AGEC
Applied GeoTech

GEOTECHNICAL INVESTIGATION

BURKE SPRINGS, PHASE 2

WASHINGTON, UTAH

PREPARED FOR:

JEFF CURTIS
10264 SOUTH JORDAN CREEK DRIVE
SOUTH JORDAN, UTAH 84095

PROJECT NO. 2213124

MAY 2, 2022

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SUMMARY

1. The subsurface profile observed within the borings generally consists of shale to siltstone bedrock with interlayered zones of sandstone to the maximum depth investigated, approximately 24½ feet. Occasional zones of mudstone bedrock were also observed within the borings. Near surface silty sand was observed to overly the bedrock in a preliminary report previously prepared for the project.

2. Groundwater was encountered perched on low permeable bedrock layers throughout the borings at various depths. Fluctuations of groundwater levels may occur over time. An evaluation of such fluctuations over time is beyond the scope of this report.

3. We anticipate that groundwater could develop and exist in a perched condition due to shallow bedrock as a result of water introduced through development. Therefore, landscaping requiring water should be minimized. It may be necessary to install a cut off drains along portions of the project. AGEC previously provided groundwater cutoff drain recommendations under Project Number 2213124, dated December 14, 2021.

4. The on-site soils, in their existing condition, are not suitable to support the proposed construction. The site is suitable for the proposed construction provided recommendations within this report are followed.

5. Laboratory testing indicates the underlying bedrock is non-expansive when wetted in its existing condition, but contains occasional relatively high plastic layers of mudstone bedrock which exhibit expansive characteristics. The mudstone bedrock should be removed and disposed of if encountered during grading.

6. Our testing from the preliminary report also indicates that processed bedrock will exhibit moderately to moderate to high expansive characteristics if used as fill and compacted in its existing moisture content.

7. The proposed residences may be supported on conventional spread and spot footings bearing on properly compacted structural fill underlain by a properly prepared subgrade.

8. The on-site silty sand and properly processed shale, siltstone and sandstone bedrock, free of organics, debris and material greater than 4 inches in size, are suitable for use as site grading fill, structural fill, wall backfill and utility trench backfill provided they are properly moisture conditioned, processed and compacted. The mudstone bedrock is not suitable for use as fill in structural areas and should be discarded off site or placed in non-structural areas.

9. This report does not address swimming pool support. Support of proposed pools should addressed with a lot specific subsurface investigation and report to provide pool support recommendations.

10. To reduce the risk of movement of site improvements (flatwork, block walls, etc.), precautionary measures including strict site drainage and desert landscaping should be implemented as recommended in the site drainage section of this report.

11. Detailed recommendations for subgrade preparation, materials, foundations, and drainage are included in the report.

12. The information provided in this summary should not be used independent of that provided within the body of this report.

SCOPE

This report presents the results of a geotechnical investigation for the proposed Burke Springs, Phase 2 to be located in Washington, Utah, as shown in Figure 1. This report presents the subsurface conditions encountered, laboratory test results, and recommendations for the project. This report was prepared in general accordance with the Proposal for Professional Geotechnical Services dated April 19, 2022 under Project No. 2213124.

Field exploration was conducted to obtain information on the subsurface conditions and to obtain samples for laboratory testing. Information obtained from the field and laboratory was used to define conditions at the site and to develop recommendations for the proposed development. AGEC previously prepared a preliminary geotechnical report for the site in a report dated August 2, 2021 under AGEC Project No. 2210795. A groundwater cutoff drain consultation was also provided by AGEC in a report dated December 14, 2021. Information from the preliminary report was used during preparation of the current report.

This report has been prepared to summarize the data obtained during the study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction are included in the report.

SITE CONDITIONS

The site consists of approximately 10 acres. The property slopes generally from the northwest down to the southeast. Several ephemeral washes traverse the project site with significant elevation undulations. The site is vegetated with desert grass and brush with groups of larger trees and heavy vegetation in areas where springs or groundwater seeps exist. An existing residence is located on the south of the site. Access to the project site is provided by View Point Drive on the northwest and by Leora Drive on the south. The site is bounded on the north by vacant parcels that are currently being developed, on the south and west by existing residences, and on the east by existing residences and a detention area.

FIELD STUDY

On February 28 and March 24, 2022, an engineer from AGEC visited the site and observed the drilling of 8 borings for the current scope of work at the approximate locations shown on Figure 2. The borings were drilled following grading (cutting) at the site and were drilled in areas where the cut depths exceeded the depths of the test pits which were excavated for the referenced preliminary report. The borings were drilled with 8-inch diameter hollow-stem augers. The borings were advanced into the bedrock with a 2½ inch HQ core barrel with diamond bit and compressed air to remove cuttings. The subsurface soil profile was logged and soil samples were obtained at this time for laboratory testing.

SUBSURFACE CONDITIONS

The subsurface profile observed within the borings generally consists of shale to siltstone bedrock with interlayered zones of sandstone to the maximum depth investigated, approximately 24½ feet. Occasional zones of mudstone bedrock were also observed within the borings.

Detailed descriptions of the bedrock types encountered follow:

Mudstone Bedrock - The mudstone bedrock is moderately hard, dry to wet, and purple in color.

Laboratory tests conducted on samples of the mudstone bedrock indicate gravel contents (percent retained on the No. 4 sieve) ranging from 1 to 3 percent, and fines contents (percent passing the No. 200 sieve) ranging from 34 to 70 percent. Atterberg Limits tests indicate liquid limits ranging from 34 to 40 percent and plasticity indices ranging from 16 to 21 percent.

Shale Bedrock - The shale bedrock is soft to moderately hard, slightly moist to moist, low to medium plastic, and is reddish brown to grey in color.

Laboratory tests conducted on samples of the shale bedrock indicate in-place moisture contents ranging from 3 to 8 percent, in-place dry densities ranging from 142 to 153 pounds per cubic foot (pcf), gravel contents ranging from 0 to 6 percent, and fines contents (percent passing the No. 200 sieve) ranging from 56 to 85 percent. Atterberg Limits tests indicate liquid limits ranging from 25 to 36 percent and plasticity indices ranging from 8 to 15 percent.

One-dimensional consolidation tests conducted on a relatively undisturbed samples of the shale bedrock indicate it is non-moisture sensitive when wetted under a constant pressure of approximately 1,000 psf and slightly compressible under additional loading.

Siltstone Bedrock - The siltstone bedrock is moderately hard, dry to wet, non- to low-plastic, and is red in color.

Laboratory tests conducted on samples of the siltstone bedrock indicate an in-place moisture contents ranging from 5 to 9 percent, gravel contents ranging from 0 to 2 percent, and fines contents ranging from 50 to 85 percent. Atterberg Limits tests indicate Liquid Limits ranging from 22 to 30 percent and Plasticity Indices ranging from non-plastic to 7 percent.

<u>Sandstone Bedrock</u> - The sandstone bedrock is moderately hard, dry to wet, and red in color.

Laboratory tests conducted on samples of the sandstone bedrock indicate a gravel content of 1 percent and a fines content of 36 percent. An Atterberg Limits test indicates a Liquid Limit 22 percent and a Plasticity Index 3 percent.

The Logs, Legend and Notes of Borings are shown on Figures 3 and 4. Results of the laboratory tests are also shown on Figures 3 and 4 and are summarized in the Summary of Laboratory Test Results, Table 1. The consolidation/swell test results are shown graphically on Figures 5-6. Test Pit logs from previous study are included in Appendix I of this report.

SUBSURFACE WATER

Groundwater was encountered perched on low permeable bedrock layers throughout the borings at various depths. Fluctuations of groundwater levels may occur over time. An evaluation of such fluctuations over time is beyond the scope of this report.

PROPOSED CONSTRUCTION

The site will be developed for construction of a residential subdivision containing 30 lots. Slab on grade, wood framed residences will be constructed. The development will also include interior asphalt roadways with 50 foot right-of-ways (ROW), utilities and site improvements. As per the City of Washington specifications, a Traffic Index (TI) of 5 was used for design purposes.

If the proposed construction, or building loads are significantly different from those listed, we should be notified so that we can reevaluate our recommendations.

RECOMMENDATIONS

Based on our experience in the area, the subsurface conditions encountered, laboratory test results, and the proposed construction, the following recommendations are given:

A. **Site Grading**

1. Subgrade Preparation

   a. *General Subgrade Preparation*

   At the time of this report, the building pads and roadway areas had been graded. Prior to placing fill or concrete beneath building areas, pavement/flatwork or improvements, the site should be scarified and compacted to meet the recommendations given in the Compaction section of this report.

   b. Building Pads and Flatwork - Cut Areas

   The proposed residences may be supported directly on, or on structural fill extending to the underlying shale, siltstone or sandstone bedrock. The full depth of mudstone bedrock should be removed from building pad areas if it encountered during building pad excavation.

   Consideration should also be given to full depth overexcavation to beneath hard surfaces and CMU fences.

   The limits of overexcavation should extend at least 5 feet beyond the perimeter of the proposed construction. The lateral extent of the overexcavation should be determined by survey and is the responsibility of the owner/contractor.

c. *Building Pad, Flatwork and Pavement - Fill Areas*

Prior to placing fill, the loose and dry on-site soils should be overexcavated to expose the underlying shale, siltstone or sandstone bedrock. The removed soils, free of organics and particles greater than 4 inches, may be placed in fill areas provided it is processed such that the moisture content is 0 to 2 percent above the optimum moisture content as determined by ASTM D-1557.

Shale, siltstone and sandstone bedrock may be placed in fill areas provided they are processed such that the moisture content is 4 to 6 percent above the optimum moisture content as determined by ASTM D-1557. Particle sizes should not exceed 4 inch in size prior to and during mixing.

The full depth of mudstone bedrock should be removed from building pad areas if it encountered during building pad excavation.

d. *Pavement, Flatwork and Improvements*

Subsequent to grubbing and prior to placing site grading fill or road base in pavement areas, a portion of the underlying collapsible silty sand soil should be removed. As a minimum, we recommend the exposed subgrade beneath pavement, flatwork and improvement areas be prepared by over excavating a minimum of 2 feet below existing grade or 1 foot below the proposed subgrade (whichever is greater) prior to placing fill or road base. The removed soil may then be replaced in properly moisture conditioned and compacted lifts.

Pavement and flatwork may be supported directly on the underlying the underlying shale, siltstone or sandstone bedrock. The full depth of mudstone bedrock should be removed from pavement and flatwork areas if it encountered during grading.

Subsequent to overexcavation and prior to placing fill, the exposed subgrade should be scarified to a depth of approximately 8 inches, properly moisture conditioned and compacted to meet the recommendations provided in the compaction section of this report. Scarification is not necessary if the subgrade consists of bedrock

2. Excavation

We anticipate that excavation of the overburden soils and soft bedrock at the site can be accomplished with typical excavation equipment. Portions of deeper, hard bedrock may require the use of heavy duty excavation such as a single tooth ripper or a hydraulic hammer. Groundwater could be present in excavations which extend into the bedrock and dewatering may be required.

3. Grading Slopes and Trenches

The following table summarizes recommendations for excavation of temporary and permanent cut slope excavations, trench excavations and permanent fill slope construction. Slopes should include benches in accordance with the 2018 IBC.

Slope Condition	**Maximum Slope (Horizontal:Vertical)**
Permanent Cut Slopes in Overburden Soils/Soft Bedrock	2:1
Permanent Cut Slopes in Competent Bedrock	¾:1
Permanent Fill Slopes - Compacted fill	2½:1
Utility Trenches in On-site Soils/Soft Bedrock (OSHA Soil Class C)	1½:1*
Utility Trenches in Competent Bedrock(OSHA Soil Class A)	¾:1

*Steeper trenches will require the use of shoring or a trench box to provide a safe work environment. Safe trench excavation is the responsibility of the contractor.

Fill slopes should be graded by overbuilding and then cutting back to the desired grade to provide a compacted slope face. Fill placed on existing slopes steeper than 3:1 should be placed using a benching procedure to key the fill into the existing slope. Benches should be of sufficient width to allow adequate area for the compaction equipment. Slopes should include benches in accordance with the 2018 IBC.

The cut and fill slopes will be highly susceptible to erosion, particularly resulting from run off from the adjacent slopes. Water should be directed around slopes using drainage swales to reduce potential erosion. A lot specific drainage study should be conducted by the civil engineer to control localized runoff.

4. Materials

Import materials should be non-expansive, non-gypsiferous, granular soil. Listed below are the materials recommended for imported fill.

Area	Fill Type	Recommendations
Foundations/slabs	Site grading/ structural fill	**-200** <35%, **LL** <30% Maximum size: 4 inches Solubility < 1%
Underslab (upper 4 inches)	Base course	**-200** <12% Maximum size: 1 inch Solubility < 1%

-200 = Percent Passing the No. 200 Sieve
LL = Liquid Limit

The on-site silty sand, free of organics, debris and material greater than 4 inches in size, is suitable for use as site grading fill, structural fill, wall backfill and utility trench backfill. The shale, siltstone and sandstone bedrock is suitable for use as site grading fill, structural fill, wall backfill and utility trench backfill provided that they are processed such that the maximum particle size is 4 inches and at least 60 percent of the material passes the No. 4 sieve. If layers of the potentially expansive layers of mudstone bedrock are encountered, they should be removed and disposed of off-site.

5. <u>Compaction</u>

Compaction of materials placed at the site should equal or exceed the following minimum densities when compared to the maximum dry density as determined by ASTM D-1557:

Area	**Moisture Content (%)**	**Compaction (%)**
Subgrade	± 2 of w_{opt}	≥ 90
Building Pad - Granular Fill	± 2 of w_{opt}	≥ 95
Building Pad - Processed Bedrock	0 - 4 over w_{opt}	≥ 95
Footings/Foundation Subgrade	± 2 of w_{opt}	≥ 95
Site Grading - Structural Areas	± 2 of w_{opt}	≥ 95
Wall Backfill - Nonstructural	± 2 of w_{opt}	≥ 90
Wall Backfill - Supporting Structure	± 2 of w_{opt}	≥ 95
Utility Trenches	± 2 of w_{opt}	≥ 95

Fill should be placed in loose lift thicknesses which do not exceed the capacity of the equipment being utilized. Generally, 6 to 8-inch loose lifts are adequate. Lift thicknesses should be reduced to 4-inches for hand compaction equipment.

6. Surface Drainage

The following drainage recommendations should be implemented to reduce the potential for wetting of remaining underlying expansive support soils and to reduce the potential for wetting of foundation support soils.

- Positive site drainage away from foundations should be maintained during the course of construction.

- After construction has been completed, positive drainage of surface water away from the residences should be maintained throughout the life of the structures. We recommend a minimum slope of 6 inches in the first 10 feet from the perimeter of the structures.

- Landscaping on the subject site will introduce significant water which will infiltrate below the ground surface. If bedrock is shallow, this could result in accumulation of water at the site. This should be considered when designing the site. It may be necessary to slope the bedrock surface below the site so water does not accumulate or install various cutoff drains to capture water and discharge it off site. Placement of at least 2 feet of fill across landscaped areas and the building/parking (above the bedrock) would be beneficial in providing a zone of soil which will allow for infiltration of surface water.

- Landscaping, which requires minimal water, should be implemented due to the expansive characteristics of the interbedded layers of mudstone bedrock which were encountered within the borings.

- In no case should water be allowed to pond adjacent to foundations.

- Rain gutters should be utilized and roof down spouts should be piped horizontally to discharge away from the residence and preferably off site.

- Below grade portions of walls/fences which are backfilled with soil should be protected with an impermeable membrane and a subsurface drain on the backfilled side of the wall. A gravel covered, perforated PVC pipe should also be placed at the base of the wall to carry water to a discharge point. This is intended to reduce the potential for salt weathering on concrete/masonry.

7. Subsurface Drainage

AGEC previously provided groundwater cutoff drain recommendations under Project Number 2213124, dated December 14, 2021.

8. Low Impact Development (LID)

AGEC has reviewed the *planned areas for surface infiltration areas shown as LID on the grading plans and the Dixie Storm Water Coalition Guide (DSWCG) for Low Impact Development dated June 20, 2020* and provided the following evaluation:

Using the following reference for determining the USDA mapped soil type https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm, a soil type of "EB" or "Eroded Land - Shale Complex, Warm". A Hyrologic Soil Class of D was provided for the site. The subsurface bedrock should be considered impermeable. Our evaluation also used our findings during the geotechnical study for drainage design parameters below.

LID design constraints: Using the DSWCG, Figure 2 (flow chart), and based on the groundwater and soil types and conditions, Step1 is "NO". Shallow bedrock is present across the site. Thus, no BMP's are available. We recommend piping water away from residences to streets or storm drains to localized areas where a suitable BMP may be used.

The subject site and adjacent parcels contain expansive bedrock layers and shallow bedrock across the site. Wetting of these soils could cause ground movement. Also, the bedrock on site will not percolate and allow for water infiltration (USDA report is attached - Appendix II).

The following parameters may be used in the Application-Template form.

Groundwater	
Depth to Groundwater (ft)	Varies Throughout Bedrock
Historical High Depth to Groundwater if known (ft)	> 80 inches
Source	USDA Web Site Ref. above
Groundwater Contamination at Site:	N/A
Soil Information	
Infiltration Rate (in/hr)*	0 (for bedrock)
Infiltration Rate (in/hr)*	0 to 0.2 in/hr (for silty sand)
Hydrologic Soil Group:	D
Source:	USDA Web Site Ref. above
Soil Contamination at Site:	N/A

B. **Foundations**

This report does not address swimming pools. Support of proposed pools should addressed with a lot specific subsurface investigation and report to provide pool support recommendations. Recommendations for design of conventional spread and spot footing are provided below.

1. Bearing Material

   The proposed residences may be supported on conventional spread footings bearing on a properly prepared subgrade. Specifically, the subgrade should be prepared during site grading by overexcavating the building pads to remove unsuitable soils and place properly prepared and compacted fill as recommended in the Subgrade Preparation section of this report.

2. Bearing Pressure

   Footings bearing on properly compacted structural fill may be designed for a net allowable bearing pressure of 2,000 psf.

3. Footing Width and Embedment

   Footings should have a minimum width of 18 inches and should be embedded at least 12 inches below the lowest adjacent grade.

4. Temporary Loading Conditions

   The allowable bearing pressures may be increased by one-half for temporary loading conditions such as wind or seismic loads.

5. Settlement

   We estimate that settlement will be approximately 1 inch for footings designed as indicated above due to the load of the structure. Differential settlement is estimated to be approximately ½ inch.

6. Foundation Base

   The base of excavations should be cleared of loose or deleterious material prior to placement of fill or concrete.

7. Foundation Setback

   Foundations should be set back from the top crest of slopes a horizontal distance equal to or greater than ⅓ the total slope height.

C. **Concrete Slab-on-Grade**

1. Slab Support

Concrete slabs may be supported on a properly prepared subgrade as stated in the Subgrade Preparation section of this report.

2. Underslab Base Course

A 4-inch layer of properly compacted base course should be placed below slabs to provide a firm and consistent subgrade and promote even curing of the concrete.

3. Vapor Barrier

A vapor barrier should be placed below all slab areas due to potential for shallow groundwater. Vapor barriers are especially critical in areas which will receive sensitive floor coverings or coverings which are impermeable. Vapor barriers also provide protection from salt and sulfate attack.

D. **Lateral Earth Pressures**

1. Lateral Resistance for Footings

Lateral resistance for spread footings is controlled by sliding resistance developed between the footing and the subgrade soil. An ultimate friction value of 0.40 may be used in design for ultimate lateral resistance of footings bearing on properly compacted structural fill or bedrock.

2. Retaining Structures

The following equivalent fluid weights are given for design of subgrade walls and retaining structures. The active condition is where the wall moves away from the soil. The passive condition is where the wall moves into the soil and the at-rest condition is where the wall does not move. We recommend the walls be designed in an at-rest condition.

The values listed below assume a horizontal surface adjacent the top and bottom of the wall.

Description	Active	At-Rest	Passive
Granular Backfill (On-site Silty Sand and Imported Structural Fill) - Equivalent Fluid Weight (pcf)	35 pcf	55 pcf	325 pcf
Granular Backfill - Earth Pressure Coefficient	0.28	0.44	-
Fine-Grained Backfill (Processed Bedrock) - Equivalent Fluid Weight (pcf)	40 pcf	60 pcf	230 pcf
Fine-Grained Backfill - Earth Pressure Coefficient	0.36	0.55	-

The above values account for the lateral earth pressures due to the soil and level backfill conditions and do not account for hydrostatic pressures or surcharge loads.

Lateral loading should be increased to account for surcharge loading (using the appropriate earth pressure coefficient) and a rectangular distribution if structures are placed above the wall and are within a horizontal distance equal to the height of the wall. If the ground surface slopes up away from the wall, the equivalent fluid weights should also be increased.

Care should be taken to prevent percolation of surface water into the backfill material adjacent to the retaining walls. The risk of hydrostatic build up can be reduced by placing a subdrain behind the walls consisting of free-draining gravel wrapped in a filter fabric.

3. <u>Seismic Conditions</u>

Under seismic conditions, the equivalent fluid weight should be modified as follows according to the Mononobe-Okabe method assuming a level backfill condition:

Lateral Earth Pressure Condition	Seismic Modification (2% PE in 50 yrs)	
	Granular Backfill	**Fine-Grained Backfill**
Active	9 pcf increase	10 pcf increase
At-rest	no increase	no increase
Passive	22 pcf decrease	16 pcf decrease

The resultant of the seismic increase should be placed up from the base of the wall a distance equal to ⅓ the height of the wall.

4. <u>Safety Factors</u>

The values recommended assume mobilization of the soil to achieve the assumed soil strength. Conventional safety factors used for structural analysis for such items as overturning and sliding resistance should be used in design.

E. Seismicity, Liquefaction and Faulting

1. Seismic design parameters are provided below in accordance with ASCE 7-16:

Description	Seismic Parameter
	2,500 yr event (≈2% PE in 50 yrs)
2018 IBC	C
PGA - Site Class B	0.25g
S_s (0.2 second period) - Site Class B	0.57g
S_1 (1 second period) - Site Class B	0.19g
F_{pga} - Site Class Factor	1.20
F_a - Site Class Factor	1.27
F_v - Site Class Factor	1.50

The data provided above was determined using the ASCE 7 Seismic Hazard Tool. Based on the subsurface conditions encountered, the seismic parameters mapped for the site as per ASCE 7-16, and our understanding of the proposed construction, a ground motion hazard analysis (GMHA) is not required by the 2018 IBC.

2. Liquefaction

The subsurface soils observed are non-liquefiable to the depths investigated during a seismic event.

3. Faulting

Based on a review of available geologic literature, there are no mapped faults extending near or through the site.

F. **Soil Corrosion**

Our experience in the area on indicates onsite soil, bedrock and many imported sources of soil are highly corrosive to concrete. Therefore, we recommend concrete elements that will be exposed to the on-site soils be designed in accordance with provisions provided in the American Concrete Institute Manual of Concrete Practice (ACI) 318-II. Table 4.2.1 and 4.2.1 of ACI 318-11 should be referenced for design of concrete elements utilizing a Sulfate Exposure Class of S2, and a sulfate exposure severity of “severe”.

Consideration should also be given to cathodic protection of buried metal pipes. We recommend utilizing PVC pipes where local building codes allow.

G. Pavement

1. Subgrade Support

We anticipate that the subgrade materials beneath the pavement areas will varies from shale bedrock to properly compacted silty sand and processed bedrock. Prior to placement of road base, the subgrade should be prepared as recommended in the subgrade preparation section of this report. A California Bearing Ratio (CBR) of 6 percent was assumed for a properly compacted subgrade for purposes of design.

2. Pavement Thickness

Based on the assumed traffic loadings and Washington City traffic indexes, a 20-year design life, and AASHTO design methods, the following pavement sections are recommended.

Roadway	Asphalt (in.)	Base Course (in.)
50 foot right-of-way	2½	6

3. Pavement Materials

The pavement materials should meet Washington City specifications for gradation and quality. The pavement thicknesses indicated above assume that the base course is a high quality material with a CBR of at least 50 percent and the asphaltic concrete has a minimum Marshall stability of 1,800 pounds. Other materials may be considered for use in the pavement section. The use of other materials may result in other pavement material thicknesses.

4. Drainage

The collection and diversion of drainage away from the pavement surface is extremely important to the satisfactory performance of the pavement section. Proper drainage should be provided.

H. Construction Testing and Observations

We recommend the following testing and observations be done as a minimum as required by the Washington City.

1. Observe grubbing and verify removal of soil containing roots and organics.

2. Verify that recommended overexcavation depths are achieved in the building pads and beneath roadways. The lateral extent of the building pad should be located by survey (not included in AGEC's Scope of Services) and includes an area which extends at least 5 feet beyond the buildable area as per city set-back requirements.

3. Verify that fill placement, processing, mixing and compaction recommendations are being implemented.

4. Conduct compaction testing on fill placed below foundations and in building pads. We recommend testing each foot of fill placed.

5. Conduct construction materials testing on city improvements at a frequency which meets or exceeds Washington City requirements.

I. Geotechnical Recommendation Review

The client should familiarize themselves with the information contained in this report. If specific questions arise or if the client does not fully understand the conclusions/recommendations provided, AGEC should be contacted to provide clarification.

LIMITATIONS

This report has been prepared in accordance with generally accepted soil and foundation engineering practices in the area for the use of the client for design purposes. The conclusions and recommendations included within the report are based on the information obtained from the borings drilled, the referenced reports, the data obtained from laboratory testing, and our experience in the area. Variations in the subsurface conditions may not become evident until excavation is conducted. If the subsurface conditions or groundwater level are found to be significantly different from those described above, we should be notified to reevaluate our recommendations.

If you have any questions or if we can be of further service please call.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

LICENSED PROFESSIONAL ENGINEER
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Jon Russell Hanson, P.E.

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BURKE SPRINGS, PHASE 2
WASHINGTON, UTAH

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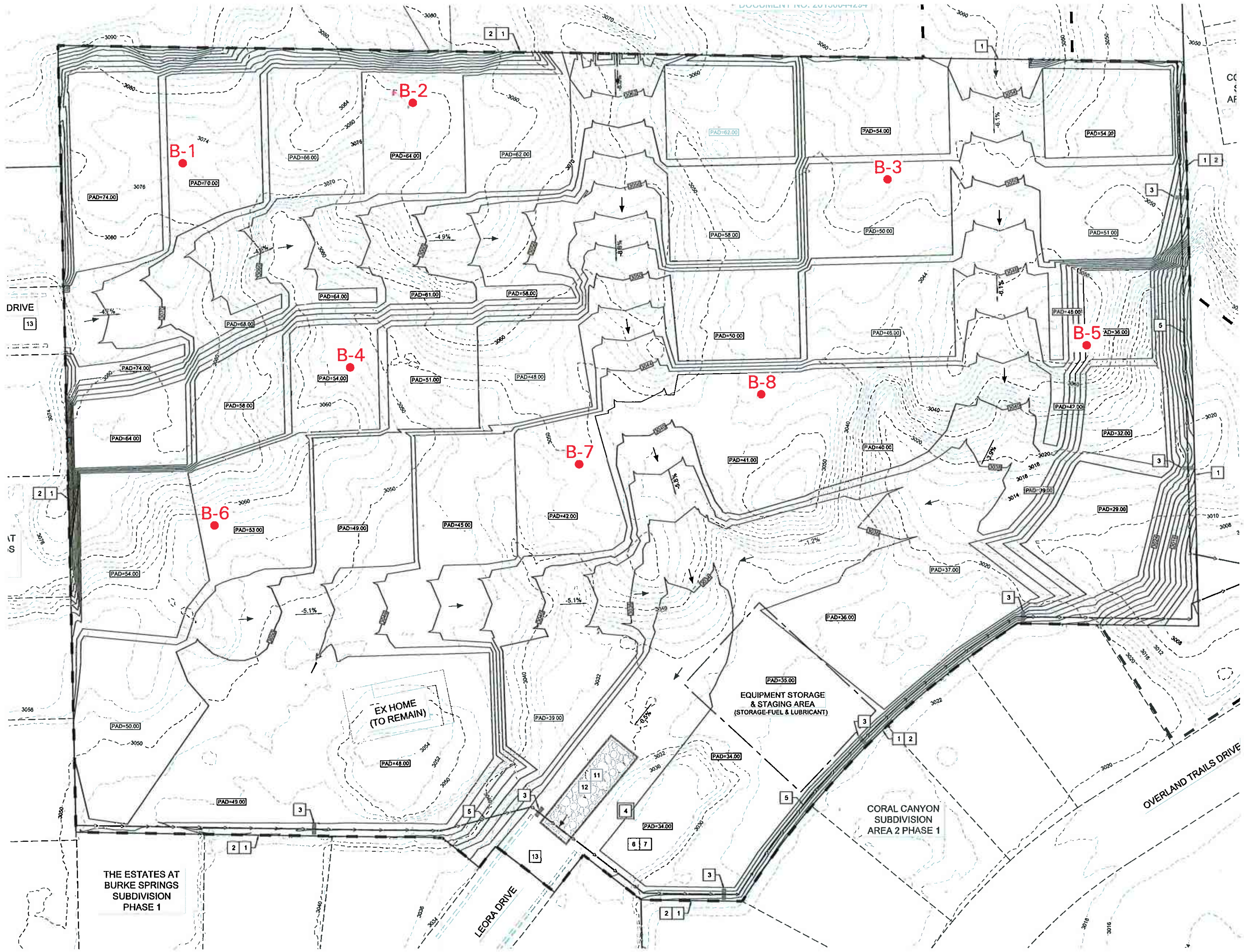
Not to Scale

2213124	AGEC	Vicinity Map	Figure 1

BURKE SPRINGS, PHASE 2
WASHINGTON, UTAH

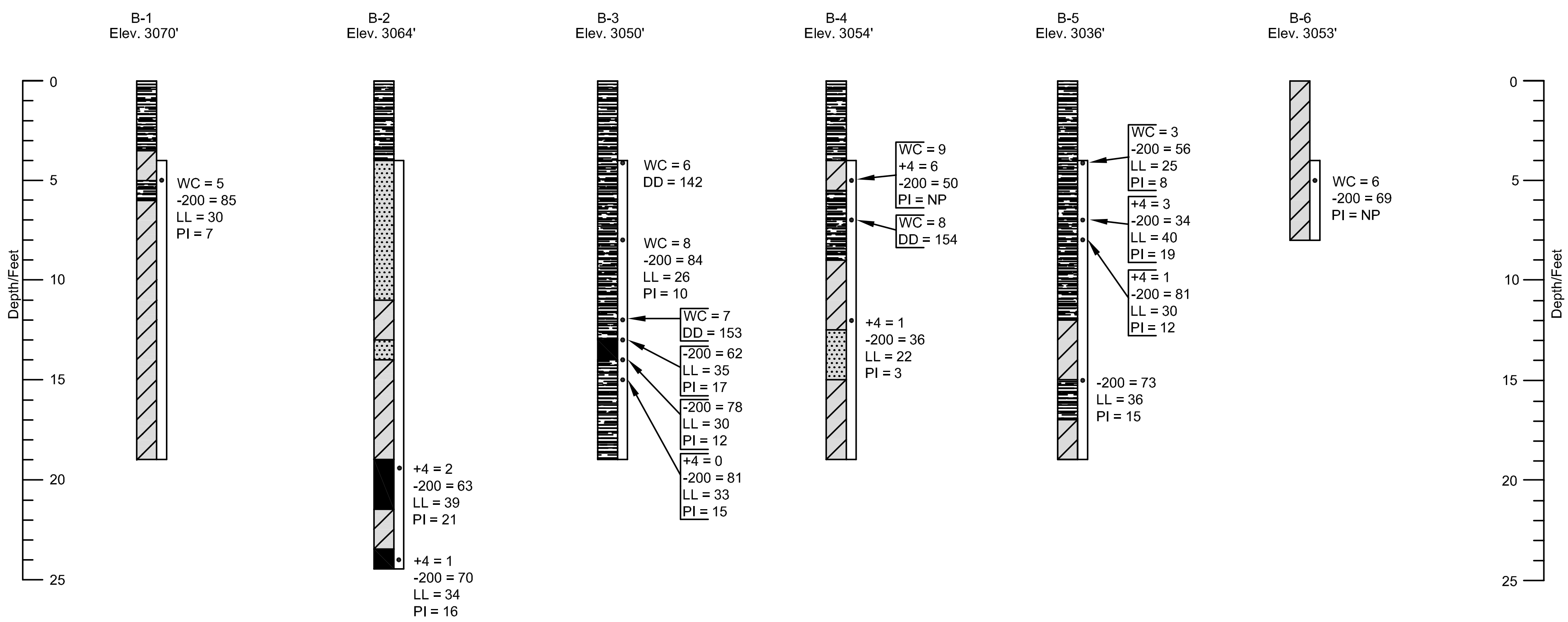


● Approximate boring location

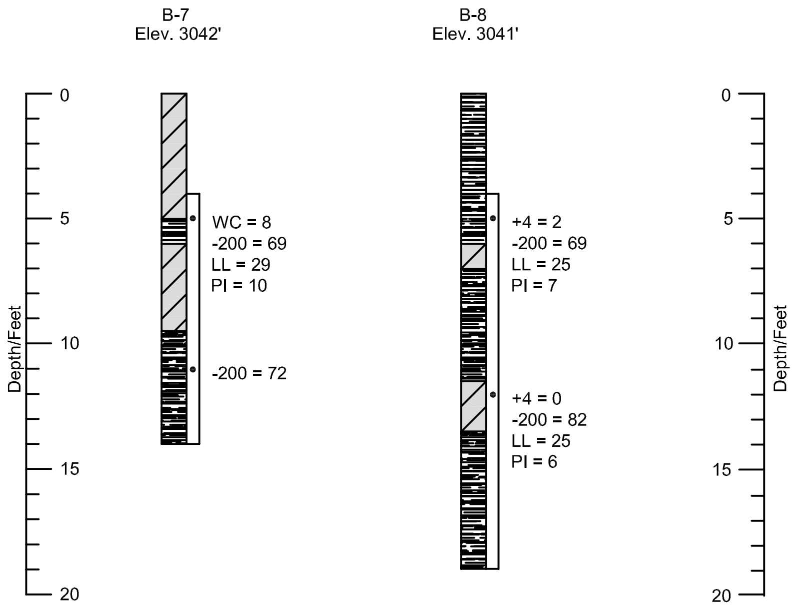
N

0 80 160 feet

2213124	AGEC	Site Plan	Figure 2



2213124 | AGEC | Logs of Exploratory Borings | Figure 3



LEGEND:

Mudstone Bedrock; moderately hard, dry to wet, and purple to grey in color.

Shale Bedrock; soft to moderately hard, slightly moist to moist, low to medium plastic and is reddish brown to grey in color.

Siltstone Bedrock; moderately hard, dry to wet, non to low plastic, and red in color.

Sandstone Bedrock; moderately hard, dry to wet, and red in color.

Indicates core sample taken.

NOTES:

1. The borings were drilled on February 28 and March 24, 2022 with a truck mounted drill rig equipped with 8-inch hollow-stem augers. Borings were advanced into the bedrock using a 2½" HQ core barrel with a diamond bit and compressed air to remove cuttings.
2. The locations of the borings were measured by pacing from features shown on Figure 2.
3. The elevations of the borings were interpolated from contours provided in a grading plan prepared by Civil Science dated October 15, 2021.
4. The boring locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between the materials shown on the boring logs represent the approximate boundaries between material types and the transitions may be gradual.
6. Free water was not encountered in the borings at the time of drilling.
7. WC = water content (%);
   DD = dry density (pcf);
   +4 = percent retained on the No. 4 sieve;
   -200 = percent passing No. 200 sieve;
   LL = liquid limit (%);
   PI = plasticity index (%);
   NP = non-plastic;

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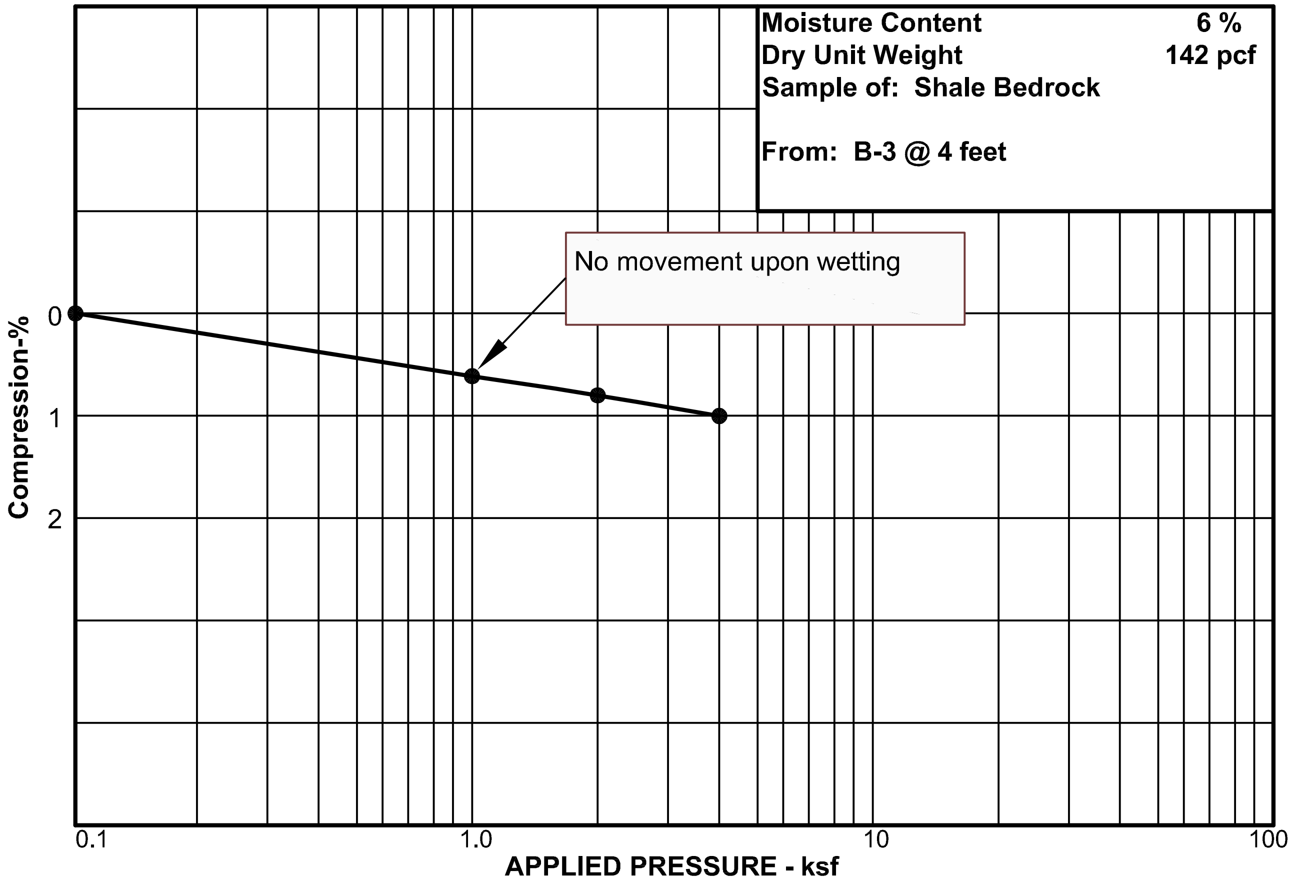

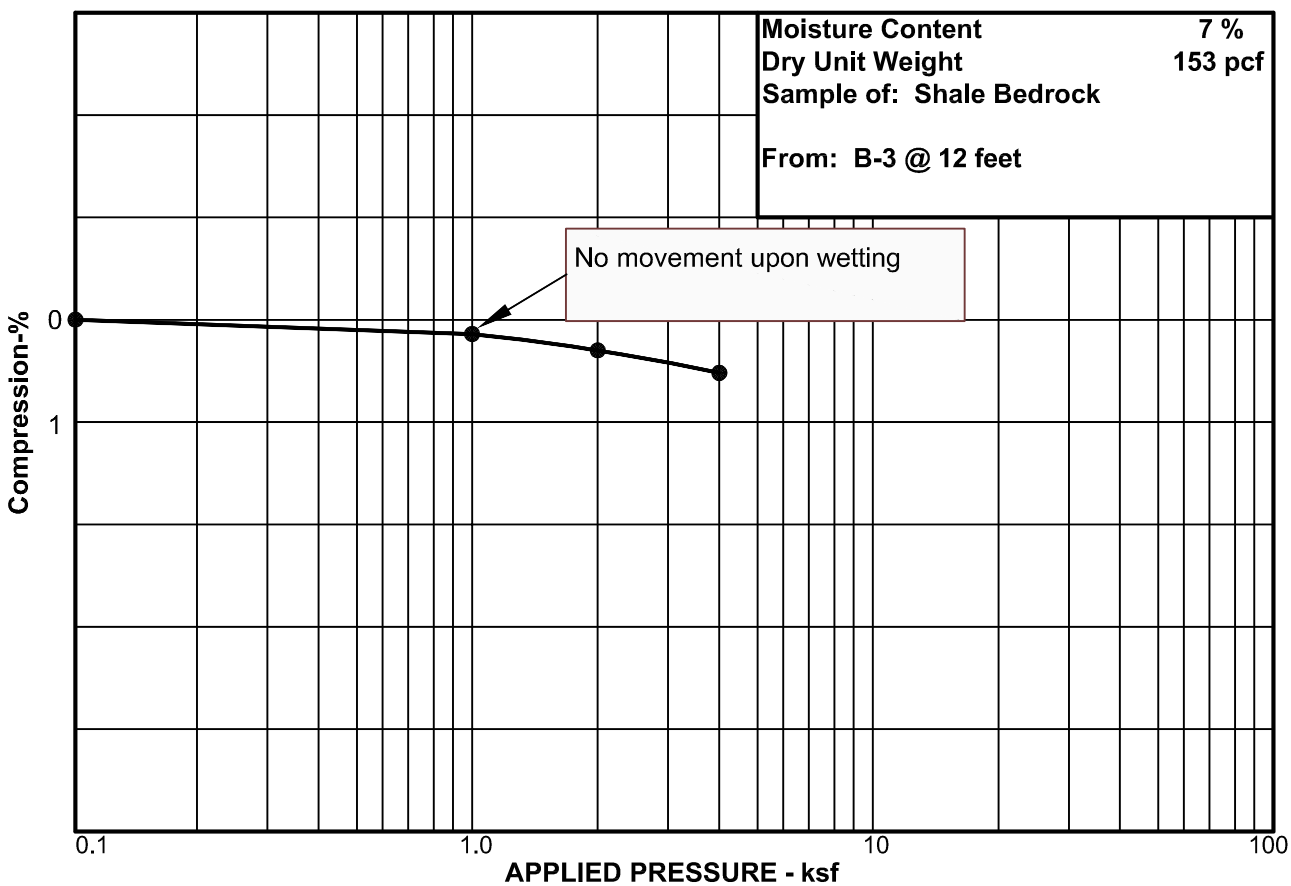

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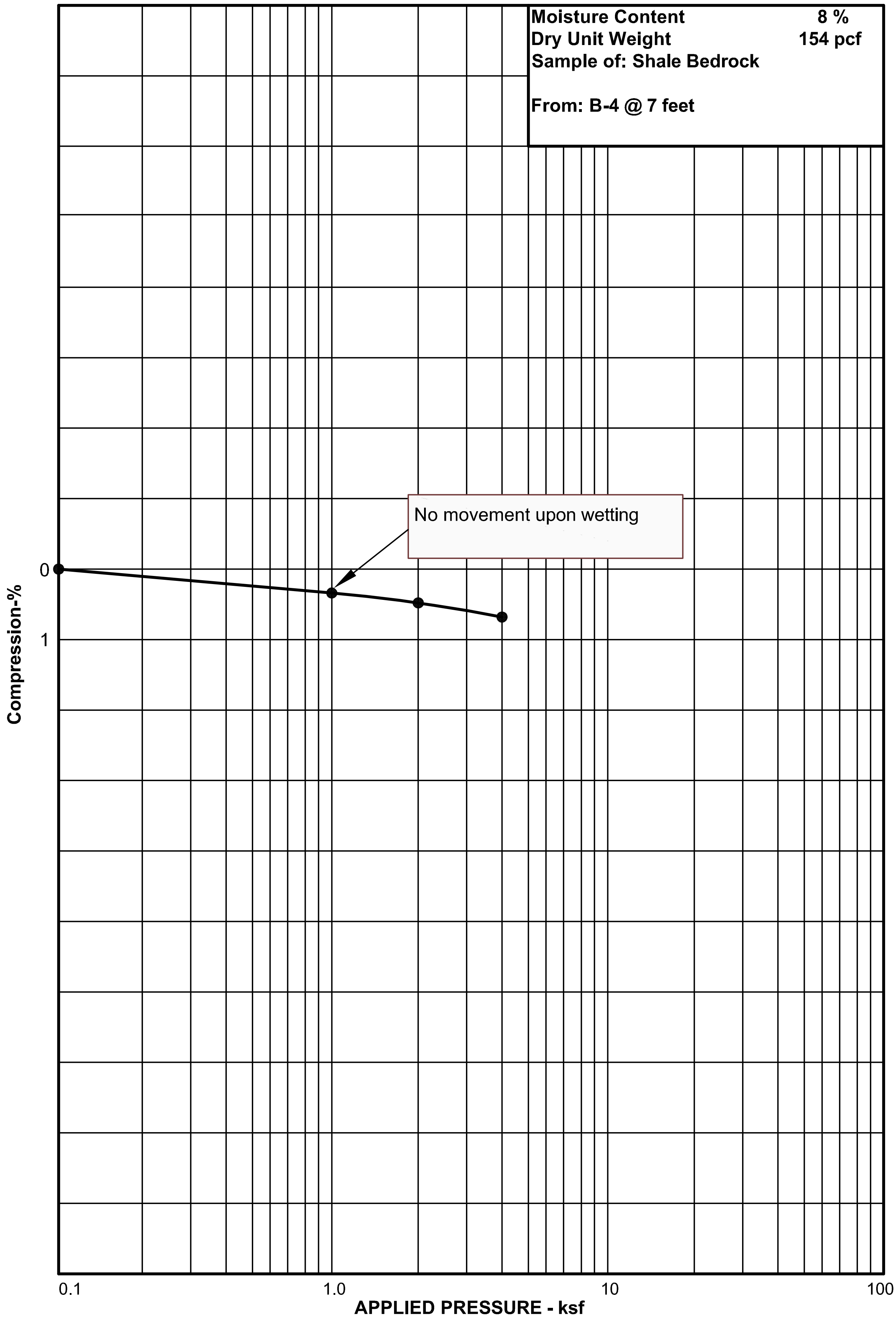


Project No. 2213124 CONSOLIDATION TEST RESULTS Figure 6

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Burke Springs Phase 2

Project Number 2213124

Sample Location		Natural Moisture Content (%)	Natural Dry Density (pcf)	Gradation			Atterberg Limits		Sample Classification
Boring No.	Depth (feet)			Gravel (%)	Sand (%)	Silt/ clay (%)	Liquid Limit (%)	Plasticity Index (%)	
B-1	5	5				85	30	7	Siltstone Bedrock
B-2	19½			2	35	63	39	21	Mudstone Bedrock
B-2	24			1	29	70	34	16	Mudstone Bedrock
B-3	4	6	142						Shale Bedrock
B-3	8	8				84	26	10	Shale Bedrock
B-3	12	7	153						Shale Bedrock
B-3	13					62	35	17	Mudstone Bedrock
B-3	14					78	30	12	Shale Bedrock
B-3	15			0	19	81	33	15	Shale Bedrock
B-4	5	9		6	44	50		NP	Siltstone Bedrock
B-4	7	8	154						Shale Bedrock
B-4	12			1	63	36	22	3	Sandstone Bedrock
B-5	4	3				56	25	8	Shale Bedrock
B-5	7			3	63	34	40	19	Mudstone Bedrock
B-5	8			1	18	81	30	12	Shale Bedrock

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I
SUMMARY OF LABORATORY TEST RESULTS

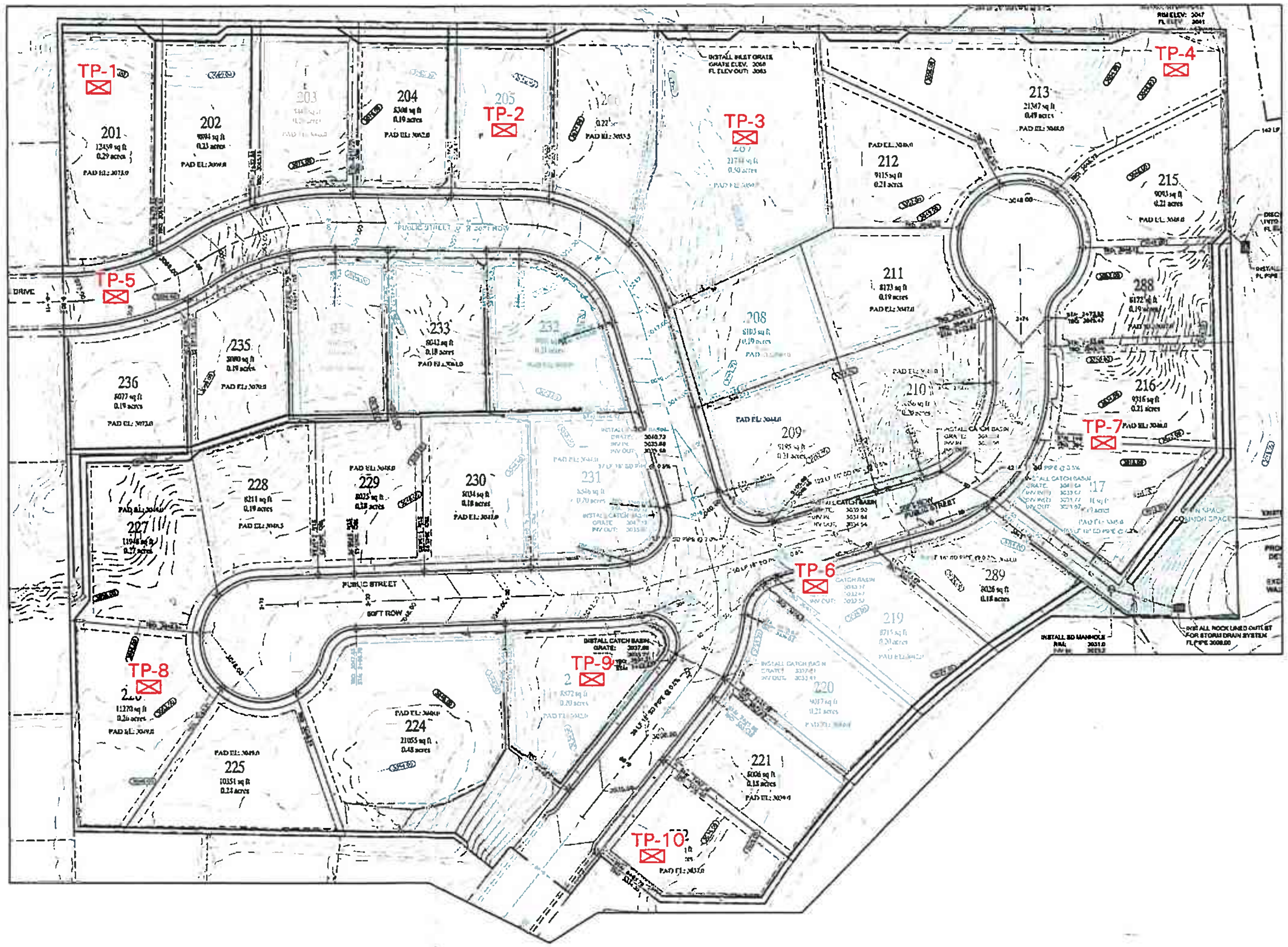
Burke Springs Phase 2

Project Number 2213124

Sample Location		Natural Moisture Content (%)	Natural Dry Density (pcf)	Gradation			Atterberg Limits		Sample Classification
Boring No.	Depth (feet)			Gravel (%)	Sand (%)	Silt/ clay (%)	Liquid Limit (%)	Plasticity Index (%)	
B-5	15					73	36	15	Shale Bedrock
B-6	5	6				69		NP	Siltstone Bedrock
B-7	5	8				69	29	10	Shale Bedrock
B-7	11					72			Shale Bedrock
B-8	5			2	29	69	25	7	Siltstone Bedrock
B-8	12			0	18	82	25	6	Siltstone Bedrock

APPENDIX I

BURKE SPRINGS PHASE 2
WASHINGTON, UTAH



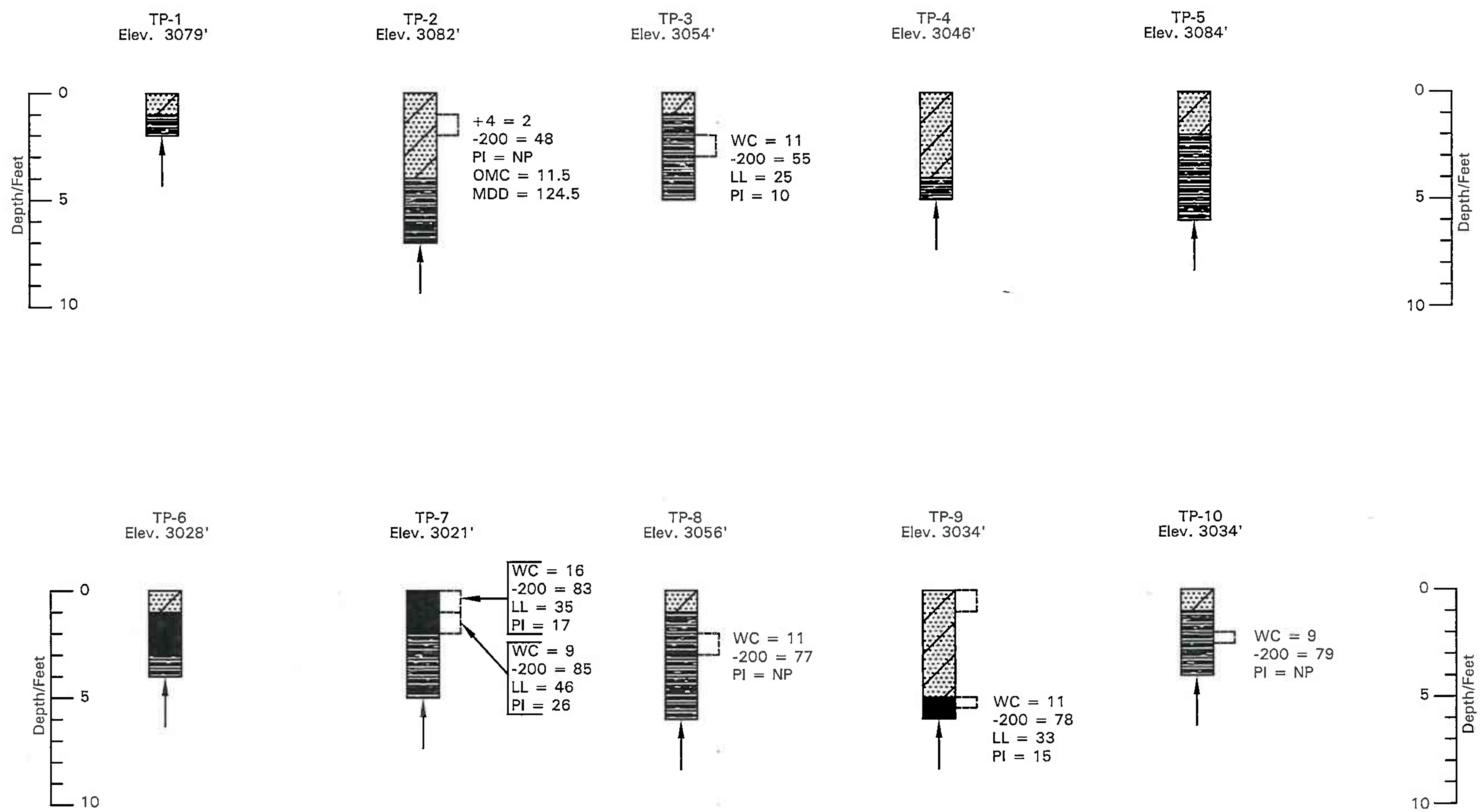
⊠ Approximate test pit location

N

0 80 160 feet

Approximate Scale

2210795	AGEC	Site Plan	Figure 2



2210795 | AGEC | Logs of Test Pits | Figure 3

LEGEND:

Silty Sand (SM); loose, dry to slightly moist, and is reddish brown to yellow in color.

Shale Bedrock; soft to moderately hard (hardness increases with depth), slightly moist to moist, varies from non-plastic to low plastic, and is reddish brown to grey in color.

Mudstone Bedrock; soft, slightly moist to moist, highly plastic, and dark brown to grey to green in color.

Indicates relatively undisturbed hand drive sample taken.

Indicates relatively undisturbed block sample taken.

Indicates disturbed sample taken.

Indicates practical excavator refusal on shale bedrock.

NOTES:

1. The test pits were excavated on April 28, 2021 with a mini track mounted excavator.
2. The locations of the test pits were estimated by pacing from features shown on the site plan, Figure 2.
3. The elevations of the test pits were interpolated from contours shown on a site plan provided by LR Pope Engineering, Inc. dated August 21, 2019.
4. The test pit locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between the materials shown on the test pit logs represent the approximate boundaries between material types and the transitions may be gradual.
6. Free water was not encountered in the test pits at the time of excavation. Seeps and springs were encountered throughout the project site.
7. WC = water content (%);
   +4 = percent retained on the No. 4 sieve;
   -200 = percent passing No. 200 sieve;
   LL = liquid limit (%);
   PI = plasticity index (%);
   NP = non-plastic;
   MDD = maximum dry density (pcf);
   OMC = optimum moisture content (%).

APPENDIX II

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Washington County Area, Utah

April 26, 2022

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

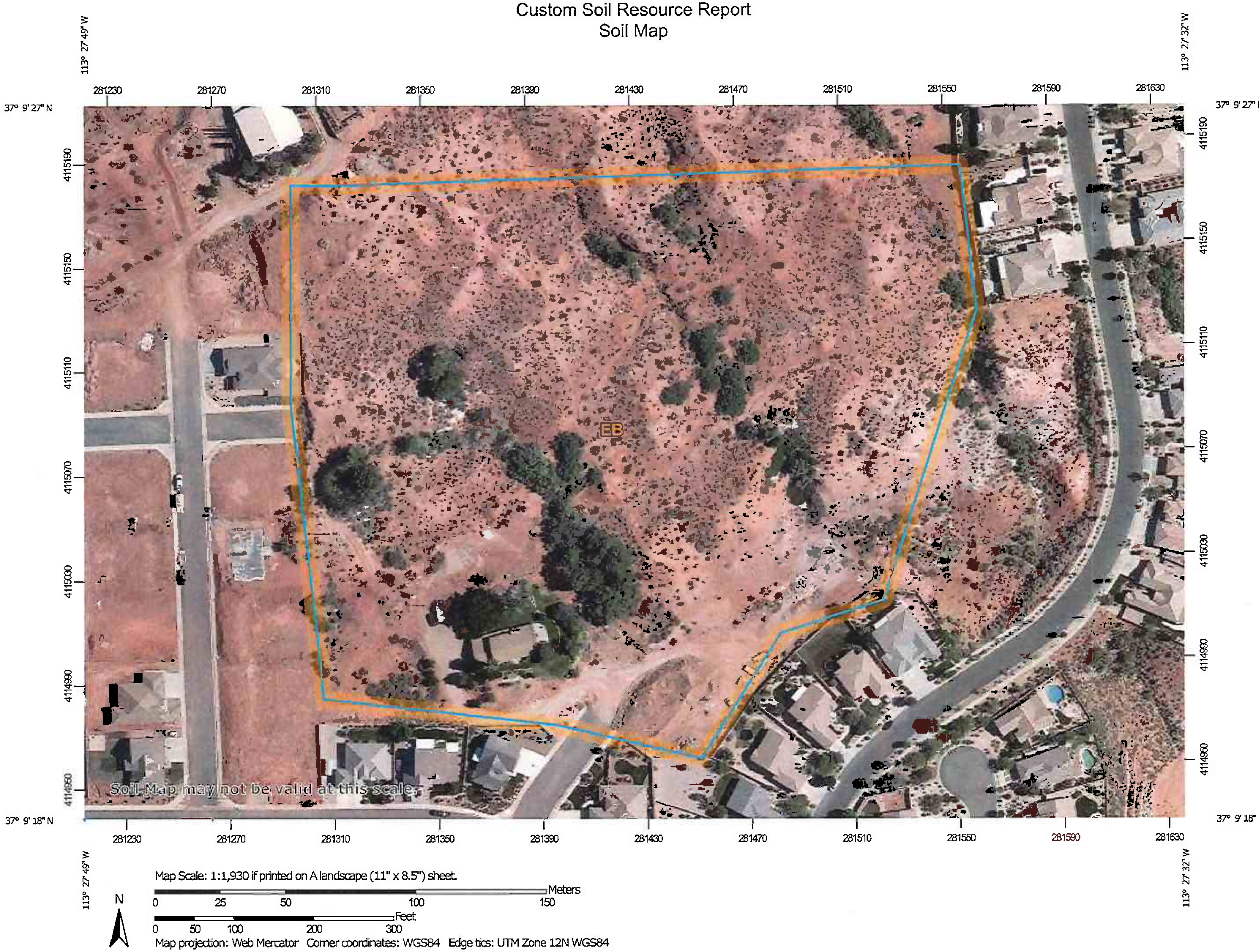
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


113° 27' 49" W
113° 27' 32" W
37° 9' 27" N
37° 9' 18" N
281230
281270
281310
281350
281390
281430
281470
281510
281550
281590
281630
4115190
4115150
4115110
4115070
4115030
4114990
4114950
EB
Soil Map may not be valid at this scale.
N
Map Scale: 1:1,930 if printed on A landscape (11" x 8.5") sheet.
Meters
0 25 50 100 150
Feet
0 50 100 200 300
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Washington County Area, Utah
Survey Area Data: Version 15, Sep 7, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 1, 2018—Aug 1, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
EB	Eroded land-Shalet complex, warm	12.1	100.0%
Totals for Area of Interest		**12.1**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Washington County Area, Utah

EB—Eroded land-Shalet complex, warm

Map Unit Setting

National map unit symbol: j8ds
Elevation: 3,600 to 5,550 feet
Mean annual precipitation: 10 to 13 inches
Mean annual air temperature: 52 to 56 degrees F
Frost-free period: 165 to 170 days
Farmland classification: Not prime farmland

Map Unit Composition

Eroded land: 78 percent
Shalet and similar soils: 20 percent
Minor components: 2 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Eroded Land

Setting

Landform: Erosion remnants
Parent material: Residuum weathered from shale

Description of Shalet

Setting

Landform: Swales
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Residuum weathered from shale

Typical profile

H1 - 0 to 4 inches: clay loam
H2 - 4 to 12 inches: clay loam
H3 - 12 to 16 inches: weathered bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 4 to 15 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Gypsum, maximum content: 10 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water supply, 0 to 60 inches: Very low (about 2.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D
Ecological site: R030XY134UT - Desert Shallow Loam (Creosotebush)
Hydric soil rating: No

Minor Components

Badland

Percent of map unit: 2 percent

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