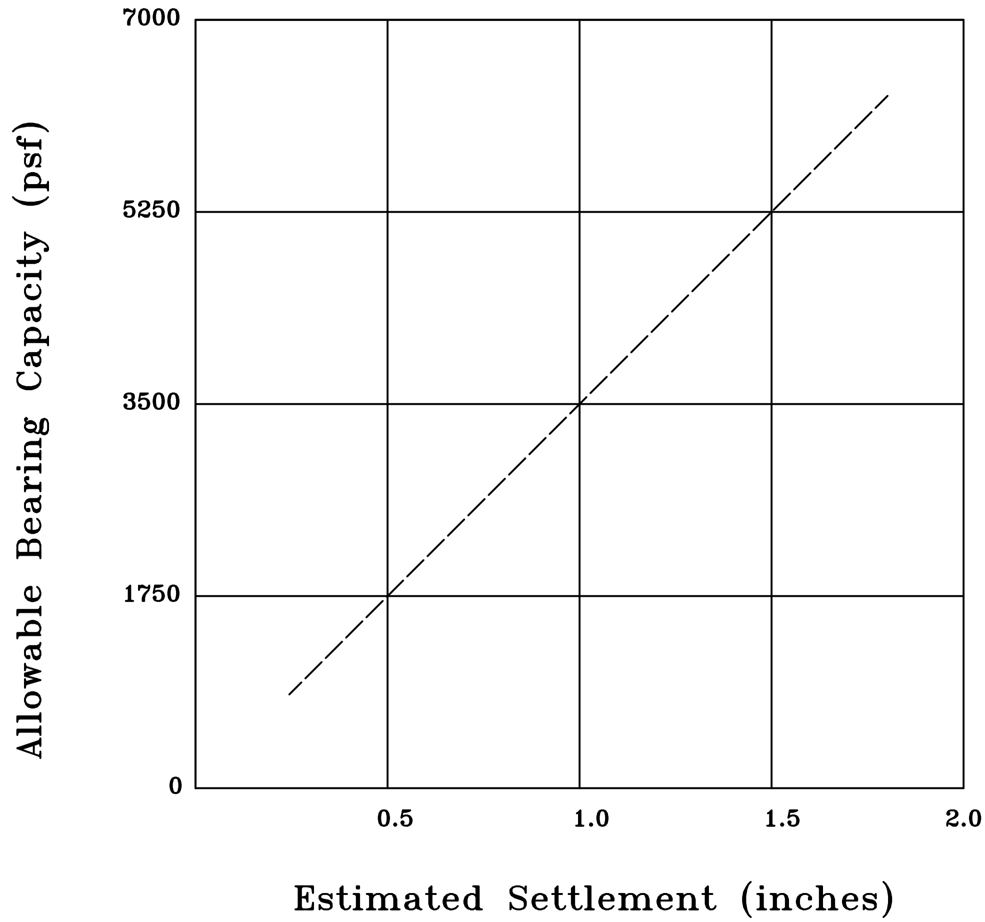

Note: These values are based on footing widths of 1 to 4 feet. If the footing width is to be greater than 4 feet in width, then we should be notified to re-evaluate these recommendations.

Title: BEARING CAPACITY CHART	**Date:** 12/19/22	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering • Materials Testing
Job Name: The Amble-Steamboat Grand Phase II	**Job No.** 21-12448	(970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80477
Location: Steamboat Grand, Steamboat Springs, Colorado	**Figure** #20	

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 HOLE	DEPTH (feet)			LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)				
1	4	20.7	117.2	31	18	1	29	71		FILL: Sandy Clay	CL
2	9	10.8	108.9	30	15	0	32	68	3,200	Claystone Bedrock	CL
3	2	8.2	118.2	32	17	9	36	55		FILL: Slightly Gravelly Very Sandy Clay	CL
3	9	12.9	107.2	29	10	0	43	57		Claystone Bedrock	CL
4	9	18.4	107.5	32	15	0	35	65		Claystone Bedrock	CL
5	4	11.5	119.9	31	16	35	29	36		FILL: Sandy Gravelly Clay	CL
5	19	14.3	106.2	31	15	0	31	69	4,750	Claystone Bedrock	CL

JOB NUMBER: 21-12448

NWCC, Inc.

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT	NATURAL DRY DENSITY	ATTERBERG LIMITS		GRADATION		PERCENT PASSING No. 200 SIEVE	UNCONFINED COMPRESSIVE STRENGTH (PSF)	SOIL or BEDROCK DESCRIPTION	UNIFIED SOIL CLASS.
TEST HOLE	DEPTH (feet)	(%)	(pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)				
6	9	18.1	109.8	35	18	0	27	73		Sandy Clay	CL
7	4	13.3	95.0	32	17	0	29	71		Claystone Bedrock	CL
8	9	15.5	115.4	33	17	0	31	69		Claystone Bedrock	CL
P1	0–5	16.2*	122.3*	32	19	0	25	75		FILL: Sandy Clay	CL
P1	2	7.7	105.3	29	16	4	38	58		FILL: Very Sandy Clay	CL
P2	9	14.9	117.5	30	13	0	26	74	14,300	Claystone Bedrock	CL
P3	2	22.7	99.1	46	25	0	13	87	4,650	Sandy Clay	CL

*Indicates optimum moisture contend and maximum dry density determined in accordance with ASTM D698.

JOB NUMBER: 21–12448

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 HOLE	DEPTH (feet)			LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)				
9	9	15.6	112.9	36	19	0	55	45		Sandstone Bedrock	SC
9	14	13.6	117.2	29	10	0	46	54		Claystone Bedrock	CL
10	4	12.8	110.0	28	8	0	55	45		Sandstone Bedrock	SC
10	14	13.8	114.0	31	14	0	44	56		Claystone Bedrock	CL

JOB NUMBER: 21-12448

NWCC, INC.

TABLE 2

SUMMARY OF CORROSION TEST RESULTS

SAMPLE LOCATION		OPTIMUM MOISTURE CONTENT (%)	WATER SOLUBLE SULFATES (%)	PH	CHLORIDE CONTENT (%)	MINIMUM ELECTRICAL RESISTIVITY (ohm−cm)
SAMPLE	DEPTH (feet)					
TH−2	2−14'	16.2	<0.01	7.86	0.002	1,100

JOB NUMBER: 21−12448