CMT ENGINEERING LABORATORIES

ENGINEERING •GEOTECHNICAL •ENVIRONMENTAL (ESA I & II) • MATERIALS TESTING •SPECIAL INSPECTIONS • ORGANIC CHEMISTRY • PAVEMENT DESIGN •GEOLOGY

GEOTECHNICAL ENGINEERING AND GEOLOGICAL RECONNAISSANCE STUDY

Proposed Sunshine Valley Estates

About 9275 East Sunshine Valley Drive
Huntsville, Weber County, Utah
CMT PROJECT NO. 12557

FOR:
Mr. Matt Lowe
Lowe Companies
5028 South Ridge Drive, #203
South Ogden, Utah 84403

April 18, 2019

CMT ENGINEERING LABORATORIES

April 18, 2019

Mr. Matt Lowe
Lowe Companies
5028 South Ridge Drive, #203
South Ogden, Utah 84403

Subject: Geotechnical Engineering and Geological Reconnaissance Study
Proposed Sunshine Valley Estates
Weber County Tax ID Nos. 210230031, 210230032, 210230034 and 210350003
About 9275 East Sunshine Valley Drive
Huntsville, Weber County, Utah
CMT Project No. 12557

Mr. Lowe:

Submitted herewith is the report of our geotechnical engineering and geological reconnaissance study for the subject site. This report contains the results of our findings and an interpretation of the results with respect to the available project characteristics. It also contains recommendations to aid in the design and construction of the earth related phases of this project.

Between April 2 and 3, 2019 CMT Engineering Laboratories (CMT) personnel were on-site and supervised the excavation of 8 test pits extending to depths of 11 to 13 feet below the existing ground surface. Soil samples were obtained during the field operations and subsequently transported to our laboratory for further testing and observation.

Conventional spread and/or continuous footings may be utilized to support the proposed structures, provided the recommendations in this report are followed. A detailed discussion of design and construction criteria is presented in this report.

We appreciate the opportunity to work with you at this stage of the project. CMT offers a full range of Geotechnical Engineering, Geological, Material Testing, Special Inspection services, and Phase I and II Environmental Site Assessments. With 8 offices throughout Utah and Arizona, our staff is capable of efficiently serving your project needs. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (801) 870-6730.

Sincerely,
CMT Engineering Laboratories

LICENSED PROFESSIONAL GEOLOGIST
04-12-2019
BILL DUANE BLACK
NO. 5224898-2250
STATE OF UTAH

LICENSED PROFESSIONAL ENGINEER
276476
BRYAN N. ROBERTS
STATE OF UTAH

Bill D. Black, P.G.
State of Utah No. 5224898-2250
Senior Engineering Geologist

Bryan N. Roberts, P.E.
State of Utah No. 276476
Senior Geotechnical Engineer

TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 General 1
1.2 Objectives, Scope and Authorization 1
1.3 Description of Proposed Construction 1
1.4 Executive Summary 2
2.0 FIELD EXPLORATION 2
3.0 LABORATORY TESTING 3
4.0 ENGINEERING GEOLOGY 4
4.1 Seismotectonic Setting 4
4.2 Surficial Geology 4
4.3 Lake Bonneville History 11
4.4 Seismic Hazards 12
4.4.1 Strong Ground Motions 12
4.4.2 Site Class 12
4.4.3 Seismic Design Category 12
4.4.4 Surface Faulting 13
4.4.5 Liquefaction 13
4.4.6 Tectonic Subsidence 13
4.5 Landslide and Slump Deposits 14
4.6 Other Geologic Hazards 14
4.6.1 Sloping Surfaces 14
4.6.2 Alluvial Fan Flooding 14
4.6.3 Stream Flooding Hazards 14
4.6.4 Rockfall and Avalanche Hazards 15
5.0 SITE CONDITIONS 15
5.1 Surface Conditions 15
5.2 Subsurface Soils 15
5.3 Groundwater 15
5.4 Site Subsurface Variations 16
6.0 SITE PREPARATION AND GRADING 16
6.1 General 16
6.2 Temporary Excavations 16
6.3 Fill Material 17
6.4 Fill Placement and Compaction 18
6.5 Utility Trenches 18
6.6 Soil Stabilization 19
7.0 FOUNDATION RECOMMENDATIONS 19
7.1 Foundation Recommendations 19
7.2 Installation 20
7.3 Estimated Settlement 20
7.4 Lateral Resistance 20
8.0 LATERAL EARTH PRESSURES 20
9.0 FLOOR SLABS 21
10.0 DRAINAGE RECOMMENDATIONS 21
10.1 Surface Drainage 21
12.0 QUALITY CONTROL 23
13.0 LIMITATIONS 23
14.0 REFERENCES 24

CMT ENGINEERING LABORATORIES

APPENDIX

Figure 1: Vicinity Map
Figure 2: Site Plan
Figure 3: Geologic Map
Figure 4: LiDAR Analysis
Figure 5: Site Evaluation
Figures 6-13: Logs of Test Pits 1 through 8

1.0 INTRODUCTION

1.1 General

In response to your request, CMT Engineering Laboratories (CMT) has prepared this Geotechnical Engineering and Geologic Study for the proposed Sunshine Valley Estates subdivision located in Huntsville, Utah (the Project). The Project consists of a two-phase development with a total of 29.024 acres that is proposed for development of nine residential lots with an average size of 140,476 square feet. The site is located in southeastern Ogden Valley in the SE1/4 Section 16 and NE1/4 Section 21, Township 6 North, Range 2 East (Salt Lake Base Line and Meridian) at an elevation of 4,996 to 5,024 feet above sea level. The Project location is shown on **Figure 1, Vicinity Map**. The current development plan for the Project is provided on **Figure 2, Site Plan**. Regional geology of the Project and nearby area is provided on **Figure 3, Geologic Map**. Slope-terrain information is provided on **Figure 4, LiDAR Analysis**. Locations of test pits excavated for our subsurface evaluation are shown on **Figure 5, Site Evaluation**.

1.2 Objectives, Scope and Authorization

The objectives and scope of our study were planned in discussions between Mr. Matt Lowe of Lowe Companies and Mr. Andrew Harris of CMT Engineering Laboratories (CMT) and are outlined in our proposal dated March 25, 2019. The proposal was authorized by Mr. Lowe on March 26, 2019.

In accomplishing these objectives, our scope of work included the following:

1. Provide geological reconnaissance studies as specified by Weber County Code, Section 108-22 Natural Hazard Areas guidelines and standards (Weber County, 2018). The reconnaissance level geological study was performed to assess whether all or parts of the site are exposed to the hazards that are included in the Weber County Code, Section 108-22 Natural Hazard Areas. These hazards include, but are not limited to: Surface-Fault Ruptures, Landslide, Tectonic Subsidence, Rock Fall, Debris Flows, Liquefaction Areas, Flood, or other Hazardous Areas.

2. Define and evaluate the subsurface soil and groundwater conditions at the site.

3. Provide appropriate foundation and earthwork recommendations as well as geoseismic information to be utilized in the design and construction of the proposed home site including; a field program consisting of the excavating, logging, and sampling of five geotechnical test pits; a laboratory soils testing program; and an office program consisting of the correlation of available data, engineering and geological analyses, and the preparation of this summary report.

1.3 Description of Proposed Construction

Based on the site plan developed by Reeve and Associates, Inc. as shown on **Figure 2**, the proposed development includes two phases. Phase I on the south includes two lots (101 and 102) with a total of 6.179

acres. Phase 2 on the north includes an additional seven lots (201 through 207) with a total of 22.845 acres. The development will reportedly be for single family residences. Structures are to be of wood-frame construction and founded on spread footings with basements (if conditions allow). Maximum continuous wall and column loads are anticipated to be 1 to 3 kips per lineal foot and 10 to 40 kips, respectively.

1.4 Executive Summary

Proposed structures can be supported upon conventional spread and continuous wall foundations established on suitable natural soils or on structural fill extending to suitable natural soils. The most significant geotechnical/geological aspects of the site are:

1. The site is in an area mapped by the Utah Geological Survey (UGS) as being underlain by Holocene to uppermost Pleistocene stream alluvium and floodplain deposits (Coogan and King, 2016). The land surface slopes gently to the west-northwest at an overall 0.7% gradient. Slopes at the site are mainly gentler than 15% except for some narrow stream-cut bank slopes in the floodplain of South Fork Ogden River. Groundwater was not observed in any of the test pits conducted for our study, but may occur seasonally and/or locally given the site location. Soils encountered in the test pits generally consisted of a mixture of sand and gravel with rounded cobbles and boulders and lesser silt.

2. The natural undisturbed sand and gravel soils encountered free of significant organics are suitable for bearing foundations and slabs; collapse and expansive potentials are considered low to negligible for this site.

A geotechnical engineer from CMT should be allowed to verify that all non-engineered/undocumented fill material and topsoil/disturbed soils have been completely removed from beneath proposed structures, and suitable natural soils encountered prior to the placement of structural fills, floor slabs, footings, foundations, or concrete flatwork.

In the following sections, detailed discussions pertaining to proposed construction, field exploration, the geologic setting and mapped hazards, geoseismic setting of the site, earthwork, foundations, lateral pressure and resistance, floor slabs, and subdrains are provided.

2.0 FIELD EXPLORATION

Subsurface soil conditions at the site were explored by excavating eight test pits located as shown on **Figure 5, Site Evaluation**. The test pits were excavated using a rubber-tire backhoe to depths of 6 to 9 feet for geologic logging, and then extended to depths of 11 to 13 feet for geotechnical logging and sampling and to ensure no differing conditions were present. During the course of the excavating operations, a continuous log of the subsurface conditions encountered was maintained. Within the test pits, bulk samples of the typical soils encountered were obtained for subsequent laboratory testing and examination. The representative soil samples were placed in sealed plastic bags and containers prior to transport to the laboratory.

The collected samples were logged and described in general accordance with ASTM D-2488, packaged, and transported to our laboratory. The soils were classified in the field based upon visual and textural examination. These classifications were supplemented by subsequent inspection and testing in our laboratory. The subsurface conditions encountered in the field exploration are discussed below in **Section 5.2**. Geologic logs of the test pits are illustrated on **Figures 6 through 13, Test Pit Logs**. Sampling information and other pertinent data and observations are also included on the logs.

When backfilling the test pits, only minimal effort was made to compact the backfill and no compaction testing was performed. Thus, the backfill must be considered as non-engineered and settlement of the backfill in the test pits over time must be anticipated.

3.0 LABORATORY TESTING

Selected samples of the subsurface soils were subjected to various laboratory tests to assess pertinent engineering properties, as follows:

1. Moisture Content, ASTM D-2216, Percent moisture representative of field conditions
2. Dry Density, ASTM D-2937, Dry unit weight representing field conditions
3. Atterberg Limits, ASTM D-4318, Plasticity and workability
4. Gradation Analysis, ASTM D-1140/C-117, Grain Size Analysis

Laboratory test results are presented in the following Lab Summary table:

LAB SUMMARY TABLE

Bore Hole	Depth (feet)	Soil Class	Sample Type	Moisture Content (%)	Gradation			Atterberg Limits		
					Grav	Sand	Fines	LL	PL	PI
TP-1	7	GP-GM	Bag	5.3	67	23	10			
TP-3	2.5	GP	Bag	3.5	41	37	1.9	NP		NP
TP-4	12	GP	Bag	5.2	64	32	3.7			
TP-6	6	GP	Bag	5.2	68	30	2.3	NP	NP	
TP-7	10	GP	Bag	3.1	72	26	2.3			
TP-8	3	GP	Bag	5.0	57	38	5			

4.0 ENGINEERING GEOLOGY

4.1 Seismotectonic Setting

The property is located in southeastern Ogden Valley, a roughly 40-square mile back valley described by Gilbert (1928) as a structural trough similar to Cache and Morgan Valleys to the north and south, respectively. The back valleys of the northern Wasatch Range are in a transition zone between the Basin and Range and Middle Rocky Mountains physiographic provinces (Stokes, 1977, 1986). The Basin and Range is characterized by a series of generally north-trending elongate mountain ranges, separated by predominately alluvial and lacustrine sediment-filled valleys and typically bounded on one or both sides by major normal faults (Stewart, 1978). The boundary between the Basin and Range and Middle Rocky Mountains provinces is marked by the Wasatch fault zone at the base of the Wasatch Range. Late Cenozoic normal faulting, a characteristic of the Basin and Range, began between about 17 and 10 million years ago in the Nevada (Stewart, 1980) and Utah (Anderson, 1989) portions of the province. The faulting is a result of a roughly east-west directed, regional extensional stress regime that has continued to the present (Zoback and Zoback, 1989; Zoback, 1989). The back valleys are morphologically similar to valleys in the Basin and Range, but exhibit less structural relief (Sullivan and others 1988).

Ogden Valley occupies a structural trough created by up to 2,000 feet of vertical displacement on normal faults bounding the northeastern and southwestern margins of the valley. These faults are mapped by Coogan and King (2016) and the Utah Geological Survey Quaternary Fault Database (Black and others, 2003; January 2017 update) about 0.7 miles to the northeast and 4.7 miles to the west, respectively. Both faults were most-recently active more than 10,000 years ago (Sullivan and others, 1986). The nearest active (Holocene-age) fault to the site is the Weber segment of the Wasatch fault zone about 10.3 miles to the west.

The site is also situated near the central portion of the Intermountain Seismic Belt (ISB). The ISB is a north-south-trending zone of historical seismicity along the eastern margin of the Basin and Range province which extends for approximately 900 miles from northern Arizona to northwestern Montana (Sbar and others, 1972; Smith and Sbar, 1974). At least 16 earthquakes of magnitude 6.0 or greater have occurred within the ISB since 1850, with the largest of these events the MS 7.5 1959 Hebgen Lake, Montana earthquake. However, none of these events have occurred along the Wasatch fault zone or other known late Quaternary faults in the region (Arabasz and others, 1992; Smith and Arabasz, 1991). The closest of these events to the site was the 1934 Hansel Valley (MS 6.6) event north of the Great Salt Lake and south of the town of Snowville.

4.2 Surficial Geology

The site is located in southeastern Ogden Valley in an area mapped by Coogan and King (2016) as Holocene to uppermost Pleistocene stream and floodplain alluvium (unit Qal, **Figure 3**).

Coogan and King (2016) describe surficial geologic units in the site area on **Figure 3** as follows:

> ***Qal, Qal1, Qal2, Qal2?*** *- Stream alluvium and floodplain deposits (Holocene and uppermost Pleistocene).* Sand, silt, clay, and gravel in channels, floodplains, and terraces typically less than 16 feet (5 m) above

river and stream level; moderately sorted; unconsolidated; along the same drainage Qal2 is lower than Qat2 and has likely been subject to flooding, at least prior to dam building; present in broad plains along the Bear, Ogden, and Weber Rivers and larger tributaries like Deep, Cottonwood, East Canyon, Lost, and Saleratus Creeks, along Box Elder, Heiners, and Yellow Creeks, and in narrower plains of larger tributary streams; locally includes muddy, organic overbank and oxbow lake deposits; composition depends on source area, so in back valleys typically contains many quartzite cobbles recycled from the Wasatch Formation; mostly Holocene, but deposited after regression of Lake Bonneville from the late Pleistocene Provo shoreline; width in Morgan Valley is combined floodplain of Weber River and East Canyon and Deep Creeks; 6 to 20 feet (2-6 m) thick and possibly as much as 50 feet (15 m) along Weber River and thinner in the Kaysville quadrangle; greater thicknesses (>50 feet [15 m]) are reported in Morgan Valley (Utah Division of Water Rights, well drilling database), but likely include Lake Bonneville and older Pleistocene deposits.

Suffixes 1 and 2 indicate ages where they can be separated, with 1 including active channels and 2 including low terraces 10 to 20 feet (3-6 m) above the Weber and Ogden Rivers, and the South Fork Ogden River that may have been in the floodplain prior to damming of these waterways. Qal2 queried in low terraces above Bear River, Saleratus Creek, and Dry Creek where deposits may not be in the floodplain.

Qaf1, Qaf2, Qaf2?, Qafy, Qafy? – *Younger alluvial-fan deposits (Holocene and uppermost Pleistocene)*. Like undivided alluvial fans, but all of these fans are unconsolidated and should be considered active; height above present drainages is low and is within certain limits; generally less than 40 feet (12 m) thick; near former Lake Bonneville, fans are shown as Qafy where Qaf1 and Qaf2 cannot be separated, and all contain well-rounded recycled Lake Bonneville gravel. Younger alluvial fan deposits are queried where relative age is uncertain (see Qaf for details).

Qaf1 fans are active because they impinge on and deflect present-day drainages. Qaf2 fans appear to underlie Qaf1 fans but may be active. Qafy fans are active, impinge on present-day floodplains, divert active streams, overlie low terraces, and/or cap alluvial deposits (Qap) related to the Provo and regressive shorelines. Therefore, Qafy fans are younger than the Provo shoreline and likely mostly Holocene in age, but may be as old as latest Pleistocene and may be partly older than Qaf1 fans.

Qla, Qla? – *Lake Bonneville lacustrine deposits and post- and pre-Lake Bonneville alluvial deposits, undivided (Holocene and upper? Pleistocene).* Mostly poorly sorted and poorly bedded sand, silt, and clay, with some gravel; mapped where Lake Bonneville deposits are reworked by later stream action or covered by thin stream and fan deposits, and where lake deposits are thin and overlie older alluvial deposits; unit queried where may be dominantly alluvium; deposits typically eroded from shallow Norwood Formation; mostly mapped near Bonneville shoreline; also mapped in Peterson quadrangle along upper Deep Creek above Bonneville shoreline where lake deposits seem to indicate landslide dam of creek; thickness uncertain.

Qa, Qa? – *Alluvium, undivided (Holocene and Pleistocene)*. Sand, silt, clay, and gravel in stream and alluvial-fan deposits near late Pleistocene Lake Bonneville and are geographically in the Ogden and Weber River, and lower Bear River drainages; composition depends on source area; variably sorted;

variably consolidated; deposits lack fan shape of Qaf and are distinguished from terraces (Qat) based on upper surface sloping toward adjacent streams from sides of drainage, or are shown where fans and terraces are too small to show separately at map scale; Qa with no suffix used where age uncertain or alluvium of different ages cannot be shown separately at map scale; Qa queried where relative age uncertain, generally due to height not fitting into ranges in table 1 and/or typical order of surfaces contradicts height-derived age (see following paragraphs); generally 6 to 20 feet (2-6 m) thick.

Where possible, alluvium is subdivided into relative ages, indicated by number and letter suffixes. This alluvium is listed and described separately below. The relative ages of alluvium, including terraces and fans, are in part based on deposit heights above present adjacent drainages in Morgan and Round Valleys, and this subdivision apparently works in and is applied in Ogden, Henefer, and Lost Creek Valleys and above the North, Middle, and South Forks of Ogden River (see table 1 and 2). Alluvial deposits mapped in the Henefer quadrangle (Coogan, 2010b) and Lost Creek drainage (Coogan, 2004a-c) were revised during mapping of the Devils Slide quadrangle (see table 2). Comparable alluvium along Box Elder Creek in the northwest part of the map area (Mantua quadrangle) seems to be slightly higher than in Morgan Valley. Units Qa2, Qay, Qap, Qab, Qapb, Qao, and Qaoe described below are near Lake Bonneville. Their relative age is queried where age uncertain, generally due to height not fitting into ranges in table 1 and/or typical order of surfaces contradicts height-derived age.

Qms, Qms?, Qmsy, Qmsy?, Qmso, Qmso? *- Landslide deposits (Holocene and upper and middle? Pleistocene).* Poorly sorted clay- to boulder sized material; includes slides, slumps, and locally flows and floods; generally characterized by hummocky topography, main and internal scarps, and chaotic bedding in displaced blocks; composition depends on local sources; morphology becomes more subdued with time and amount of water in material during emplacement; Qms may be in contact with Qms when landslides are different/ distinct; thickness highly variable, up to about 20 to 30 feet (6-9 m) for small slides, and 80 to 100 feet (25-30 m) thick for larger landslides. Qmsy and Qmso queried where relative age uncertain; Qms queried where classification uncertain. Numerous landslides are too small to show at map scale and more detailed maps shown in the index to geologic mapping should be examined.

Qms without a suffix is mapped where the age is uncertain (though likely Holocene and/or late Pleistocene), where portions of slide complexes have different ages but cannot be shown separately at map scale, or where boundaries between slides of different ages are not distinct. Estimated time of emplacement is indicated by relative-age letter suffixes with: Qmsy mapped where landslides deflect streams or failures are in Lake Bonneville deposits, and scarps are variably vegetated; Qmso typically mapped where deposits are “perched” above present drainages, rumpled morphology typical of mass movements has been diminished, and/or younger surficial deposits cover or cut Qmso. Lower perched Qmso deposits are at Qao heights above drainages (95 ka and older) and the higher perched deposits may correlate with high level alluvium (QTa_) (likely older than 780 ka) (see table 1). Suffixes y and o indicate probable Holocene and Pleistocene ages, respectively, with all Qmso likely emplaced before Lake Bonneville transgression. These older deposits are as unstable as other slides, and are easily reactivated with the addition of water, be it irrigation or septic tank drain fields.

Qlf, Qlf?, Qlfb, Qlfb? *– Fine-grained lacustrine deposits (Holocene and upper Pleistocene).* Mostly silt, clay, and fine-grained sand deposited near- and off-shore in Lake Bonneville; typically mapped as Qlf below the Provo shoreline (P) because older transgressive (Qlfb) deposits are indistinguishable from younger regressive deposits; mapped as Qlfb above the Provo shoreline because these deposits can only be related to the Bonneville shoreline (B) and transgression; grades upslope with more sand into Qls or Qlsp; typically eroded from shallow Norwood Formation in Ogden and Morgan Valleys and at least 12 feet (4 m) thick near Mountain Green. Qlf and Qlfb queried where grain size is uncertain.

In the Kaysville quadrangle, Qlf deposits that are below the Gilbert (G) shoreline are at least partly the same age as this shoreline (Holocene-latest Pleistocene) and post-date late Pleistocene Lake Bonneville. Qlf deposits below the Holocene (H) highstand shoreline are Holocene. Both ages of deposits are generally less than 15 feet (5 m) thick.

Deeper water fine-grained deposits overlie older shoreline and delta gravels (Qlf/Qdlb) at the mouths of several drainages along the Weber River. These gravels were deposited above the Provo shoreline during transgression of Lake Bonneville to the Bonneville shoreline (see unit Qdlb).

Qmc *- Landslide and colluvial deposits, undivided (Holocene and Pleistocene).* Poorly sorted to unsorted clay- to boulder-sized material; mapped where landslide deposits are difficult to distinguish from colluvium (slope wash and soil creep) and where mapping separate, small, intermingled areas of landslide and colluvial deposits is not possible at map scale; locally includes talus and debris flow and flood deposits; typically mapped where landslides are thin ("shallow"); also mapped where the blocky or rumpled morphology that is characteristic of landslides has been diminished ("smoothed") by slope wash and soil creep; composition depends on local sources; 6 to 40 feet (2-12 m) thick. These deposits are as unstable as other landslide units (Qms, Qmsy, Qmso).

Qac *– Alluvium and colluvium (Holocene and Pleistocene).* Unsorted to variably sorted gravel, sand, silt, and clay in variable proportions; includes stream and fan alluvium, colluvium, and, locally, mass-movement deposits too small to show at map scale; typically mapped along smaller drainages that lack flat bottoms; more extensive east of Henefer where Wasatch Formation (Tw) strata easily weather to debris that "chokes" drainages; 6 to 20 feet (2-6 m) thick.

Some deposits are "perched" on benches 80 feet (25 m) and more above present-day drainages like Left Fork Heiners Creek (Heiners Creek quadrangle) and Harris Canyon (Henefer quadrangle). In the Devils Slide quadrangle, some deposits are "perched" on benches about 60 to 130 feet (18-40 m) above Quarry Cottonwood Canyon indicating the alluvium is at least partly Lake Bonneville age and older (see Qab and Qao in tables 1 and 2).

Qcg *– Gravelly colluvial deposits (Holocene and Pleistocene).* Gravelly materials present downslope from gravel-rich deposits of various ages (for example units Keh, Tw, Tcg, Thv, QTaf, QTa, Qafoe, Qaoe, Qafo, and Qa); may contain residual deposits; typically differentiated from colluvium and residual gravel (Qc, Qng) by prominent stripes trending downhill on aerial photographs; stripes are concentrations of gravel up to boulder size; generally 6 to 20 feet (2-6 m) thick.

Qafp, Qafp?, Qafb, Qafb?, Qafpb, Qafpb? *– Lake Bonneville-age alluvial-fan deposits (upper Pleistocene).* Like undivided alluvial fans, but height above present drainages appears to be related to shorelines of Lake Bonneville and is within certain limits (see table 1); these fans are inactive, unconsolidated to weakly consolidated, and locally dissected; fans labeled Qafp and Qafb are related to the Provo (and slightly lower) and Bonneville shorelines of late Pleistocene Lake Bonneville, respectively, while unit Qafpb is used where fans may be related to the Provo or Bonneville shoreline (for example Qafpb is ~40 feet [12 m] above Lost Creek Valley), or where fans of different ages cannot be shown separately at map scale; Qafp fans typically contain well-rounded, recycled Lake Bonneville gravel and sand and are moderately well sorted; generally 10 to less than 60 feet (3-18 m) thick. Lake Bonneville-age fans are queried where relative age is uncertain (see Qaf for details); fans labeled Qafpb? are above the Bonneville shoreline and might be Qafo or like Qafm; see the note under Qao about two possible ages of older alluvium (Qao, Qato, and Qafo).

Most of the Lake Bonneville-age fans in the James Peak quadrangle are far from the Bonneville shoreline and their age is inferred from their stratigraphic relationship(s) to coeval Pinedale glacial outwash (see age equality in Table 3).

The channels (Qafp/Qdlb) on the Weber River delta and Lake Bonneville fines (Qafp on Qlfb) probably record scour and fill during the rapid drawdown of the lake as it fell from the Bonneville shoreline to the Provo shoreline.

Qdlb, Qdlb? – *Transgressive and Bonneville-shoreline deltaic and lacustrine deposits (upper Pleistocene).* Mostly sand, silty sand, and gravelly sand deposited near shore in Lake Bonneville; extensive at mouth of Weber Canyon; related to transgression to and occupation of the Bonneville shoreline with lacustrine deposits covering deltaic deposits; in Morgan Valley and near mouth of Coldwater Canyon (North Ogden quadrangle) contain more cobbles and overall more gravel; 0 to at least 40 feet (12 m) thick in Ogden and Morgan Valleys; about 400 feet (120 m) thick in bluff at the mouth of Weber Canyon. These deposits are prone to slope failures.

Ql, Ql? – *Lake Bonneville deposits, undivided (upper Pleistocene).* Silt, clay, sand, and cobbly gravel in variable proportions; mapped where grain size is mixed, deposits of different materials cannot be shown separately at map scale, or surface weathering obscures grain size and deposits are not exposed in scarps or construction cuts; thickness uncertain.

Qls, Qls?, Qlsp, Qlsb, Qlsb? - *Lake Bonneville sand (upper Pleistocene).* Mostly sand with some silt and gravel deposited nearshore below and near the Provo shoreline (Qlsp) and between the Provo and Bonneville shorelines (Qlsb); Qls mapped downslope from slope break below Provo shoreline beach deposits where thin Lake Bonneville regressional sand may overlie transgressional sand; grades downslope into unit Qlf with decreasing sand content and laterally with more gravel into units Qdlp, Qdlb, and upslope with more gravel into unit Qlgb; Qls and Qlsb queried where grain size or unit identification uncertain; may be as much as 75 feet (25 m) thick, and thickest near Ogden; typically less than 20 feet (6 m) thick in Morgan Valley; may include small deltas and deltas that lack typical delta shape.

Thv? – *Fanglomerate of Huntsville area(?) (Pliocene and/or Miocene).* Brown to reddish-brown weathering sand, silt, and gravel (pebbles to boulders) on flat area near 7313-foot [2230 m] elevation hill on eastern margin of Mantua quadrangle; queried due to uncertain origin; located on Rendezvous Peak erosion surface of Williams (1948), so uncertain age (compare Williams, 1948 to 1958); similar patches on topographic highs to north and south are mapped as Salt Lake Formation conglomerate (Tslc); reddish color may be from erosion of Wasatch Formation and/or terra rossa development on underlying karstic carbonate rocks; may be post- or late-Salt Lake Formation age, like Thv on Durst Mountain.

Tcg, Tcg? – *Unnamed Tertiary conglomeratic rocks (Oligocene?).* Characterized by rounded, cobble- to boulder-sized, quartzite-clast conglomerate with pebbles and less than 10 percent to more than 50 percent gray, tan, or reddish-gray to reddish-tan matrix; conglomerate clasts locally angular to subangular Tintic Quartzite and angular to rounded lower Paleozoic carbonate rocks; interbedded with tan, gray, and reddish-brown, pebble-bearing mudstone to sandstone and some claystone (altered tuff); most beds poorly indurated and poorly exposed; mudstone likely constitutes matrix of conglomeratic beds; in Morgan and Durst Mountain quadrangles, about 500 to 700 feet (150-210 m) thick and thickening northward to possibly 3000 feet (900 m), though faulting may make this estimate too large.

Reddish-hued Tcg strata mostly contain recycled Wasatch Formation clasts (quartzite and carbonate) with a distinct reddish patina in a reddish matrix. Some non-conglomeratic beds in Tcg look like gray upper Norwood Formation (Tn) and are locally tuffaceous, indicating the units are interbedded. Further, some Tcg pebble beds have carbonate and chert clasts (like the Norwood) and lesser quartzite clasts, and Tcg conglomerate includes rare altered tuff clasts from the Norwood Formation. Despite tuffaceous matrix, unit Tcg seems to be less prone to mass movements than Norwood strata.

Tn, Tn? – *Norwood Formation (lower Oligocene and upper Eocene).* Typically light-gray to light-brown altered tuff (claystone), altered tuffaceous siltstone and sandstone, and conglomerate; unaltered tuff, present in type section south of Morgan, is rare; locally colored light shades of red and green; variable calcareous cement and zeolitization; involved in numerous landslides of various sizes; estimate 2000-foot *(600 m) thick in exposures on west side of Ogden Valley (based on bedding dip,* outcrop width, and topography). Norwood Formation queried where poor exposures may actually be surficial deposits. For detailed Norwood Formation information see description under heading “Sub-Willard Thrust - Ogden Canyon Area” since most of this unit is in and near Morgan Valley and covers the Willard thrust, Ogden Canyon, and Durst Mountain areas.

TRt – *Thaynes Formation, undivided (Lower Triassic).* Brownish-gray, thin-bedded, calcareous siltstone; gray, thin-bedded, silty shale; and thin- to medium-bedded, gray, fossiliferous limestone in upper and lower part; separated by a resistant ridge of gray, very thick- to medium-bedded, fossiliferous limestone in middle part (Coogan, 2004a, 2006a-b; this report); estimated thickness of 1850 feet (565 m) (upper tongue of Dinwoody not included) from several miles south of Weber River in Devils Slide quadrangle, about the same total thickness as to northeast in Lost Creek drainage, 1835 feet (560 m) (Coogan, 2006a-b; note about 1300 feet (400 m) in Dairy Ridge quadrangle (Coogan, 2006a).

In subsurface north of the map area, about 1930 feet (590 m) of Thaynes was cut in the American Quasar Putnam well in the Birch Creek fold belt (API 43-033-30002, Utah DOGM) and about 1700 to 1800 feet (510-540 m) was cut in the American Quasar Hoffman well near Randolph, Utah (API 43-033-30001, Utah

DOGM). In the map area, estimate 2273 feet (693 m) of Thaynes penetrated in the Amoco Deseret WIU well, but not dip corrected (King after AMSTRAT log D-4948 and API 43-029-30009, Utah DOGM well file), and 2057 feet (627 m) of Thaynes was reportedly penetrated in the Champlin 432-Amoco C well in the Peck Canyon quadrangle (see API 043-29-30011, Utah DOGM well file). Member names are after Kummel (1954). Note that Kummel's (1954) members, from about 70 miles (110 km) to the north near Bear Lake in Idaho, are recognizable near Devils Slide and that most of these members are recognizable another 25 miles (40 km) to the southwest near Salt Lake City, Utah (see Mathews, 1931; Solien and others, 1979). Member descriptions from Coogan (2004a, 2006a-b) and this report.

Jn – *Nugget Formation (Lower Jurassic).* Pale-grayish-orange, pinkish-tan, and locally white, well cemented, cross-bedded, quartz sandstone with frosted sand grains; typically about 1000 to 1100 feet (300-335 m) thick in subsurface.

Numerous subsurface thicknesses have been reported because the Nugget is a reservoir rock in the gas and oil fields near the Utah-Wyoming state line. About 1050 feet (320 m) of Nugget was cut in the American Quasar Minnow Hill well (API 43-033-30018, Utah DOGM; AMSTRAT log D-4952); about 1000 feet (300 m) of Nugget was cut in the Woodruff Narrows field Amoco 1-4H and Chevron-Amoco 1-32G wells (API 49-041-20289 and 49-041-20627 wells, WOGCC), with the 1-4H well just east of the Ogden map area. South of Woodruff Narrows 1011 feet (308 m) and 956 feet (291 m) of Nugget was cut in the Amoco Bradley and Chevron 1-35 wells (API 49-041-20509 and 49-041-20315, respectively, WOGCC), and 1040 feet (317 m) was cut in the Amoco A-MF-Chev well (after AMSTRAT log D-4943, API 43-033-30011). Farther south in the Yellow Creek field 1050 to 1150 feet (320-350 m) of Nugget was cut in the Champlin 375-Amoco C, Amoco Bradbury, Celsius [Mtn Fuel] 4-36, and Urroz wells, (API 49-041-20413, 49-041-20421, 49-041-20578, and API 49-041-20321, WOGCC), and 1050 feet (320 m) of Nugget was cut in the Anschutz 14-33 well (API 43-043-30315, Utah DOGM). In the Cave Creek field about 1100 feet (335 m) of Nugget was cut in the Champlin 846-Amoco A (API 43-043-30100, Utah DOGM well file) and Fawcett & Son wells (AMSTRAT log D-5672, API 43-043-30078). In the Anschutz Ranch East field, 1145 feet, 1118 and 1056 feet (349, 340, and 322 m) of Nugget was cut in the ARE 30-10, U14-20, and Champlin 458-Amoco D1 wells (API 43-043-30215, 43-043-30145 and 43-043-30129, respectively, Utah DOGM). In the Anschutz Ranch (west) field 1096 and 1053 feet (334 and 321 m) of Nugget was cut in the Anschutz 28-1 and 34-2 wells (API 43-043-30032 and 43-043-30106, respectively, Utah DOGM), while the 1209 feet (369 m) of Nugget was cut in the Island Ranching D-1 well (API 43-043-30161, Utah DOGM) seems too large.

Cn – *Nounan Formation (Cambrian).* Medium-dark-gray, thick-bedded dolomite and some limestone; estimated thickness 350 to 400 feet (105-120 m); see also Eardley (1944, his Cambrian units 6-8). The Nounan Formation does not appear to be present to the north of the map area in the Birch Creek fold belt (API 43-033-30042, 43-033-30043, 43-033-30028, and 43-033-30002, Utah DOGM), likely due to the unconformity that excised Silurian and Ordovician strata, and the Cambrian part of the St. Charles Formation elsewhere in the map area (see above).

Cm, Cm? – *Maxfield Limestone (Middle Cambrian).* Limestone and calcareous siltstone; estimated thickness 300 feet (60 m); see also Eardley (1944, his Cambrian units 3-5). Queried where may be

Nounan Formation (Cn). Bloomington Formation is not present on Durst Mountain. Strata in subsurface that are lithologically similar to Maxfield are called Gallatin Limestone (Cg) (Wyoming terminology).

Zkc, Zkc? – Kelley Canyon Formation (Neoproterozoic). Dark-gray to black, gray to olive-gray-weathering argillite to phyllite, with rare metacarbonate (for example basal meta-dolomite); grades into overlying Caddy Canyon quartzite with increasing quartzite; gradational interval mapped as Papoose Creek Formation (Zpc); 1000 feet (300 m) thick in Mantua quadrangle (this report), where Papoose Creek Formation is mapped separately, and reportedly 2000 feet (600 m) thick near Huntsville (Crittenden and others, 1971, figure 7), but only shown as about 1600 feet (500 m) thick to Papoose Creek transition zone by Crittenden (1972). The Kelley Canyon Formation is prone to slope failures.

Zmcg, Zmcg? – Maple Canyon Formation, Lower (green arkose) member (Neoproterozoic). Grayish-green, fine-grained arkosic (feldspathic)
meta-sandstone and sandy argillite (meta-graywacke), with local quartzite lenses up to 200 feet (60 m) thick; weathers darker gray to brown to greenish-gray and greenish-brown; 500 to 1000 feet (150-305 m) thick and lower thickness would eliminate the need for faulting in southwest part of Huntsville quadrangle. This unit is prone to slope failures.

Citations, tables, and/or figures referenced above are not provided herein but are in Coogan and King (2016).

4.3 Lake Bonneville History

Lakes occupied nearly 100 basins in the western United States during late-Quaternary time, the largest of which was Lake Bonneville in northwestern Utah. The Bonneville basin consists of several topographically closed basins created by regional extension in the Basin and Range (Gwynn, 1980; Miller, 1990), and has been an area of internal drainage for much of the past 15 million years. Lake Bonneville consisted of numerous topographically closed basins, including the Salt Lake and Cache Valleys (Oviatt and others, 1992). Portions of Ogden Valley were inundated by Lake Bonneville at its highstand and sediments from Lake Bonneville are mapped in the Project area on **Figure 3**.

Timing of events related to the transgression and regression of Lake Bonneville is indicated by calendar age estimates of significant radiocarbon dates in the Bonneville Basin (Oviatt, 2015). Approximately 30,000 years ago, Lake Bonneville began a slow transgression (rise) to its highest level of 5,160 to 5,200 feet above mean sea level. The lake rise eventually slowed as water levels approached an external basin threshold in northern Cache Valley at Red Rock Pass near Zenda, Idaho. Lake Bonneville reached the Red Rock Pass threshold and occupied its highest shoreline, termed the Bonneville beach, around 18,000 years ago. During the transgression and highstand, major drainages that emanate from within the Wasatch Range (such as the Weber River) formed large deltaic complexes in the lake at their canyon mouths. Headward erosion of the Snake River-Bonneville basin drainage divide then caused a catastrophic incision of the threshold and the lake level lowered by roughly 360 feet in fewer than two months (Jarrett and Malde, 1987; O'Conner, 1993).

Following the Bonneville flood, the lake stabilized and formed a lower shoreline referred to as the Provo shoreline between about 16,500 and 15,000 years ago. Climatic factors then caused the lake to regress rapidly from the Provo shoreline, and by about 13,000 years ago the lake had eventually dropped below historic levels of Great Salt Lake. Drainages that fed Lake Bonneville began downcutting through stranded deltaic complexes and near-shore deposits as the lake receded from the Provo shoreline. Oviatt and others (1992) deem this low stage the end of the Bonneville lake cycle. Great Salt Lake then experienced a brief transgression around 11,600 years ago to the Gilbert level at about 4,250 feet before receding to and remaining within about 20 feet of its historic average level (Lund, 1990).

4.4 Seismic Hazards

4.4.1 Strong Ground Motions

Strong ground motion is likely to present a significant risk during moderate to large earthquakes located within a 60-mile radius of the Project area (Boore and others, 1993). Seismic sources include mapped active faults, as well as a random or "floating" earthquake source on faults not evident at the surface. The Utah Geological Survey Quaternary Fault Database (Black and others, 2003; January 2017 update) shows numerous class A faults within 60 miles of the Project that may pose potential seismic sources. Strong ground motions originating from the Wasatch fault or other near-by seismic sources are capable of impacting the site. The Wasatch fault zone is considered active and capable of generating earthquakes as large as magnitude 7.3 (Arabasz and others, 1992).

4.4.2 Site Class

Utah has adopted the International Building Code (IBC) 2015. IBC 2015 determines the seismic hazard for a site based upon 2008 mapping of bedrock accelerations prepared by the United States Geologic Survey (USGS) and the soil site class. The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points). For site class definitions, IBC 2015 (Section 1613.3.2) refers to Chapter 20, Site Classification Procedure for Seismic Design, of ASCE[1] 7. Given the subsurface soils at the site, including our projection of soils within the upper 100 feet of the soil profile, it is our opinion the site best fits a Site Class D – "Stiff Soil" profile, which we recommend for seismic structural design.

4.4.3 Seismic Design Category

The 2008 USGS mapping utilized by the IBC provides values of peak ground, short period and long period accelerations for the Site Class B boundary and the Maximum Considered Earthquake (MCE). This Site Class B boundary represents average bedrock values for the Western United States and must be corrected for local soil conditions. The following table summarizes the peak ground, short period and long period accelerations for the MCE event, and incorporates the appropriate soil correction factor for a Site Class D soil profile at a near centerpoint grid coordinate of 41.248972 degrees north latitude and 111.725889 degrees west longitude, calculated with a 2% chance of exceedance in 50 years:

[1] American Society of Civil Engineers

SPECTRAL ACCELERATION VALUE, T	SITE CLASS B BOUNDARY [Mapped Values] (g)	SITE COEFFICIENT	SITE CLASS D [Adjusted for Site Class Effects] (g)	DESIGN VALUES (g)
Peak Ground Acceleration	0.308	F_a = 1.192	0.367	0.245
Short Period Acceleration (0.2 Seconds)	S_S = 0.770	F_a = 1.192	S_{MS} = 0.918	S_{DS} = 0.612
Short Period Acceleration (1.0 Second)	S_1 = 0.256	F_v = 1.888	S_{M1} = 0.483	S_{D1} = 0.322

4.4.4 Surface Faulting

Movement along faults at depth generates earthquakes. During earthquakes larger than Richter magnitude 6.5, ruptures along normal faults in the intermountain region generally propagate to the surface (Smith and Arabasz, 1991) as one side of the fault is uplifted and the other side down dropped. The resulting fault scarp has a near-vertical slope. The surface rupture may be expressed as a large singular rupture or several smaller ruptures in a broad zone. Ground displacement from surface fault rupture can cause significant damage or even collapse to structures located on an active fault.

No evidence of active surface faulting is mapped or was evident at the site. The nearest active (Holocene-age) fault to the site is the Weber segment of the WFZ about 10.3 miles to the west. Surface faulting is not considered to pose a risk to the site.

4.4.5 Liquefaction

Liquefaction is a phenomenon whereby loose, saturated, granular soil units lose a significant portion of their shear strength due to excess pore water pressure buildup resulting from dynamic loading, such as that caused by an earthquake. Among other effects, liquefaction can result in densification of such deposits causing settlements of overlying layers after an earthquake as excess pore water pressures are dissipated. Horizontally continuous liquefied layers may also have a potential to spread laterally where sufficient slope or free-face conditions exist. The primary factors affecting liquefaction potential of a soil deposit are: (1) magnitude and duration of seismic ground motions; (2) soil type and consistency; and (3) occurrence and depth to groundwater.

Liquefaction potential hazards have not been studied or mapped for the Project area, but subsurface data from the test pits suggest soils susceptible to liquefaction are not likely present in the near surface.

4.4.6 Tectonic Subsidence

Tectonic Subsidence is surface tilting subsidence that occurs along the boundaries of normal faults in response to surface-faulting earthquakes (Keaton, 1986). The site is not located in near proximity to active earthquake faults and tectonic subsidence is not therefore considered to pose a risk.

4.5 Landslide and Slump Deposits

Landslides, slumps, and other mass movements are gravity-induced downslope movements of rock or soil. Such failures may be both deep and shallow seated. Deep-seated failures include rotational and translational slides and associated earthflows where the failure plane is more than 10 feet deep (Varnes, 1978; Cruden and Varnes, 1996). Landslides can develop in moderate to steep slopes where a slope has been disturbed, the head of a slope loaded, or where increased groundwater pore pressures result in driving forces within the slope exceeding restraining forces.

No landslides are mapped at the site or in adjacent slopes and no evidence of landsliding or ongoing slope instability was identified at the Project. Given the above, landslides are not considered to pose a risk.

4.6 Other Geologic Hazards

Other potential geologic hazards at the site are addressed in the following subsections.

4.6.1 Sloping Surfaces

Surface slopes at the Project developed from our LiDAR analysis, as shown on **Figure 4**, are generally gentler than 15%. Areas steeper than 30% on **Figure 4** are found only in stream bank areas along the South Fork Ogden River.

4.6.2 Alluvial Fan Flooding

Alluvial-fan flooding refers to a continuum of processes that includes debris slides, debris flows, debris floods, and flash flooding on alluvial fans (National Research Council, 1996). Debris flows and related sediment-enriched floods and flows are fast moving flow-type landslides comprised of a slurry of rock, mud, organic matter, and water that move down drainage-basin channels onto alluvial fans (Giraud, 2005). Debris flow hazards are commonly associated with areas underlain by Holocene alluvial-fan deposits at the mouths of range-front drainages, such as those along the Wasatch Range.

The Project is not in an area subject to alluvial-fan flooding and no debris-flow channels, levees, or other debris-flow features were observed. Debris flows and floods are not considered to pose a risk to the site.

4.6.3 Stream Flooding Hazards

Portions of the Project are located in Federal Emergency Management Agency flood zone AE associated with the North and South Branches of South Fork Ogden River. Zone AE includes the 100-year flood hazard zone as delimited by recent FEMA (2015) studies conducted in the Ogden Valley area. On the basis of the FEMA determination *...mandatory flood insurance purchase requirements and floodplain management standards apply...*for improvements made in the Zone AE area. River courses, flood zone boundaries, and setbacks (as determined by Reeve & Associates, Inc.) are shown on **Figure 2**.

4.6.4 Rockfall and Avalanche Hazards

The site is not located downslope from steep slope areas where such hazards may originate.

5.0 SITE CONDITIONS

5.1 Surface Conditions

The site conditions and site geology were interpreted through an integrated compilation of data, including a review of literature and mapping from previous studies conducted in the area (Coogan and King, 2016); photogeologic analyses of 2012 imagery shown on **Figure 2**; GIS analyses of elevation and geoprocessed 2016 LiDAR terrain data as shown on **Figure 4**; field reconnaissance of the general site area; and interpretation of the test pits conducted at the site as part of our field program. Seismic hazards information was developed from United States Geologic Survey (USGS) databases (Peterson and others, 2008).

As shown on Figure 2, the site consists of an area of 29.024 acres in size that is presently vacant and/or developed for agricultural use. Vegetative cover consists mainly of grasses, brush, and mature trees. The site straddles the floodplain of South Fork Ogden River, which includes a north and a south branch. The north branch flows westward across the northwest site corner, whereas the south branch flows southwestward across the middle of the northern part of the Project. The surrounding area is generally developed for rural residential and agricultural uses. Topography of the site is generally flat.

5.2 Subsurface Soils

Eight test pits were excavated throughout the property to evaluate subsurface soil conditions at the locations indicated on **Figure 5**. Detailed stratigraphic unit descriptions are shown on the test pit logs (**Figures 6 through 13**). All of the test pits exposed stream alluvium comprised of sand, gravel, cobbles, boulders, and lesser silt deposited by South Fork Ogden River since Holocene time. No groundwater was encountered in any of the test pits to their explored depths of 11 to 13 feet.

5.3 Groundwater

Groundwater was not encountered in the test pits conducted at the site for our evaluation to their maximum explored depths of about 11 to 13 feet below the existing ground surface. However, groundwater levels may vary locally in close proximity to active drainages, as well as annually from climatic fluctuations, seasonally from snow-melt runoff or from man-made sources such as landscape irrigation. Although some groundwater fluctuations may occur, we do not anticipate groundwater will significantly affect the proposed construction.

5.4 Site Subsurface Variations

Based on the results of the subsurface explorations and our experience, variations in the continuity and nature of subsurface conditions should be anticipated. Due to the heterogeneous characteristics of natural soils, care should be taken in interpolating or extrapolating subsurface conditions between or beyond the exploratory locations.

Also, when logging and sampling of the test pits was completed, the test pits were backfilled with the excavated soils but minimal to no effort was made to compact these soils. Test pit backfill soils must be considered non-engineered/undocumented. Thus, settlement of the backfill in the test pits over time should be anticipated, and footings should not be placed over such areas without removal/replacement or other approved mitigation.

6.0 SITE PREPARATION AND GRADING

6.1 General

All deleterious materials should be stripped from the site prior to commencement of construction activities. This includes loose and disturbed soils, topsoil, vegetation, etc. The removal of any surface vegetation, topsoil, and any other deleterious materials shall extend out at least 3 feet beyond new structures and 2 feet beyond pavements. Based upon the conditions observed in the test pits there is topsoil on the surface of the site which we estimated to be about 12 inches (plus or minus) in thickness. When stripping and grubbing, topsoil should be distinguished by the apparent organic content and not solely by color; thus we estimate that topsoil stripping will need to include at least the upper 6 inches. Where scrub oak exists and is removed, larger roots (greater than about ½ inch) will likely extend deeper and should be removed beneath the residence in those localized areas. Also, any existing undocumented fill shall be removed from beneath the structure.

The site should be examined by a CMT geotechnical engineer to assess that suitable natural soils have been exposed and any deleterious materials, loose and/or disturbed soils have been removed, prior to placing site grading fills, footings, slabs, and pavements.

Any fill should be placed on relatively level surfaces and against relatively vertical surfaces. Thus, where the existing slope is steeper than about 5H:1V (Horizontal:Vertical), the existing ground should be benched to create horizontal and vertical surfaces for receiving the fill. We recommend maximum bench heights of about 3 feet.

6.2 Temporary Excavations

Excavations deeper than about 10 feet are not anticipated at the site. Groundwater was not encountered within the depths explored, up to about 13 feet at the time of our field explorations, and thus is not anticipated to affect excavations.

The natural soils encountered at this site predominantly consisted of relatively clean, cohesionless sands and gravels. For cohesionless (sandy/gravelly) soils, temporary construction excavations not exceeding 4 feet in depth should be no steeper than one-half horizontal to one vertical (0.5H:1V). For excavations up to 8 feet and above groundwater, side slopes should be no steeper than one horizontal to one vertical (1H:1V). Excavations encountering saturated cohesionless soils will be very difficult to maintain and will require very flat side slopes and/or shoring, bracing and dewatering and these soils will tend to flow into the excavation. Where excavations extend below groundwater, the need for shoring must be anticipated.

In cohesive (clayey) soils, if encountered, temporary construction excavations not exceeding 4 feet in depth may be constructed with near-vertical side slopes. Temporary excavations up to 8 feet deep, above or below groundwater, may be constructed with side slopes no steeper than one-half horizontal to one vertical (0.5H:1V). Excavations deeper than 8 feet are not anticipated at the site.

All excavations must be inspected periodically by qualified personnel. If any signs of instability or excessive sloughing are noted, immediate remedial action must be initiated. All excavations should be made following OSHA safety guidelines.

6.3 Fill Material

Structural fill is defined as all fill which will ultimately be subjected to structural loadings, such as imposed by footings, floor slabs, pavements, etc. Structural fill will be required as backfill over foundations and utilities, as site grading fill, and as replacement fill below footings. All structural fill must be free of sod, rubbish, topsoil, frozen soil, and other deleterious materials.

Following are our recommendations for the various fill types we anticipate will be used at this site:

Fill Material Type	Description/Recommended Specification
Structural Fill	Placed below structures, flatwork and pavement. Imported structural fill should consist of well-graded sand/gravel mixture, with maximum particle size of 4 inches, a minimum 70% passing 3/4-inch sieve, a maximum 20% passing the No. 200 sieve, and a maximum Plasticity Index of 10.
Site Grading Fill	Placed over larger areas to raise the site grade. Sandy to gravelly soil, with a maximum particle size of 6 inches, a minimum 70% passing 3/4-inch sieve, and a maximum 40% passing No. 200 sieve.
Non-Structural Fill	Placed below non-structural areas, such as landscaping. On-site soils or imported soils, with a maximum particle size of 8 inches, including silt/clay soils not containing excessive amounts of degradable/organic material.
Stabilization Fill	Placed to stabilize soft areas prior to placing structural fill and/or site grading fill. Coarse angular gravels and cobbles 1 inch to 8 inches in size. May also use 1.5- to 2.0-inch gravel placed on stabilization fabric, such as Mirafi RS280i, or equivalent (see **Section 6.5**).

On-site soils are primarily granular and may be re-utilized as structural fill if screened/processed to meet the requirements for such. All fill material should be approved by a CMT geotechnical engineer prior to placement.

6.4 Fill Placement and Compaction

The various types of compaction equipment available have their limitations as to the maximum lift thickness that can be compacted. For example, hand operated equipment is limited to lifts of about 4 inches and most "trench compactors" have a maximum, consistent compaction depth of about 6 inches. Large rollers, depending on soil and moisture conditions, can achieve compaction at 8 to 12 inches. The full thickness of each lift should be compacted to at least the following percentages of the maximum dry density as determined by ASTM D-1557 (or AASHTO[2] T-180) in accordance with the following recommendations:

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Beneath an area extending at least 4 feet beyond the perimeter of structures, and below flatwork and pavement (applies to structural fill and site grading fill)	0 to 5 5 to 8	95 98
Site grading fill outside area defined above	0 to 5 5 to 8	92 95
Utility trenches within structural areas	--	96
Roadbase and subbase	-	96
Non-structural fill	0 to 5 5 to 8	90 92

Structural fills greater than 8 feet thick are not anticipated at the site. For best compaction results, we recommend that the moisture content for structural fill/backfill be within 2% of optimum. Field density tests should be performed on each lift as necessary to verify that proper compaction is being achieved.

6.5 Utility Trenches

For the bedding zone around the utility, we recommend utilizing sand bedding fill material that meets current APWA[3] requirements.

All utility trench backfill material below structurally loaded facilities (foundations, floor slabs, flatwork, parking lots/drive areas, etc.) should be placed at the same density requirements established for structural fill in the previous section.

Most utility companies and City-County governments are now requiring that Type A-1a or A-1b (AASHTO Designation – basically granular soils with limited fines) soils be used as backfill over utilities. Processed

[2] American Association of State Highway and Transportation Officials
[3] American Public Works Association

natural on-site soil may meet these requirements. These organizations are also requiring that in public roadways the backfill over major utilities be compacted over the full depth of fill to at least 96 percent of the maximum dry density as determined by the AASHTO T-180 (ASTM D-1557) method of compaction. We recommend that as the major utilities continue onto the site that these compaction specifications are followed.

Where the utility does not underlie structurally loaded facilities and public rights of way, on-site soils may be utilized as trench backfill above the bedding layer, provided they are properly moisture conditioned and compacted to the minimum requirements stated above in **Section 6.4**.

6.6 Soil Stabilization

To stabilize soft subgrade conditions (if encountered), a mixture of coarse, clean, angular gravels and cobbles and/or 1.5- to 2.0-inch clean gravel should be utilized, as indicated above in **Section 6.3**. Often the amount of gravelly material can be reduced with the use of a geotextile fabric such as Mirafi RS280i or equivalent. Its use will also help avoid mixing of the subgrade soils with the gravelly material. After excavating the soft/disturbed soils, the fabric should be spread across the bottom of the excavation and up the sides a minimum of 18 inches. Otherwise, it should be placed in accordance with the manufacturer's recommendation, including proper overlaps. The gravel material can then be placed over the fabric in compacted lifts as described above.

7.0 FOUNDATION RECOMMENDATIONS

The following recommendations have been developed on the basis of the previously described project characteristics, including the maximum loads discussed in **Section 1.3**, the subsurface conditions observed in the field and the laboratory test data, and standard geotechnical engineering practice.

7.1 Foundation Recommendations

Based on our geotechnical engineering analyses, the proposed residences may be supported upon conventional spread and/or continuous wall foundations placed on suitable, undisturbed natural granular soils and/or on structural fill extending to suitable natural soils. Footings may then be designed using a net bearing pressure of 2,500 psf. The term "net bearing pressure" refers to the pressure imposed by the portion of the structure located above lowest adjacent final grade, thus the weight of the footing and backfill to lowest adjacent final grade need not be considered. The allowable bearing pressure may be increased by 1/3 for temporary loads such as wind and seismic forces.

We also recommend the following:

1. Exterior footings subject to frost should be placed at least 36 inches below final grade.
2. Interior footings not subject to frost should be placed at least 16 inches below grade.
3. Continuous footing widths should be maintained at a minimum of 18 inches.
4. Spot footings should be a minimum of 24 inches wide.

7.2 Installation

Under no circumstances shall foundations be placed on undocumented fill, topsoil with organics, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water.

Deep, large roots may be encountered where trees and larger bushes are located or were previously located at the site; such large roots should be removed. If unsuitable soils are encountered, they must be completely removed and replaced with properly compacted structural fill. Excavation bottoms should be examined by a qualified geotechnical engineer to confirm that suitable bearing materials soils have been exposed.

All structural fill should meet the requirements for such, and should be placed and compacted in accordance with **Section 6** above. The width of structural replacement fill below footings should be equal to the width of the footing plus 1 foot for each foot of fill thickness. For instance, if the footing width is 2 feet and the structural fill depth beneath the footing is 2 feet, the fill replacement width should be 4 feet, centered beneath the footing.

7.3 Estimated Settlement

Foundations designed and constructed in accordance with our recommendations could experience some settlement, but we anticipate that total settlements of footings founded as recommended above will not exceed 1 inch, with differential settlements on the order of 0.5 inches over a distance of 25 feet. We expect approximately 50% of the total settlement to initially take place during construction.

7.4 Lateral Resistance

Lateral loads imposed upon foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footings and the supporting soils. In determining frictional resistance, a coefficient of 0.40 may be utilized for the natural granular soils or for granular structural fill in design. Passive resistance provided by properly placed and compacted structural fill may be considered equivalent to a fluid with a density of 350 pcf. A combination of passive earth resistance and friction may be utilized if the friction component of the total is divided by 1.5.

8.0 LATERAL EARTH PRESSURES

We project that basement walls up to 8 feet tall might be constructed at this site. Parameters, as presented within this section, are for backfills which will consist of drained granular soil placed and compacted in accordance with the recommendations presented herein.

The lateral pressures imposed upon subgrade facilities will, therefore, be basically dependent upon the relative rigidity and movement of the backfilled structure. For active walls, such as retaining walls which can move outward (away from the backfill), backfill may be considered equivalent to a fluid with a density of 35 pounds per cubic foot in computing lateral pressures. For more rigid walls (moderately yielding), backfill may be considered equivalent to a fluid with a density of 45 pounds per cubic foot. For very rigid non-yielding walls, granular backfill should be considered equivalent to a fluid with a density of at least 55 pounds per cubic foot. The above values assume that the surface of the soils slope behind the wall is horizontal and that the fill within 3 feet of the wall will be compacted with hand-operated compacting equipment.

For seismic loading of retaining/below-grade walls, the following uniform lateral pressures, in pounds per square foot (psf), should be added based on wall depth and wall case.

Uniform Lateral Pressures			
Wall Height (Feet)	Active Pressure Case (psf)	Moderately Yielding Case (psf)	At Rest/Non-Yielding Case (psf)
4	15	38	61
6	23	57	92
8	30	76	123

9.0 FLOOR SLABS

Floor slabs may be established upon suitable, undisturbed, natural soils and/or on structural fill extending to suitable natural soils (same as for foundations). Under no circumstances shall floor slabs be established directly on any topsoil, non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water.

In order to facilitate curing of the concrete, we recommend that floor slabs be directly underlain by at least 4 inches of "free-draining" fill, such as "pea" gravel or 3/4-inch to 1-inch minus, clean, gap-graded gravel. To help control normal shrinkage and stress cracking, the floor slabs may include have the following features:

1. Adequate reinforcement for the anticipated floor loads with the reinforcement continuous through interior floor joints;
2. Frequent crack control joints; and
3. Non-rigid attachment of the slabs to foundation walls and bearing slabs.

10.0 DRAINAGE RECOMMENDATIONS

10.1 Surface Drainage

It is important to the long-term performance of foundations and floor slabs that water not be allowed to collect near the foundation walls and infiltrate into the underlying soils. We recommend the following:

1. All areas around the structure should be sloped to provide drainage away from the foundations. We recommend a minimum slope of 4 inches in the first 10 feet away from the structure. This slope should be maintained throughout the lifetime of the structure.

2. All roof drainage should be collected in rain gutters with downspouts designed to discharge at least 10 feet from the foundation walls or well beyond the backfill limits, whichever is greater.

3. Adequate compaction of the foundation backfill should be provided. We suggest a minimum of 90% of the maximum laboratory density as determined by ASTM D-1557. Water consolidation methods should not be used under any circumstances.

4. Landscape sprinklers should be aimed away from the foundation walls. The sprinkling systems should be designed with proper drainage and be well-maintained. Over watering should be avoided.

5. Other precautions that may become evident during construction.

11.0 PAVEMENTS

All pavement areas must be prepared as discussed above in **Section 6.1**. However, it must be understood that over time settlement of any non-engineered fill soils left in place below the prepared section could result in distress to the pavements and flatwork requiring maintenance and/or repair. Under no circumstances shall pavements be established over topsoil, unprepared non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water.

We anticipate that the existing sandy and gravely soils, if properly prepared, will exhibit fair pavement support characteristics when saturated or nearly saturated. Based on our laboratory testing experience with similar soils, our pavement design utilized a California Bearing Ratio (CBR) of 10 for these soils.

Given the projected traffic as discussed above in **Section 1.3**, the following pavement sections are recommended for approximately 6 ESAL's (18-kip equivalent single-axle loads) per day:

MATERIAL	PAVEMENT SECTION THICKNESS (inches)	
Asphalt	**3**	**3**
Road-Base	**8**	**4**
Subbase	**0**	**6**
Total Thickness	**11**	**13**

Untreated base course (UTBC) should conform to city specifications, or to 1-inch-minus UDOT specifications for A–1-a/NP, and have a minimum CBR value of 70%. Material used for subbase shall have a minimum CBR of 30%. Roadbase and subbase material should be compacted as recommended above in **Section 6.4**. Asphalt material generally should conform to APWA requirements, having a ½-inch maximum aggregate size, a 75-gyration Superpave mix containing no more than 15% of recycled asphalt (RAP) and a PG58-28 binder.

Site concrete should be designed in accordance with the American Concrete Institute (ACI) and joint details should conform to the Portland Cement Association (PCA) guidelines. The concrete should have a minimum 28-day unconfined compressive strength of 4,000 pounds per square inch and contain 6 percent ±1 percent air-entrainment.

12.0 QUALITY CONTROL

We recommend that CMT be retained to as part of a comprehensive quality control testing and observation program. With CMT on-site we can help facilitate implementation of our recommendations and address, in a timely manner, any subsurface conditions encountered which vary from those described in this report. Without such a program CMT cannot be responsible for application of our recommendations to subsurface conditions which may vary from those described herein. This program may include, but not necessarily be limited to, the following:

12.1 Field Observations

Observations should be completed during all phases of construction such as site preparation, foundation excavation, structural fill placement and concrete placement.

12.2 Fill Compaction

Compaction testing by CMT is required for all structural supporting fill materials. Maximum Dry Density (Modified Proctor, ASTM D-1557) tests should be requested by the contractor immediately after delivery of any fill materials. The maximum density information should then be used for field density tests on each lift as necessary to ensure that the required compaction is being achieved.

12.3 Excavations

All excavation procedures and processes should be observed by a geotechnical engineer from CMT or their representative. In addition, for the recommendations in this report to be valid, all backfill and structural fill placed in trenches and all pavements should be density tested by CMT. We recommend that freshly mixed concrete be tested by CMT in accordance with ASTM designations.

13.0 LIMITATIONS

The recommendations provided herein were developed by evaluating the information obtained from the subsurface explorations and soils encountered therein. The exploration logs reflect the subsurface conditions only at the specific location at the particular time designated on the logs. Soil and ground water conditions may differ from conditions encountered at the actual exploration locations. The nature and extent of any variation in the explorations may not become evident until during the course of construction. If variations do appear, it may become necessary to re-evaluate the recommendations of this report after we have observed the variation.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

We appreciate the opportunity to be of service to you on this project. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (801) 870-6730. To schedule materials testing, please call (801) 381-5141.

14.0 REFERENCES

Anderson, R.E., 1989, Tectonic evolution of the intermontane system--Basin and Range, Colorado Plateau, and High Lava Plains, in Pakiser, L.C., and Mooney, W.D., editors, Geophysical framework of the continental United States: Geological Society of America Memoir 172, p. 163-176.

Arabasz, W.J., Pechmann, J.C., and Brown, E.D., 1992, Observational seismology and evaluation of earthquake hazards and risk in the Wasatch Front area, Utah, in Gori, P.L. and Hays, W.W., editors, Assessment of Regional Earthquake Hazards and Risk along the Wasatch Front, Utah: Washington, D.C, U.S. Geological Survey Professional Paper 1500-D, Government Printing Office, p. D1-D36.

Avery, Charles, 1994, Ground-water hydrology of Ogden Valley and surrounding area, eastern Weber County, Utah and simulation of ground-water flow in the valley-fill aquifer system: Utah Department of Natural Resources, Technical Publication no.99, 84 p.

Black, B.D., Hecker, Suzanne, Hylland, M.D., Christenson, G.E., and McDonald, G.N., 2003, Quaternary fault and fold database and map of Utah: Utah Geological Survey Map 193DM, CD-ROM.

Boore, D.M., Joyner, W.B., and Fumal, T.E., 1993, Estimation of Response Spectra and Peak Acceleration from Western North America Earthquakes--An interim report: U.S. Geological Survey Open-File Report 93-509.

Bowman, S.D., and Lund, W.R., 2016, Guidelines for conducting engineering-geology investigations and preparing engineering-geology reports in Utah, in Bowman, S.D., and Lund, W.R., editors, Guidelines for investigating geo¬logic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah: Utah Geological Survey Circular 122, p. 15–30.

Coogan, J.C., and King, J.K., 2016, Interim Geologic Map of the Ogden 30' x 60' Quadrangle, Box Elder, Cache, Davis, Morgan, Rich, and Summit Counties, Utah, and Uinta County, Wyoming: Utah Geological Survey Open-File Report 653DM, scale 1:100,000, 141 p. with appendices.

FEMA 2015, Flood Insurance Rate Map, Weber County, Utah, Panel 49057CO263F (6/2/2015) Scale 1 inch equals 1000 feet.

Gilbert, G.K., 1928, Studies of Basin and Range Structure: U.S. Geological Survey Professional Paper 153, 89 p.

Gwynn, J.W. (Editor), 1980, Great Salt Lake--A scientific, historical, and economic overview: Utah Geological Survey Bulletin 166, 400 p.

Jarrett, R.D., and Malde, H.E., 1987, Paleodischarge of the late Pleistocene Bonneville flood, Snake River, Idaho, computed from new evidence: Geological Society of America Bulletin, v. 99, p. 127-134.

Keaton, J.R., 1986, Potential consequences of tectonic deformation along the Wasatch fault: Utah State University, Final Technical Report to the U.S. Geological Survey for the National Earthquake Hazards Reduction Program, Grant 14-08-0001-G0074, 23 p.

King, J.K., and McDonald, G.N., 2014, Progress report geologic map of the North Ogden quadrangle, Weber County, Utah: Utah Geological Survey files, scale 1:24,000.

Lund, W.R. (Editor), 1990. Engineering geology of the Salt Lake City metropolitan area, Utah: Utah Geological and Mineral Survey Bulletin 126, 66 p.

Miller, D.M., 1990, Mesozoic and Cenozoic tectonic evolution of the northeastern Great Basin, in Shaddrick, D.R., Kizis, J.R., and Hunsaker, E.L. III, editors, Geology and Ore Deposits of the Northeastern Great Basin: Geological Society of Nevada Field Trip No. 5, p. 43-73.

O'Connor, J.E., 1993, Hydrology, hydraulics, and geomorphology of the Bonneville flood: Geological Society of America Special Paper 274, 83 p.

Oviatt, C.G., 2015, Chronology of Lake Bonneville, 30,000 to 10,000 yr B.P.: Quaternary Science Reviews, v. 110 (2015), p. 166-171.

Oviatt, C.G., Currey, D.R., and Sack, Dorothy, 1992, Radiocarbon chronology of Lake Bonneville, Eastern Great Basin, USA: Paleogeography, Paleoclimatology, Paleoecology, v. 99, p. 225-241.

Petersen, M.D., Frankel, A.D., Harmsen, S.C., Mueller, S.C., Haller, K.M., Wheeler, R.L., Wesson, R.L., Zeng, Y., Boyd, O.S., Perkins, D.M., Luco, N., Field, E.H., Wills, C.J., and Rukstales, K.S., 2008, Documentation for the 2008 Update of the United States National Seismic Hazard Maps: USGS Open-File Report 2008-1128, 128p.

Sbar, M.L., Barazangi, M., Dorman, J., Scholz, C.H., and Smith, R.B., 1972, Tectonics of the Intermountain Seismic Belt, western United States--Microearthquake seismicity and composite fault plane solutions: Geological Society of America Bulletin, v. 83, p. 13-28.

Smith, R.B., and Arabasz, W.J., 1991, Seismicity of the Intermountain Seismic Belt, in Slemmons, D.B., Engdahl, E.R., Zoback, M.D., and Blackwell, D.D., editors, Neotectonics of North America: Geological Society of America, Decade of North American Geology Map v. 1, p. 185-228.

Smith, R.B. and Sbar, M.L., 1974, Contemporary tectonics and seismicity of the western United States with emphasis on the Intermountain Seismic Belt: Geological Society of America Bulletin, v. 85, p. 1205-1218.

Stewart, J.H., 1978, Basin-range structure in western North America, a review, in Smith, R.B., and Eaton, G.P., editors, Cenozoic tectonics and regional geophysics of the western Cordillera: Geological Society of America Memoir 152, p. 341-367.

____, 1980, Geology of Nevada: Nevada Bureau of Mines and Geology Special Publication 4.

Stokes, W.L., 1977, Physiographic subdivisions of Utah: Utah Geological and Mineral Survey Map 43, scale 1:2,400,000.

____, 1986, Geology of Utah: Salt Lake City, University of Utah Museum of Natural History and Utah Geological and Mineral Survey, 280 p.

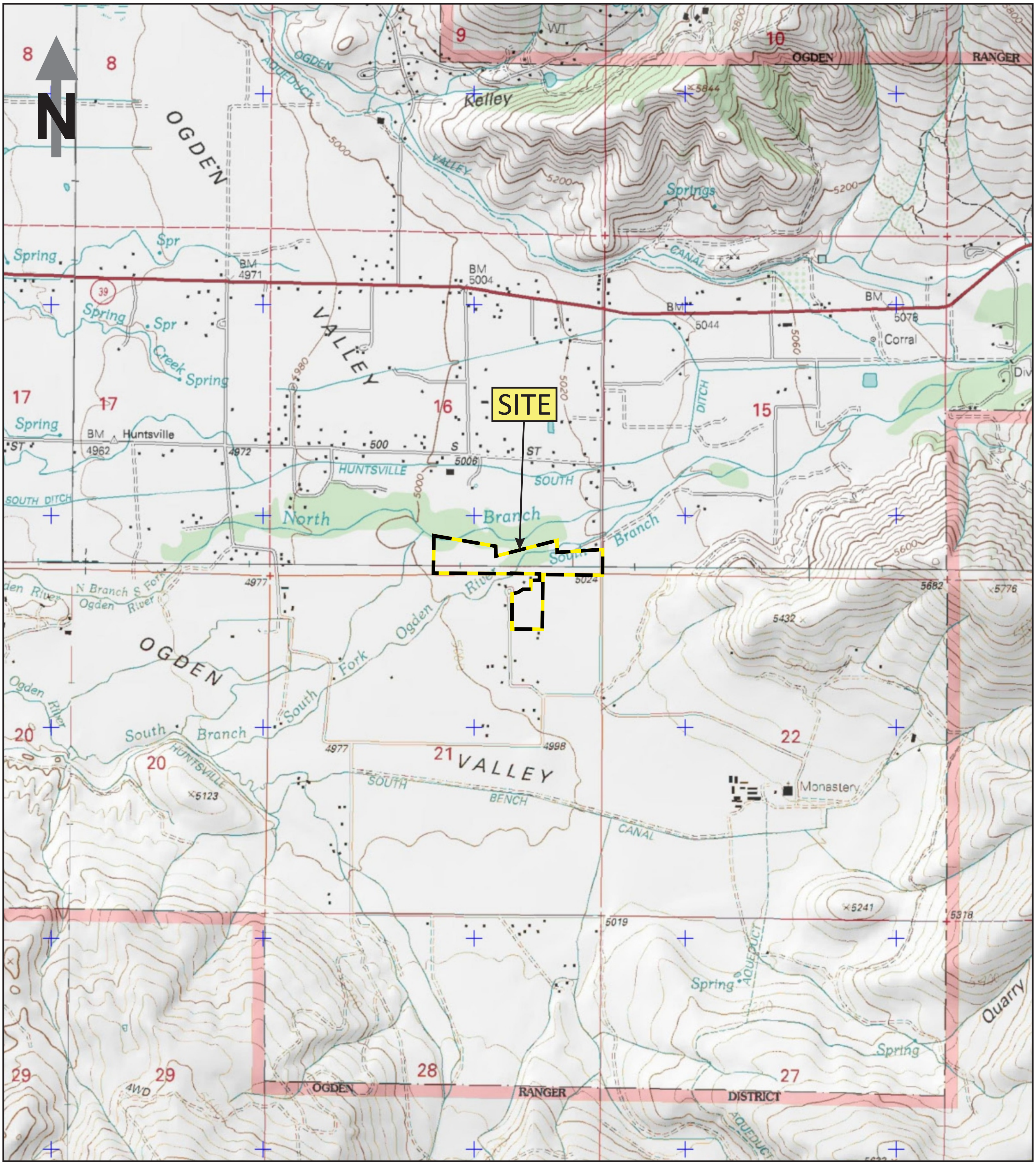
Sullivan, J.T., Nelson, A.R., LaForge, R.C., Wood, C.K., and Hansen, R.A., 1986, Regional seismotectonic study for the back valleys of the Wasatch Mountains in northeastern Utah: Denver, Colorado, U.S. Bureau of Reclamation, Seismotectonic Section, Division of Geology, Engineering and Research Center, unpublished report, 317 p.

Zoback, M.L., 1989. State of stress and modern deformation of the northern Basin and Range province: Journal of Geophysical Research, v. 94, p. 7105-7128.

Zoback, M.L. and Zoback, M.D., 1989. Tectonic stress field of the conterminous United States: Boulder, Colorado, Geological Society of America Memoir, v. 172, p. 523-539.

APPENDIX

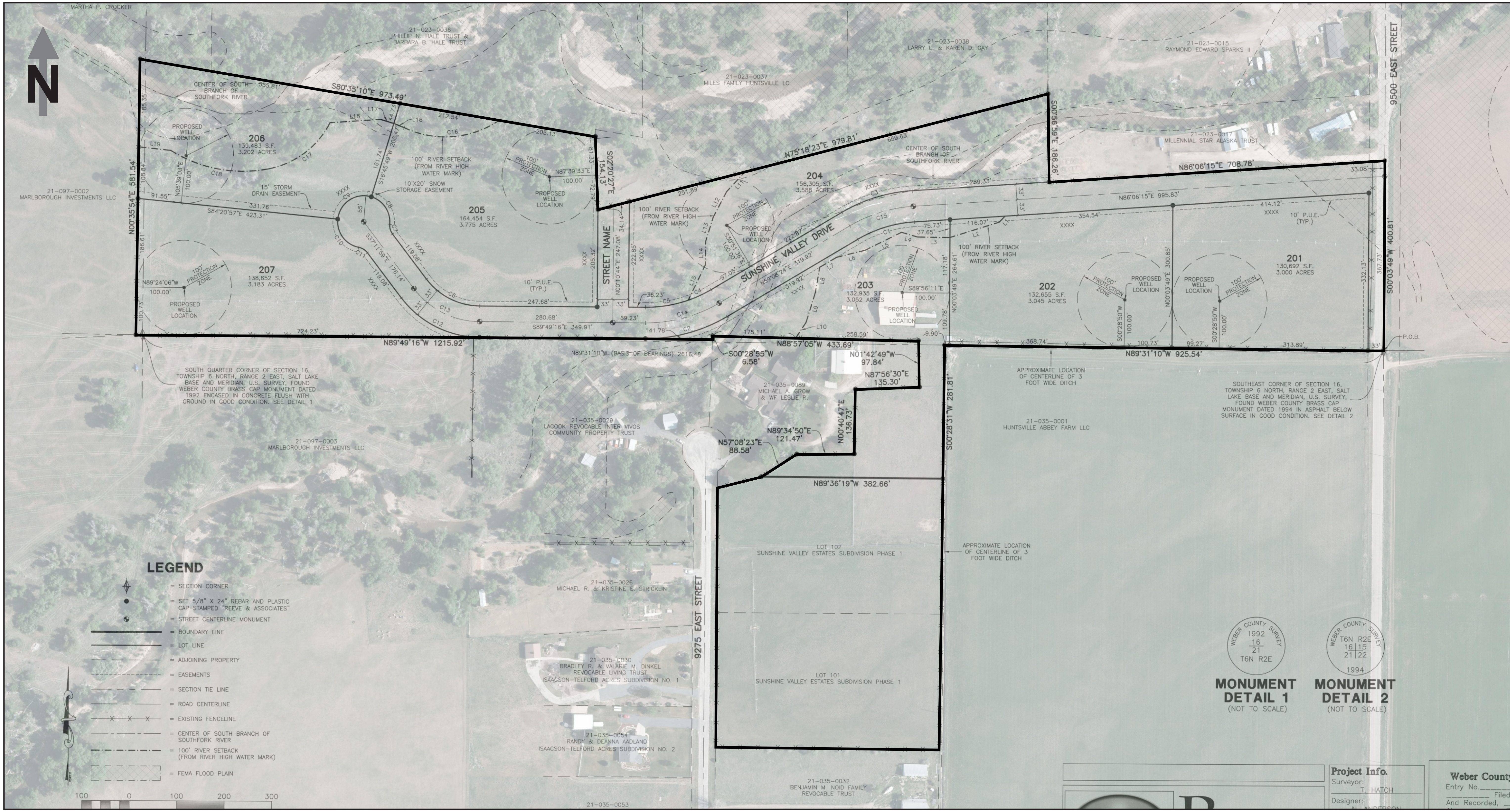
SUPPORTING DOCUMENTATION



Base:
USGS 7.5-minute topographic quadrangle, Utah; DURST MOUNTAIN, 1998.

0 2,000 ft 4,000 ft
1:24,000 (1 inch equals 2,000 feet)

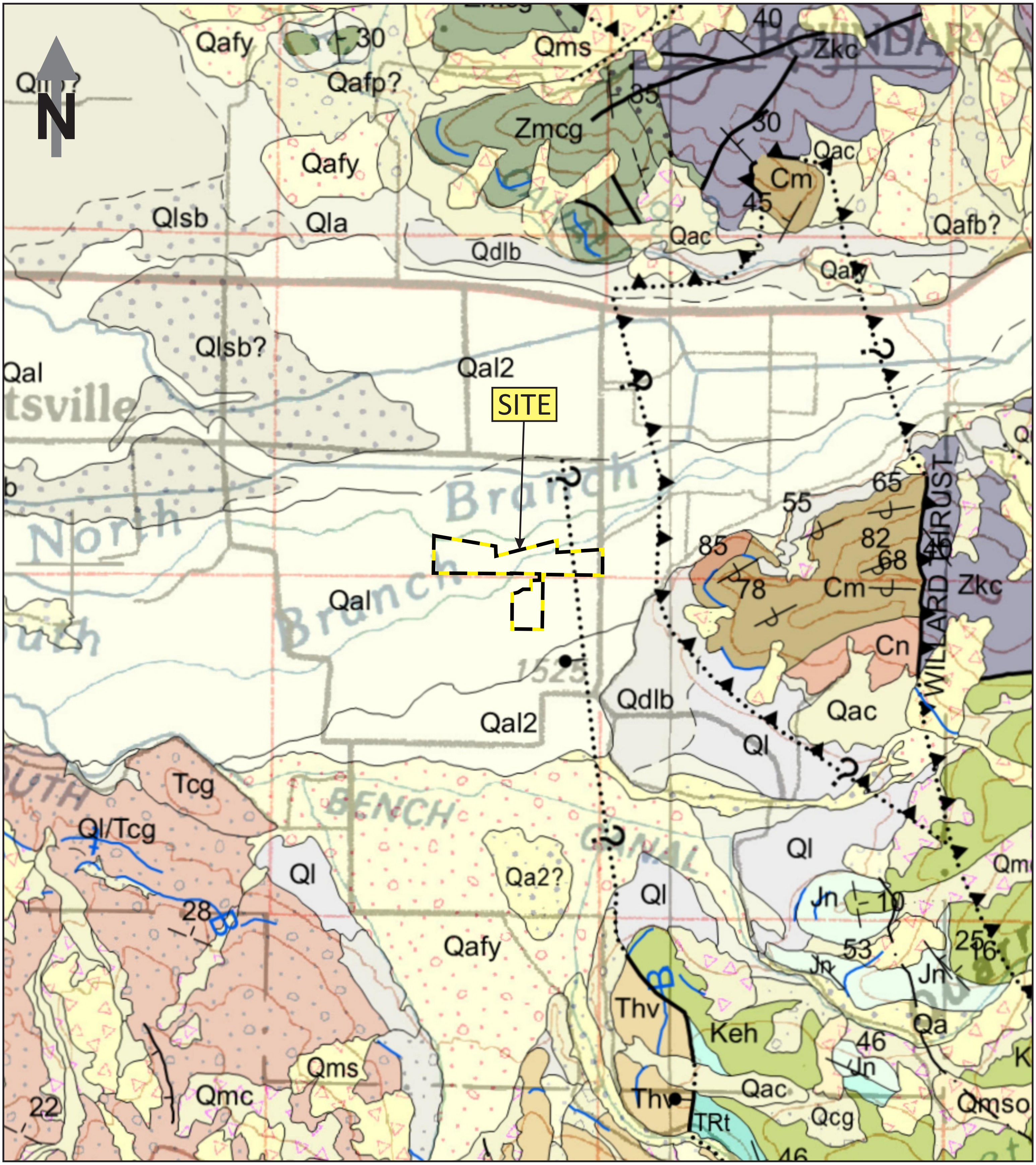
Proposed Sunshine Valley Estates About 9275 East Sunshine Valley Drive, Huntsville, Utah	CMT ENGINEERING LABORATORIES		Figure 1
	Vicinity Map	Date: 12-Apr-2019 Job # 12557	



Base:
Site plan prepared by Reeve & Associates, Inc. dated November 6, 2018
and 2012 Utah AGRC high-resolution orthophoto, 12.5 cm resolution.

0 200 ft 400 ft
1:24,000 (1 inch equals 200 feet)

CMT ENGINEERING LABORATORIES	Proposed Sunshine Valley Estates About 9275 East Sunshine Valley Drive, Huntsville, Utah	Site Plan	Date: 12-Apr-2019 CMT No.: 12557	Figure 2



Base:
Interim Geologic Map of the Ogden 30' x 60' Quadrangle (Coogan and King, 2016).

0 2,000 ft 4,000 ft
1:24,000 (1 inch equals 2,000 feet)

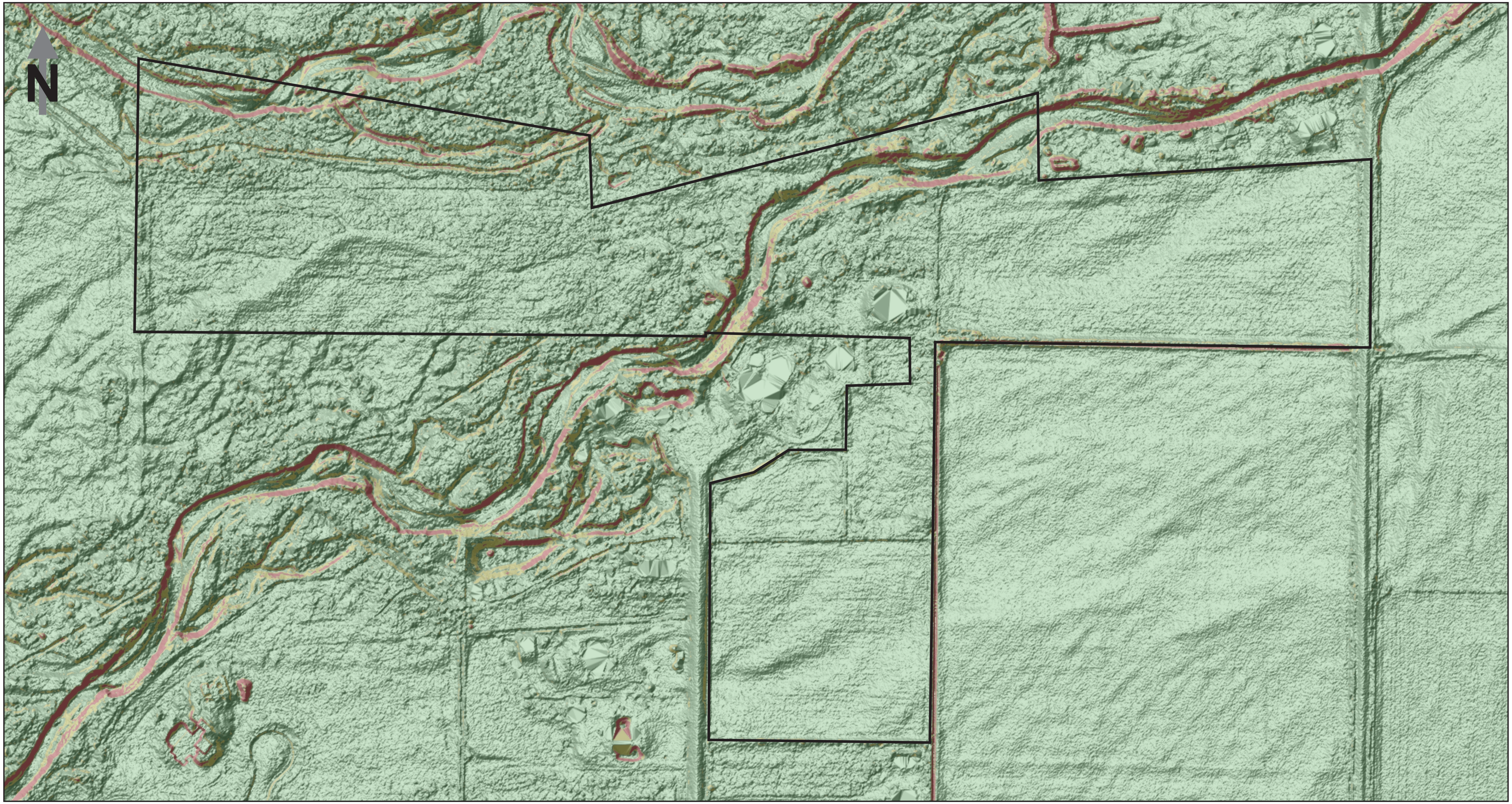
Proposed Sunshine Valley Estates
About 9275 East Sunshine Valley Drive, Huntsville, Utah

CMT ENGINEERING LABORATORIES

Geologic Map

Date:	12-Apr-2019
Job #	12557

Figure 3



Base:
2016 LIDAR imagery available from Utah AGRC, 0.5 m resolution; slope steepness >30% shaded in red, 15-30% in yellow, and <15% in green.

0 200 ft 400 ft

1:24,000 (1 inch equals 200 feet)

CMT ENGINEERING LABORATORIES

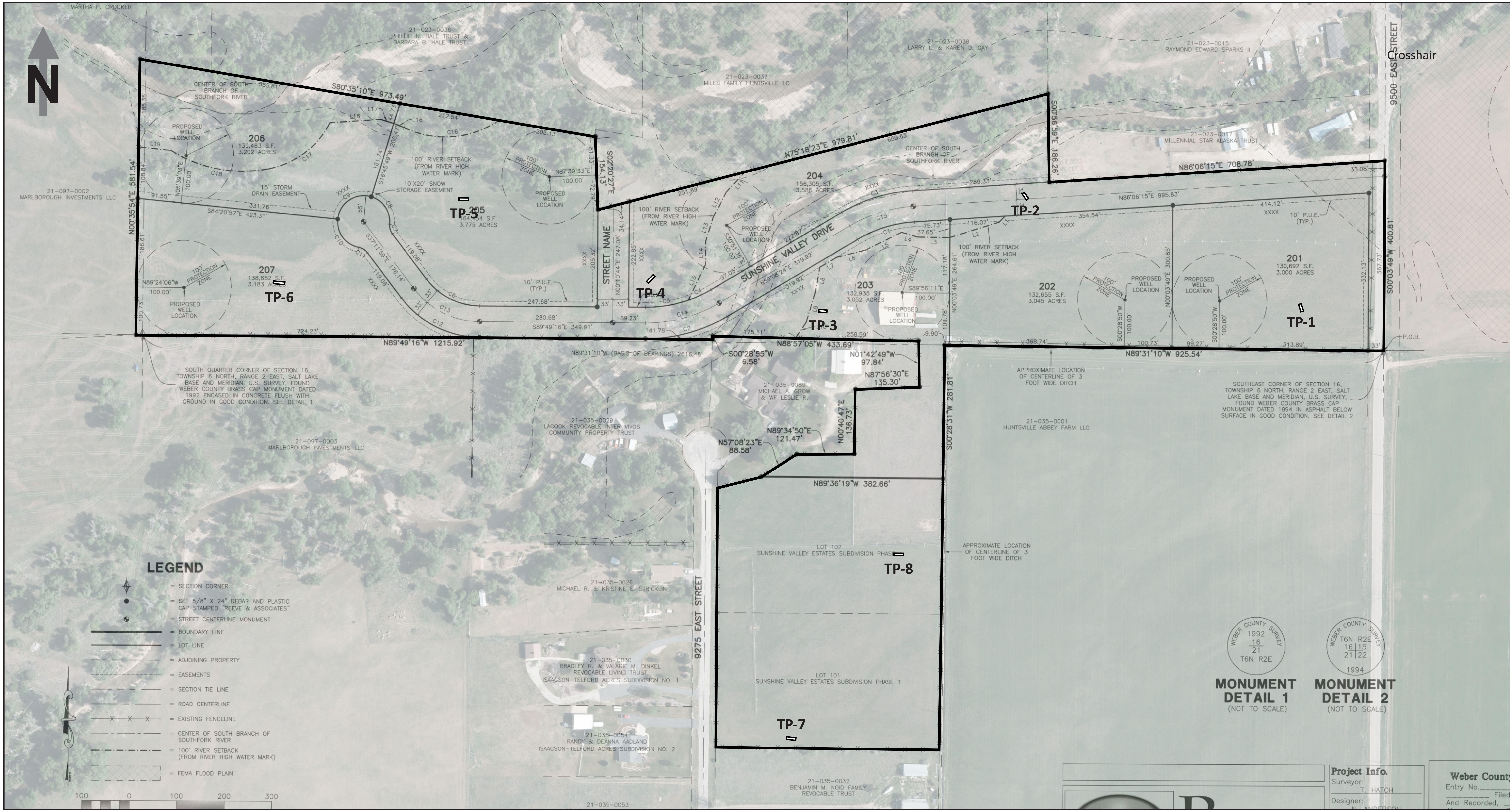
Proposed Sunshine Valley Estates

About 9275 East Sunshine Valley Drive, Huntsville, Utah

LiDAR Analysis

Date:	12-Apr-2019
CMT No.:	12557

Figure 4



Base:
Site plan prepared by Reeve & Associates, Inc. dated November 6, 2018
and 2012 Utah AGRC high-resolution orthophoto, 12.5 cm resolution.

0 200 ft 400 ft

1:24,000 (1 inch equals 200 feet)

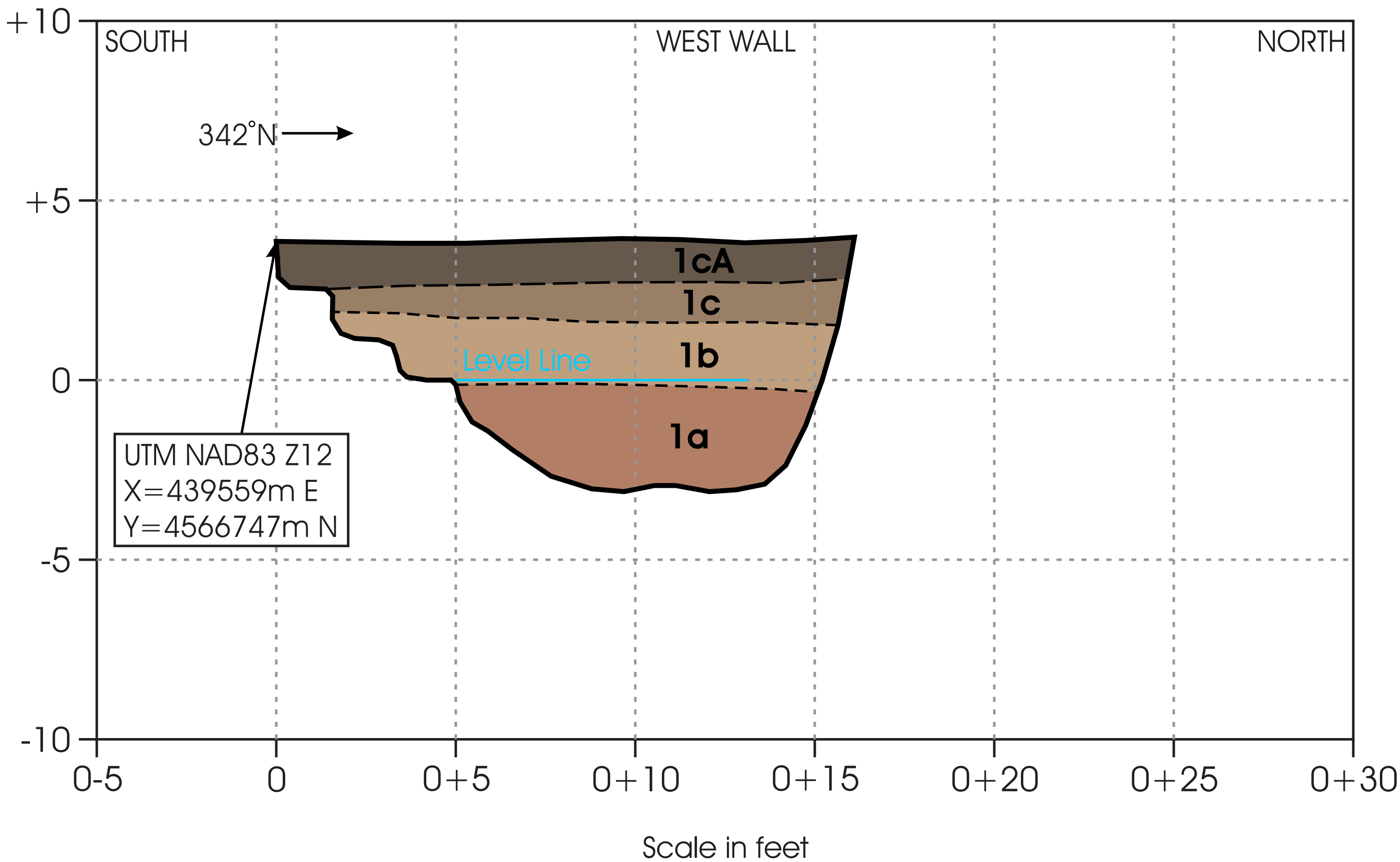
CMT ENGINEERING LABORATORIES

Proposed Sunshine Valley Estates

About 9275 East Sunshine Valley Drive, Huntsville, Utah

Site Evaluation

Date:	12-Apr-2019	Figure 5
CMT No.:	12557	

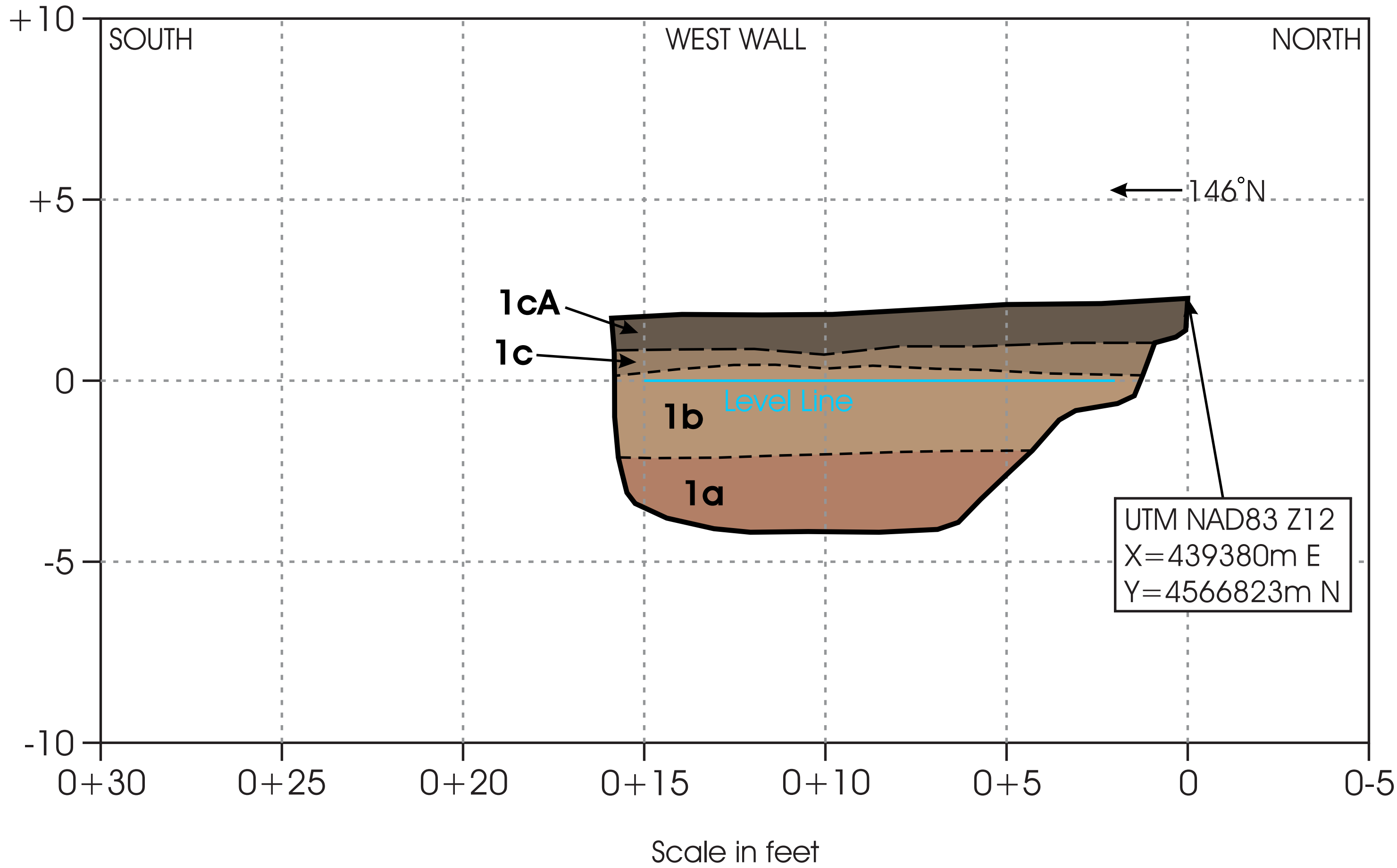


UNIT DESCRIPTIONS

Unit 1. *Holocene Stream Alluvium* - Sequence of gravel and sand with lesser silt deposited by South Fork Ogden River comprised of a lower (1a) reddish-brown, poorly bedded, low density, gravelly sand to sandy gravel (SW/GW) with silt and round to subround cobbles and boulders with stage I carbonate; a middle (1b) unit similar to unit 1a, but without boulders; and an upper (1c) brown to dark brown, massive, low density, organic-enriched sand (SW) with silt and gravel in which the modern A-horizon soil is forming (unit 1cA).

Logged by Bill D. Black, P.G. on April 2, 2019. West wall logged, south to north. Scale 1 inch equals 5 feet (1:60) with no vertical exaggeration.

Proposed Sunshine Valley Estates About 9275 East Sunshine Valley Drive, Huntsville, Utah	CMT ENGINEERING LABORATORIES Test Pit 1 Log	Date: 12-Apr-2019 Job # 12557	Figure 6

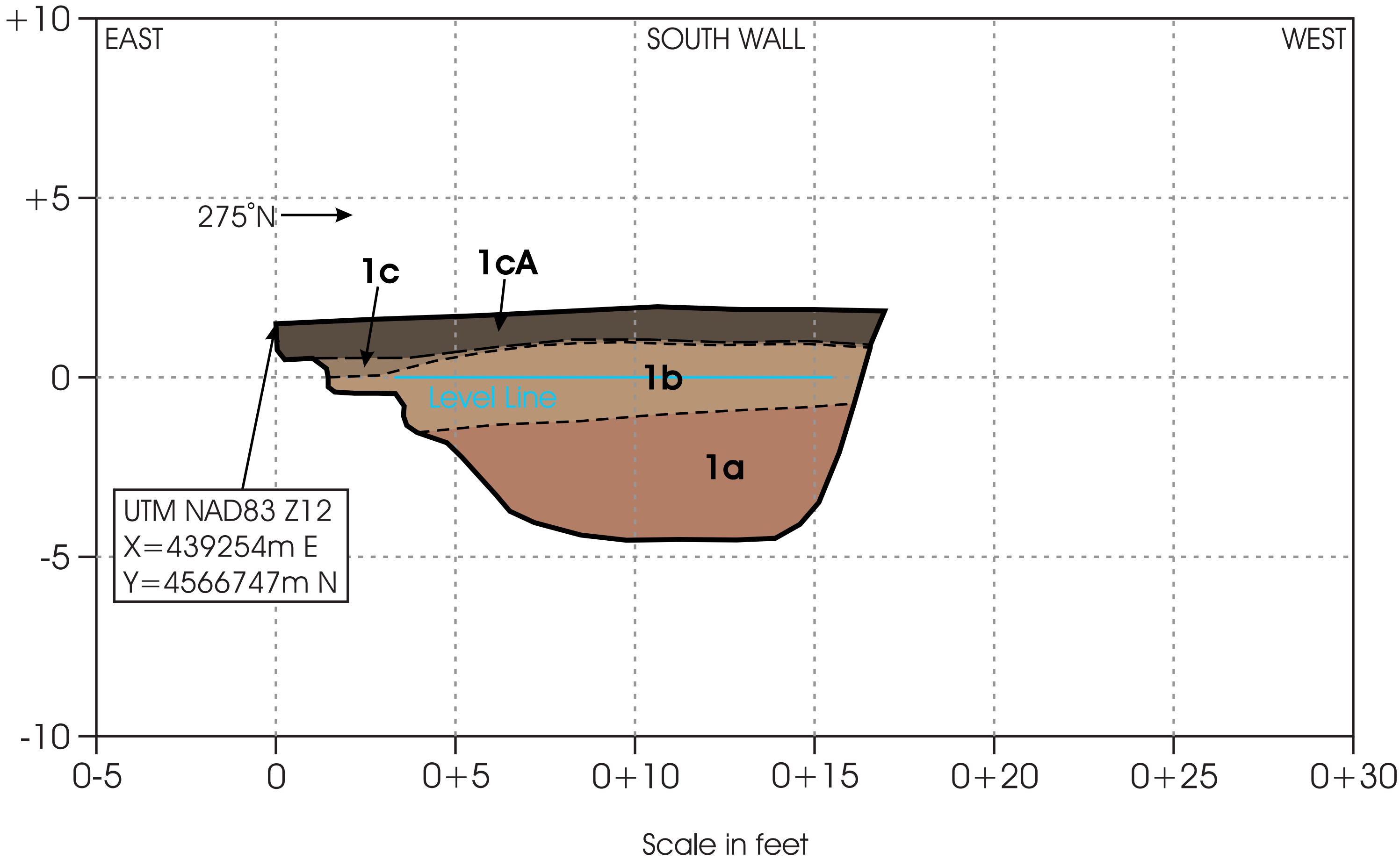


UNIT DESCRIPTIONS

Unit 1. *Holocene Stream Alluvium* - Sequence of gravel and sand with lesser silt deposited by South Fork Ogden River comprised of a lower(1a) reddish-brown, poorly bedded, low density, gravelly sand to sandy gravel (SW/GW) with silt and trace round to subround cobbles and boulders with stage I carbonate; a middle (1b) reddish brown, poorly bedded to massive, low density, gravelly sand to sandy gravel (SW/GW) with round to subround cobbles and trace boulders; and an upper (1c) brown to dark brown, massive, low density, organic-enriched sand (SW) with silt and gravel in which the modern A-horizon soil is forming (unit 1cA).

Logged by Bill D. Black, P.G. on April 2, 2019. West wall logged, north to south. Scale 1 inch equals 5 feet (1:60) with no vertical exaggeration.

Proposed Sunshine Valley Estates About 9275 East Sunshine Valley Drive, Huntsville, Utah	CMT ENGINEERING LABORATORIES **Test Pit 2 Log**	Date: 12-Apr-2019 Job # 12557	Figure 7

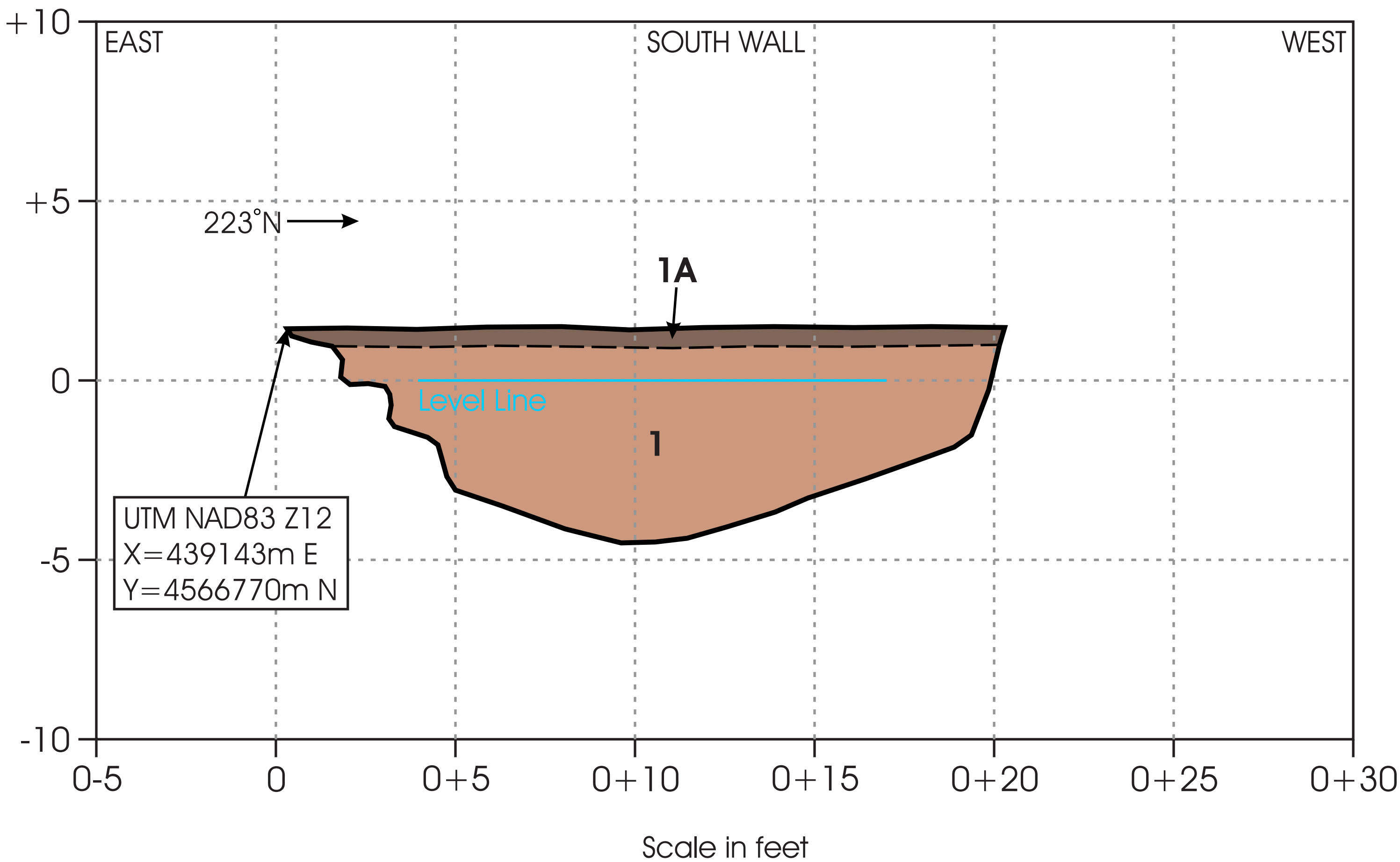


UNIT DESCRIPTIONS

Unit 1. *Holocene Stream Alluvium* - Sequence of gravel and sand with lesser silt deposited by South Fork Ogden River comprised of a lower (1a) brown to reddish-brown, poorly bedded, low density, gravelly sand to sandy gravel (SW/GW), silty in upper part and with round to subround cobbles and boulders with weak stage I carbonate; a middle (1b) reddish brown, poorly bedded to massive, low density, gravelly sand to sandy gravel (SW/GW) with trace round to subround cobbles; and an upper (1c) brown to dark brown, massive, low density, organic-enriched silty sand (SM) with gravel in which the modern A-horizon soil is forming (unit 1cA).

Logged by Bill D. Black, P.G. on April 2, 2019. South wall logged, east to west. Scale 1 inch equals 5 feet (1:60) with no vertical exaggeration.

Proposed Sunshine Valley Estates About 9275 East Sunshine Valley Drive, Huntsville, Utah	CMT ENGINEERING LABORATORIES **Test Pit 3 Log**	Date: 12-Apr-2019 Job # 12557	Figure 8

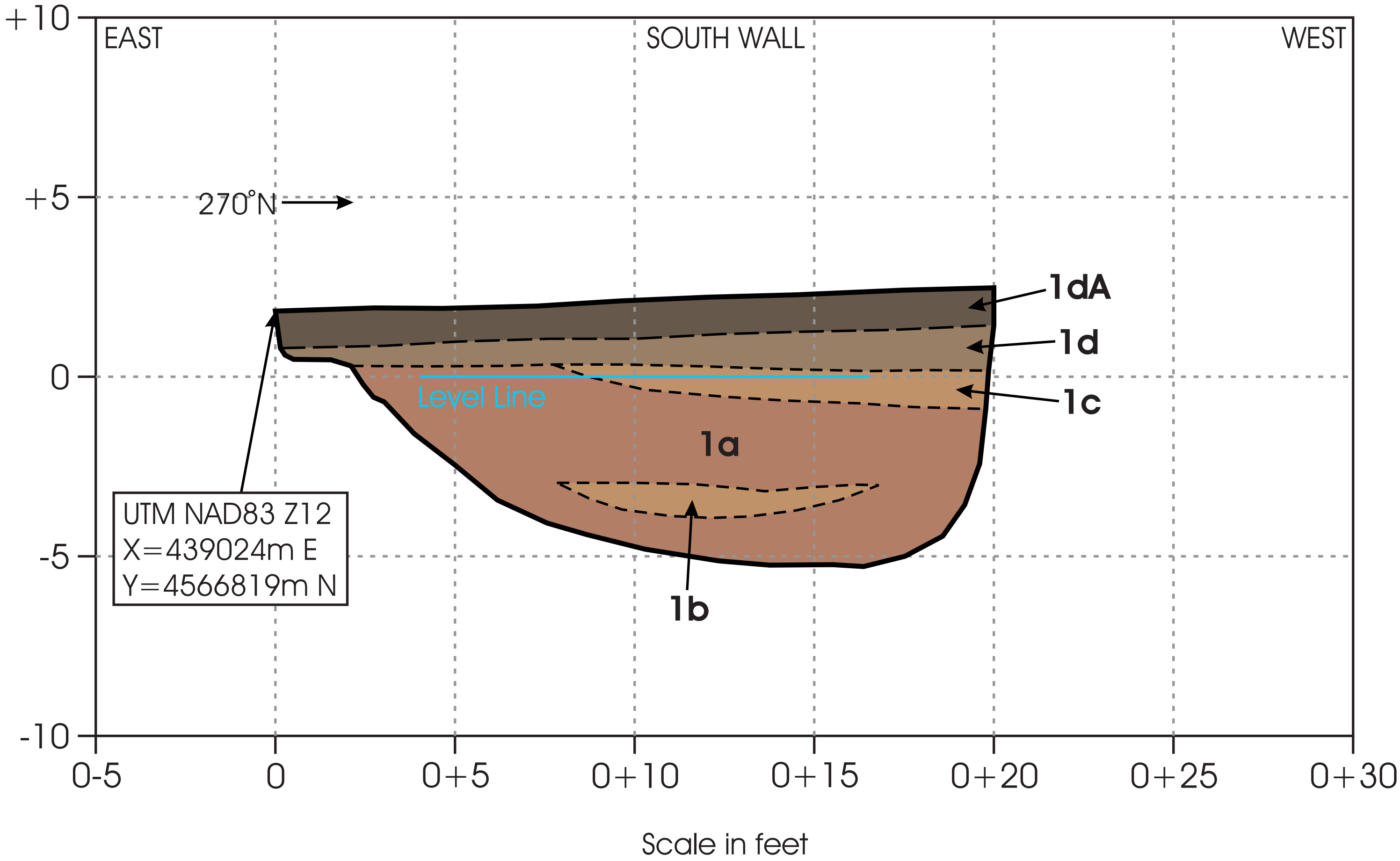


UNIT DESCRIPTIONS

Unit 1. *Holocene Stream Alluvium* - Deposits of South Fork Ogden River comprised of brown to reddish-brown, poorly bedded to massive, low density, gravelly sand to sandy gravel (SW/GW) with round to subround cobbles and trace small boulders in which the modern A-horizon soil is forming (unit 1A); upper part slightly root penetrated.

Logged by Bill D. Black, P.G. on April 2, 2019. South wall logged, east to west. Scale 1 inch equals 5 feet (1:60) with no vertical exaggeration.

Proposed Sunshine Valley Estates About 9275 East Sunshine Valley Drive, Huntsville, Utah	CMT ENGINEERING LABORATORIES **Test Pit 4 Log**	Date: 12-Apr-2019 Job # 12557	Figure 9

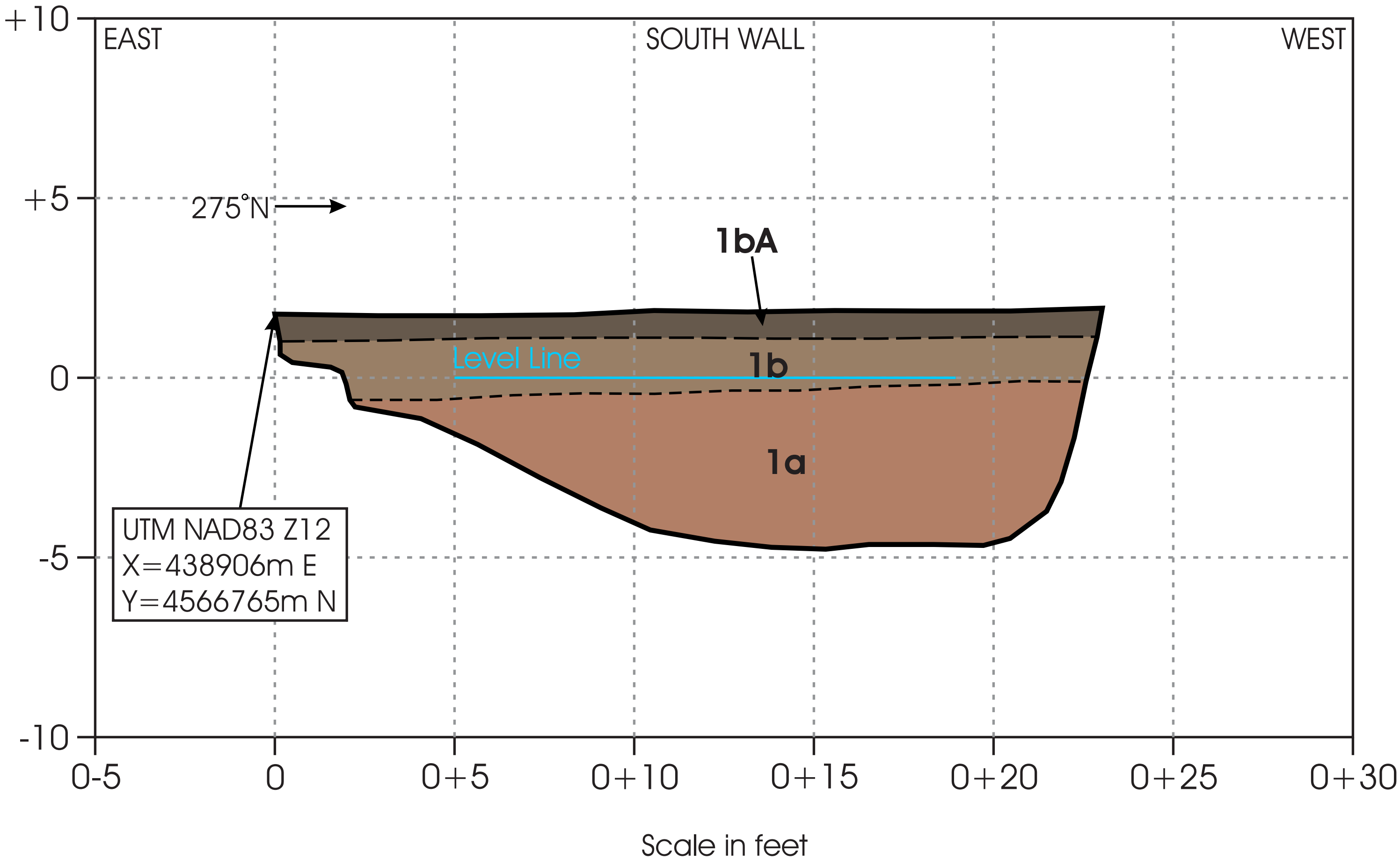


UNIT DESCRIPTIONS

Unit 1. *Holocene Stream Alluvium* - Sequence of gravel and sand with lesser silt deposited by South Fork Ogden River comprised of a lower (1a) reddish-brown, poorly bedded, loose, gravelly sand to sandy gravel (SW/GW) with round to subround cobbles with stage I carbonate; an inset channel deposit (1b) comprised of brown, poorly to well-bedded, loose, poorly to well graded sand (SW/SP) with trace gravel and manganese staining; a middle (1c) brown, poorly bedded, low density, gravelly sand (SW); and an upper (1d) brown to dark brown, low density, massive, organic-enriched sand (SW) with silt and trace gravel (SW) in which the modern A-horizon soil (1dA) is forming.

Logged by Bill D. Black, P.G. on April 3, 2019. South wall logged, east to west. Scale 1 inch equals 5 feet (1:60) with no vertical exaggeration.

Proposed Sunshine Valley Estates About 9275 East Sunshine Valley Drive, Huntsville, Utah	CMT ENGINEERING LABORATORIES **Test Pit 5 Log**	Date: 12-Apr-2019 Job # 12557	Figure 10

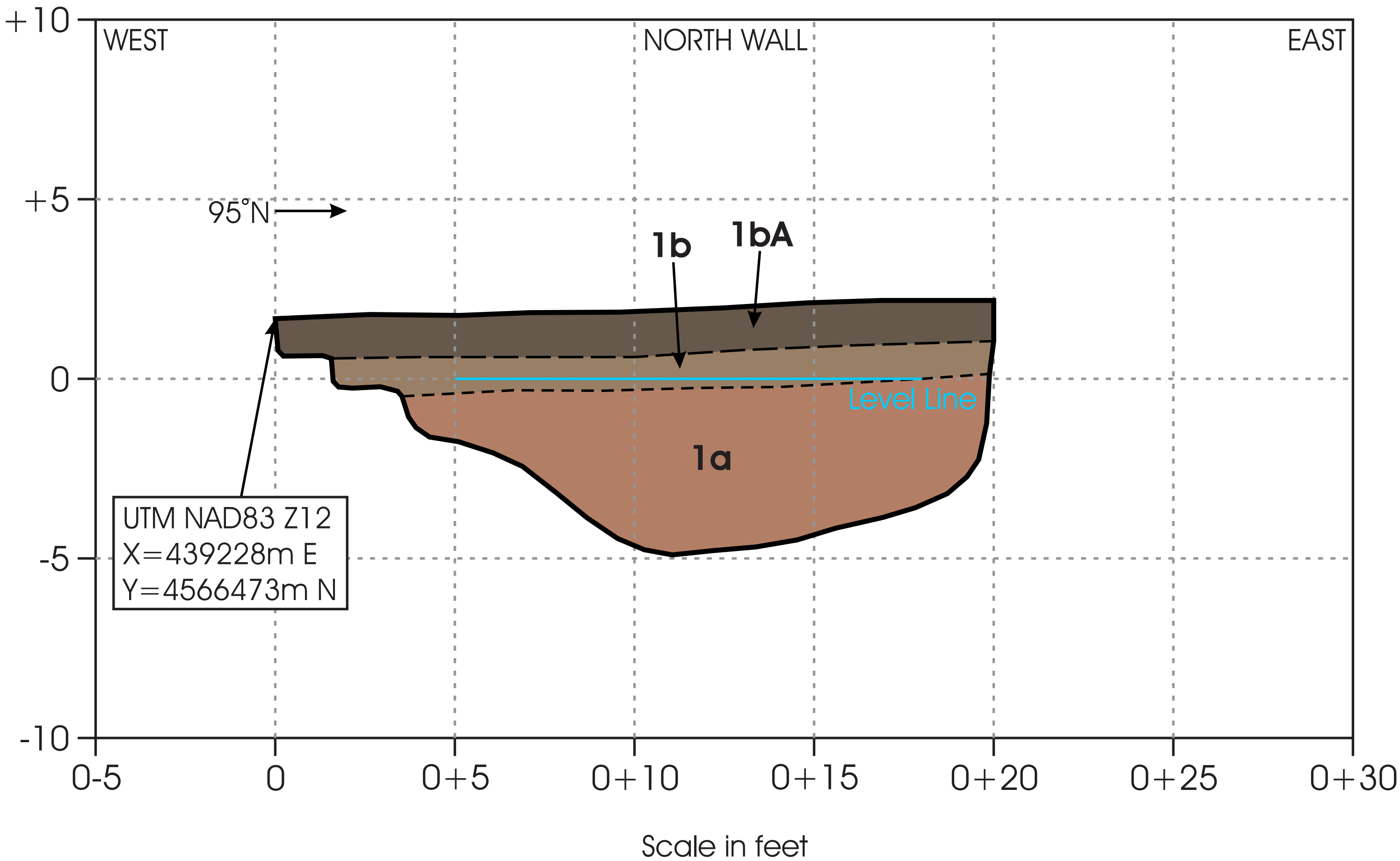


UNIT DESCRIPTIONS

Unit 1. *Holocene Stream Alluvium* - Sequence of gravel and sand with lesser silt deposited by South Fork Ogden River comprised of a lower (1a) reddish-brown, poorly bedded, low density, gravelly sand to sandy gravel (SW/GW) with round to subround cobbles and trace boulders; and an upper (1b) reddish-brown to brown, poorly to well bedded, low density, gravelly sand to sandy gravel (SW/GW) in which the modern A-horizon soil is forming (unit 1bA).

Logged by Bill D. Black, P.G. on April 3, 2019. South wall logged, east to west. Scale 1 inch equals 5 feet (1:60) with no vertical exaggeration.

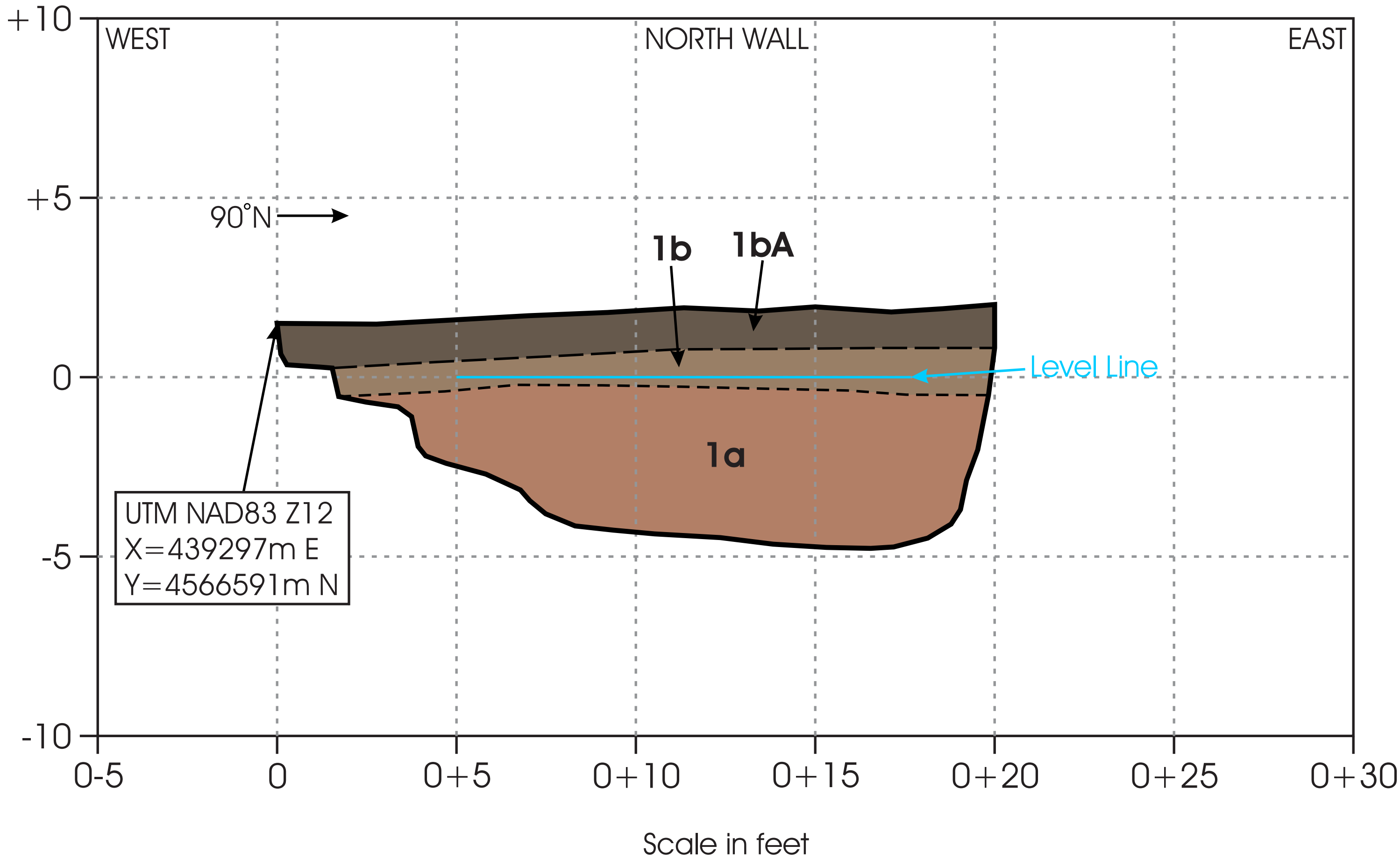
Proposed Sunshine Valley Estates About 9275 East Sunshine Valley Drive, Huntsville, Utah	CMT ENGINEERING LABORATORIES **Test Pit 6 Log**	Date: 12-Apr-2019 Job # 12557	Figure 11



UNIT DESCRIPTIONS

Unit 1. *Holocene Stream Alluvium* - Sequence of gravel and sand with lesser silt deposited by South Fork Ogden River comprised of a lower (1a) reddish-brown, poorly bedded, low density, gravelly sand to sandy gravel (SW/GW) with round to subround cobbles and boulders with strong stage I carbonate; and an upper (1b) brown to dark brown, poorly to massive, low to moderate density, organic-enriched silty sand (SM) with gravel and trace small cobbles in which the modern A-horizon soil is forming (unit 1bA); slightly clayey in upper part.

Logged by Bill D. Black, P.G. on April 3, 2019. South wall logged, east to west. Scale 1 inch equals 5 feet (1:60) with no vertical exaggeration.



UNIT DESCRIPTIONS

Unit 1. *Holocene Stream Alluvium* - Sequence of gravel and sand with lesser silt deposited by South Fork Ogden River comprised of a lower (1a) reddish-brown, poorly bedded, low density, gravelly sand to sandy gravel (SW/GW) with round to subround cobbles and boulders with strong stage I carbonate; and an upper (1b) brown to dark brown, poorly to massive, low to moderate density, organic-enriched silty sand (SM) with gravel and trace small cobbles in which the modern A-horizon soil is forming (unit 1bA); slightly clayey in upper part.

Logged by Bill D. Black, P.G. on April 3, 2019. South wall logged, east to west. Scale 1 inch equals 5 feet (1:60) with no vertical exaggeration.

Proposed Sunshine Valley Estates About 9275 East Sunshine Valley Drive, Huntsville, Utah	CMT ENGINEERING LABORATORIES **Test Pit 8 Log**	Date: 12-Apr-2019 Job # 12557	Figure 13