NOTICE OF MEETING
HILLSIDE REVIEW BOARD
CITY OF ST. GEORGE
WASHINGTON COUNTY, UTAH

Public Notice

Notice is hereby given that the Hillside Review Board of the City of St. George, Washington County, Utah, will hold meetings at the referenced site on **Wednesday, May 19, 2021** commencing on-site at approximately 8:30 a.m.

The estimated site times are in bold.
The agenda for the meeting is as follows:

1. Consider a request for a Hillside Development Permit on Netta's Knoll. The property was originally considered for hillside approval in 2005 and again in 2018 but to this point has not been developed. The property is generally located on the south-east intersection of Riverside Drive and Foremaster Drive. The property is currently zoned R-2 (Residential multi-family). The owner is Sierra Health Services. Case No. 2021-HS-004. (*See 'Meeting Place' exhibit below*). **Meeting time approx. 8:30 am**
2. Consider approval of the meeting minutes from April 21, 2021.

Dan Boles, AICP
Senior Planner
Development Services

Reasonable Accommodation: The City of St. George will make efforts to provide reasonable accommodations to disabled members of the public in accessing City programs. Please contact the City Human Resources Office at (435) 627-4674 at least 24 hours in advance if you have special needs.

Meeting Place
South-East of Riverside Drive & Foremaster Drive Intersection

St.George
Community Development

ITEM 1

Hillside Permit

HILLSIDE REVIEW BOARD AGENDA REPORT: **05/19/2021**

HILLSIDE DEVELOPMENT PERMIT
Netta's Knoll
Case No. 2021-HS-004

Request: This is a request for a Hillside Development Permit to allow disturbance of areas in the 20-30%, 30-40% and 40% and above slope areas. This application is in anticipation of a single-family subdivision on the top of Netta's Knoll.

Hillside History: The subject property was approved in 2005 for a multi-family development with 173 units (6.02 units/acre) but was never developed. Again, the Hillside Review Board reviewed a request for a development permit in 2017/18. The application went to Hillside but did not proceed any further. This is the third attempt at development on Netta's Knoll.

Exhibits Provided:

1) Exhibit A - Slope Analysis
"Exhibit A" in the packet shows the overall slope analysis for the Knoll. This includes areas to be disturbed and areas proposed to be dedicated to the City for open space.

2) Exhibit B – Cut and Fill Map
"Exhibit B" depicts the proposed cuts and fills for the site. This includes only areas of development. Areas to be dedicated to the City will remain undisturbed.

3) Exhibit C – Preliminary Grading Plan/Cross Sections/Plan& Profile
"Exhibit C" – These sheets depict preliminary grading plans as well as associated plan & profiles and hillside cross-sections.

4) Exhibit D – Geologic Hazard Study & Preliminary Geotechnical
"Exhibit D" was prepared in 2004 and contains the geologic hazards and geotechnical recommendations for the site.

5) Exhibit E – Storm Water Analysis
"Exhibit E" is a new document that analyzes the storm water runoff.

6) Exhibit F – Geotechnical Report
"Exhibit F" addresses geotechnical issues and was prepared in 2007.

7) Exhibit G -

Proposal: Open Space – Of the overall 32.84 acres, the applicant is proposing to dedicate 15.38 acres to the city to remain open space. That is approximately 46.7% of the total property which leaves 17.46 acres to be developed.

The applicant has submitted an application for hillside review. The two items before the Hillside Review Board are, 1) encroachment into sloped areas, and, 2) determination of the ridgeline. The following table has been submitted regarding slope disturbance:

SURFACE SLOPE DATA						
NUMBER	MINIMUM SLOPE	MAXIMUM SLOPE	COLOR	AREA	DIST.	% TOT.
1	0.00%	20.00%		13.15±	10.49±	78.8%±
2	20.01%	30.00%		7.34±	4.93±	67.2%±
3	30.01%	40.00%		4.45±	1.51±	33.9%±
4	40.01%	99999900.00%		7.90±	0.53±	6.7%±
		OVERALL TOTAL:		32.84	17.46	53.2%±

The applicant is making the argument that the area on the top of the hill (upper plateau) is relatively flat with small hilly areas that are not contiguous to the rest of the property. The HSRB will have to determine whether or not that argument is valid. This is the same argument that has been made and accepted in previous applications.

As for the ridgeline, the north-west side of the property is a much gentler slope to the property below while the rest of the property is a much more definable ridgeline. The HSRB will need to decide if that ridgeline is defined in the correct spot or if it need to be revised.

Owner: Sierra Health Services

Applicant: Bright Ideas REI/Todd Smith

APN: SG-5-2-28-23071

Location: Riverside Drive and Foremaster Drive

Acreage: 32.84 Acres

Zoning: R-2

Adjacent zones: R-3 (Residential Multi-family), PD-R (Planned Development Residential), C-3 (Commercial), PD-C (Planned Development Commercial), R-1-10 (Residential, single-family, 10,000 sq ft minimum lot size), A-1 (Agricultural).

Powers & Duties: Section 10-13A-8(B)(1) of the "Hillside Review Board Powers and Duties" states that the hillside board can make recommendations to "adopt, modify or reject a proposal" to the Planning Commission (PC).

Permit required: Section 10-13A-7 requires that all major development (i.e., cut greater than 4', etc.) on slopes above 20% requires a 'hillside development permit' granted by the City Council upon recommendation from the Hillside Review Board and the Planning Commission.

Applicable Ordinance(s):
(Selected portions)

10-13A-1: Density and Disturbance Standards

A. The hillside development overlay zone (HDOZ) limits development densities and provides specific development incentives to transfer underlying zone densities from hillsides (sending areas), to less steep slopes or more safe development areas (receiving areas), within a development.

Percent Natural Slope	Dwelling Units (DU) / Acre
0-19	See underlying zone
20-29	2 DU/acre, provided the units are clustered on 30 percent (30%) or less of the land area within this slope category. 70 percent of this slope category shall remain undisturbed. The 70 percent area is based upon the overall area/development rather than per lot. Also see subsections A1, A2, and A3 of this section.
30-39	1 DU/10 acres, provided no more than 5 percent (5%) of the site is disturbed, and 95 percent of the site remains undisturbed. If the cumulative area is at least 1 acre but less than 10 acres, the cumulative area shall be allowed 1 DU.
40	Development is not permitted (0%), **excep**t as provided for in subsection A2 of this section.

10-13A-2: Slope and Slope Areas Determined

A. Slope shall be determined for each significant portion of a development parcel.

B. *Procedure:* The applicant shall map the location of the natural slope by using the following procedure:

1. *Preparation of Contour Maps:* The applicant shall submit an accurate, current contour map, prepared and certified by a licensed professional engineer or surveyor, which shows all land contours at intervals no greater than five feet (5'), drawn at a one inch equals one hundred feet (1" = 100') scale maximum.

2. *Verification through Field Surveys:* The city engineer or designee may require the applicant to submit a field survey to verify the accuracy of the contour map.

C. *Determination of Slope Areas:* Using the contour map, natural slopes shall be calculated using points identified as natural slopes of twenty percent (20%), thirty percent (30%), and forty percent (40%), and shall be located on the contour map and connected by a continuous line. That area bounded by said lines and intersecting property lines shall be used for determining project density. Small washes or outcrops, which have slopes distinctly different from surrounding property, and are not part of the contiguous topography, may be excluded from the slope determination.

HSRB Motion Options: The hillside board can recommend several different options to the Planning Commission and the City Council:

1. Denial
2. Approval as presented
3. Approval with specific conditions and comments added as required.

Example Motion: The Hillside Review Board recommends _________________________ of the request for a Hillside Development Permit to allow development of Netta's Knoll as requested and outlined the staff report and has the following comments:

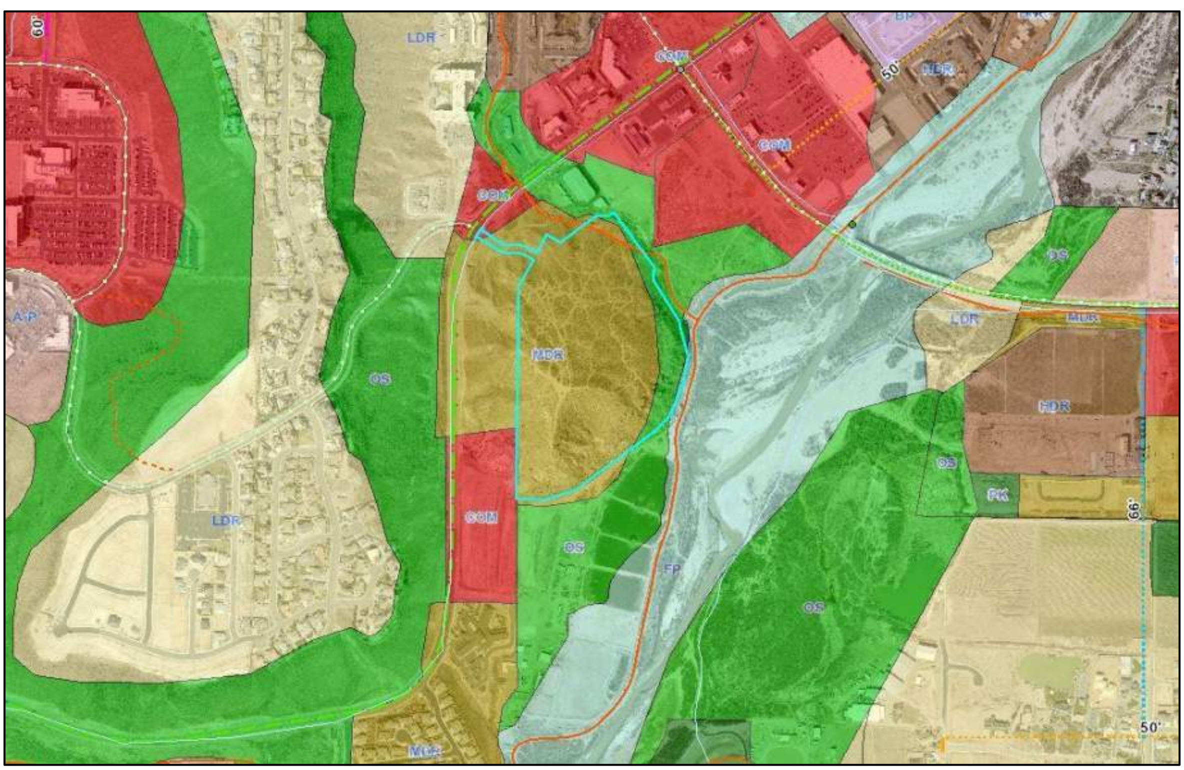
1. ____

2. ____

3. ____

Vicinity Map

General Plan - MDR



Zoning - R-2

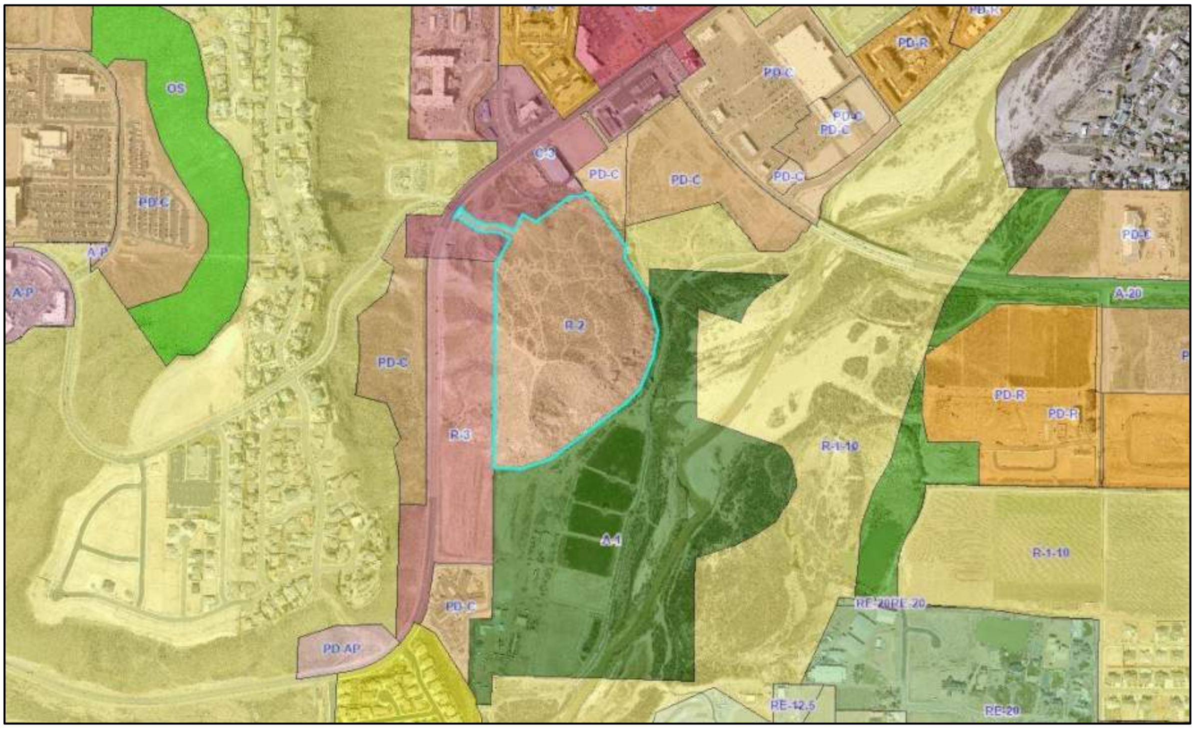
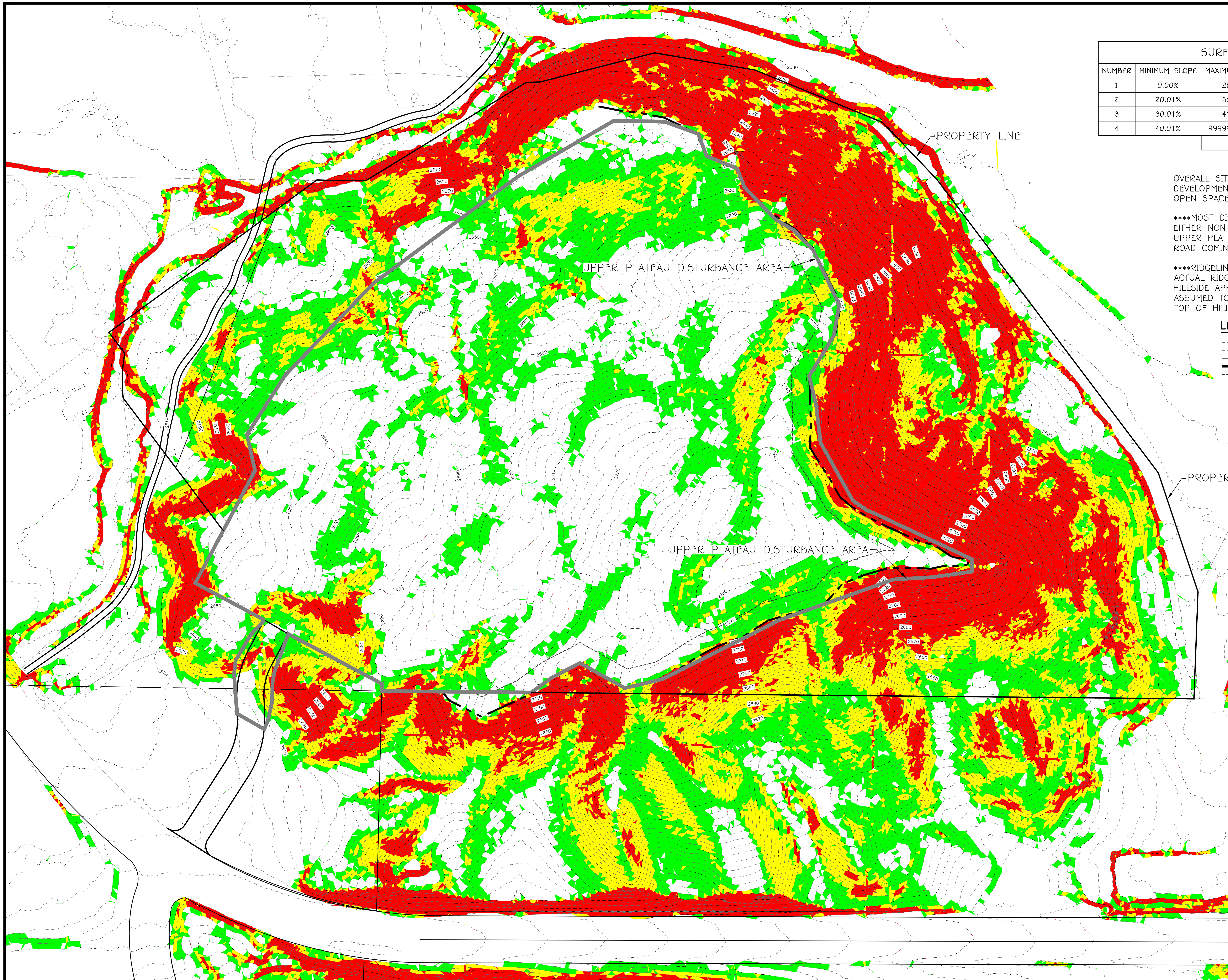


Exhibit A
Slope Analysis



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3	30.01%	40.00%	yellow	4.45±	1.51±	33.9%±
4	40.01%	99999900.00%	red	7.90±	0.53±	6.7%±
		OVERALL TOTAL:		32.84	17.46	53.2%±

OVERALL SITE: 32.84 ACRES
DEVELOPMENT: 17.46 ACRES
OPEN SPACE: 15.38 ACRES

****MOST DISTURBED AREAS OVER 20% ARE EITHER NON-CONTIGUOUS PATCHES ON THE UPPER PLATEAU BUILD AREA OR THE ACCESS ROAD COMING UP TO THE SITE.****

****RIDGELINE ON THIS MAP IS APPROXIMATE, ACTUAL RIDGE LINE TO BE DETERMINED DURING HILLSIDE APPROVAL PROCESS. RIDGE LINE ASSUMED TO BE THE ROCKY OUTCROPPING AT TOP OF HILL.****

LEGEND:

- EXISTING MINOR CONTOUR
- EXISTING MAJOR CONTOUR (2640)
- PROPOSED RETAINING WALL
- APPROXIMATE RIDGE LINE
- APPROXIMATE 30' RIDGELINE SETBACK

NOTES:

REV.	DATE

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1043 EAST 3740 SOUTH, WASHINGTON, UT 84780

SLOPE MAP
KNETTA'S KNOLL
HILLSIDE REVIEW

ST. GEORGE CITY, WASHINGTON COUNTY, UTAH
SECTIONS 28 & 33, TOWNSHIP 43 SOUTH, RANGE 15 WEST, SLB&M

DATE: 4/28/2021
JOB # 21-001
FILE: Slope.dwg

SHEET 1 / 7 SHEETS

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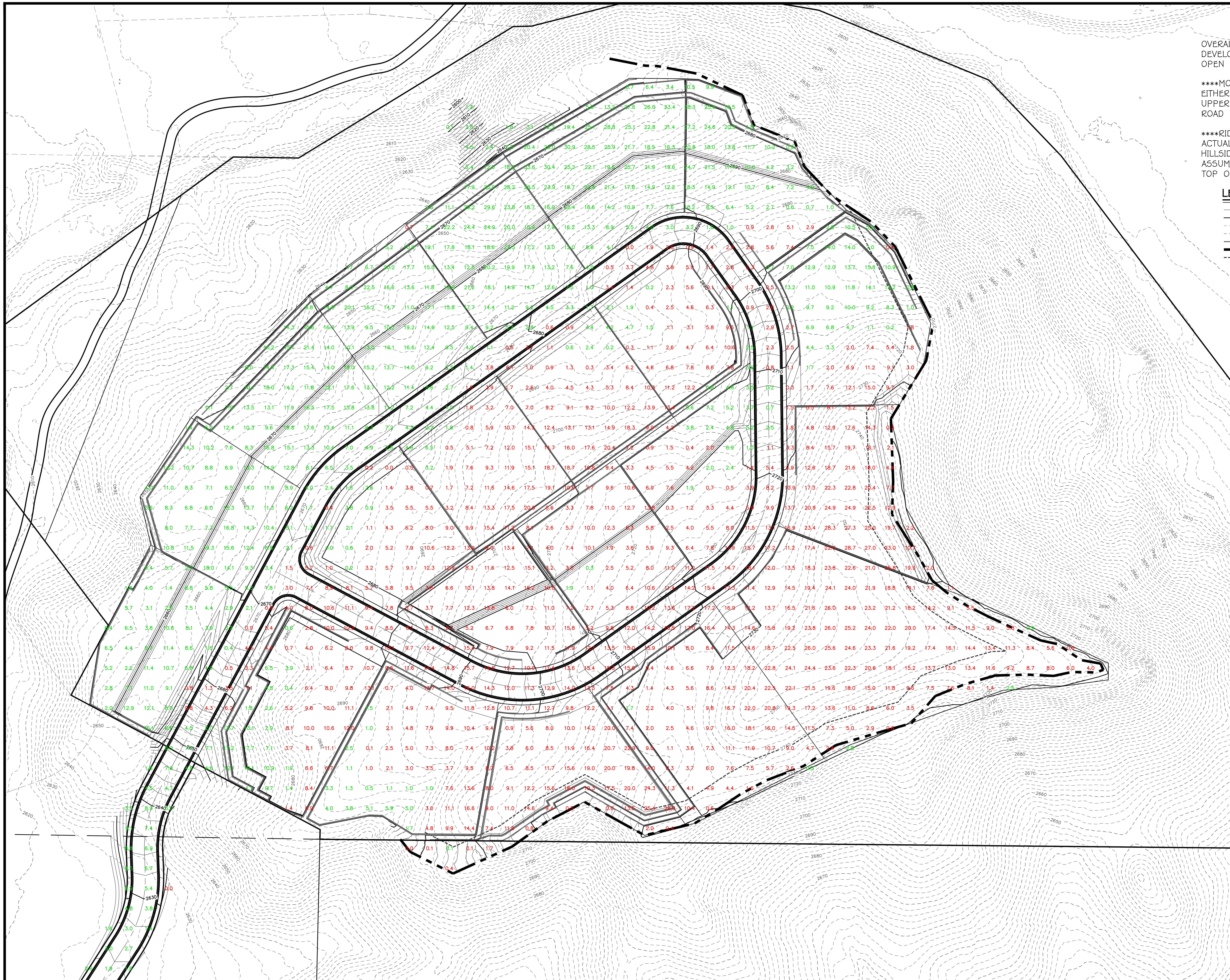
Exhibit B
Cut and Fill Map



OVERALL SITE: 32.84 ACRES
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LEGEND:

- PROPOSED MINOR CONTOUR
- 2640 PROPOSED MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- 2640 EXISTING MAJOR CONTOUR
- PROPOSED RETAINING WALL
- APPROXIMATE RIDGE LINE
- APPROXIMATE 30' RIDGELINE SETBACK

0 60 120
SCALE:1"=60'

REV.	DATE	NOTES:

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CUT AND FILL MAP

KNETTA'S KNOLL
HILLSIDE REVIEW

ST. GEORGE CITY, WASHINGTON COUNTY, UTAH
SECTIONS 28 & 33, TOWNSHIP 43 SOUTH, RANGE 15 WEST, SLB&M

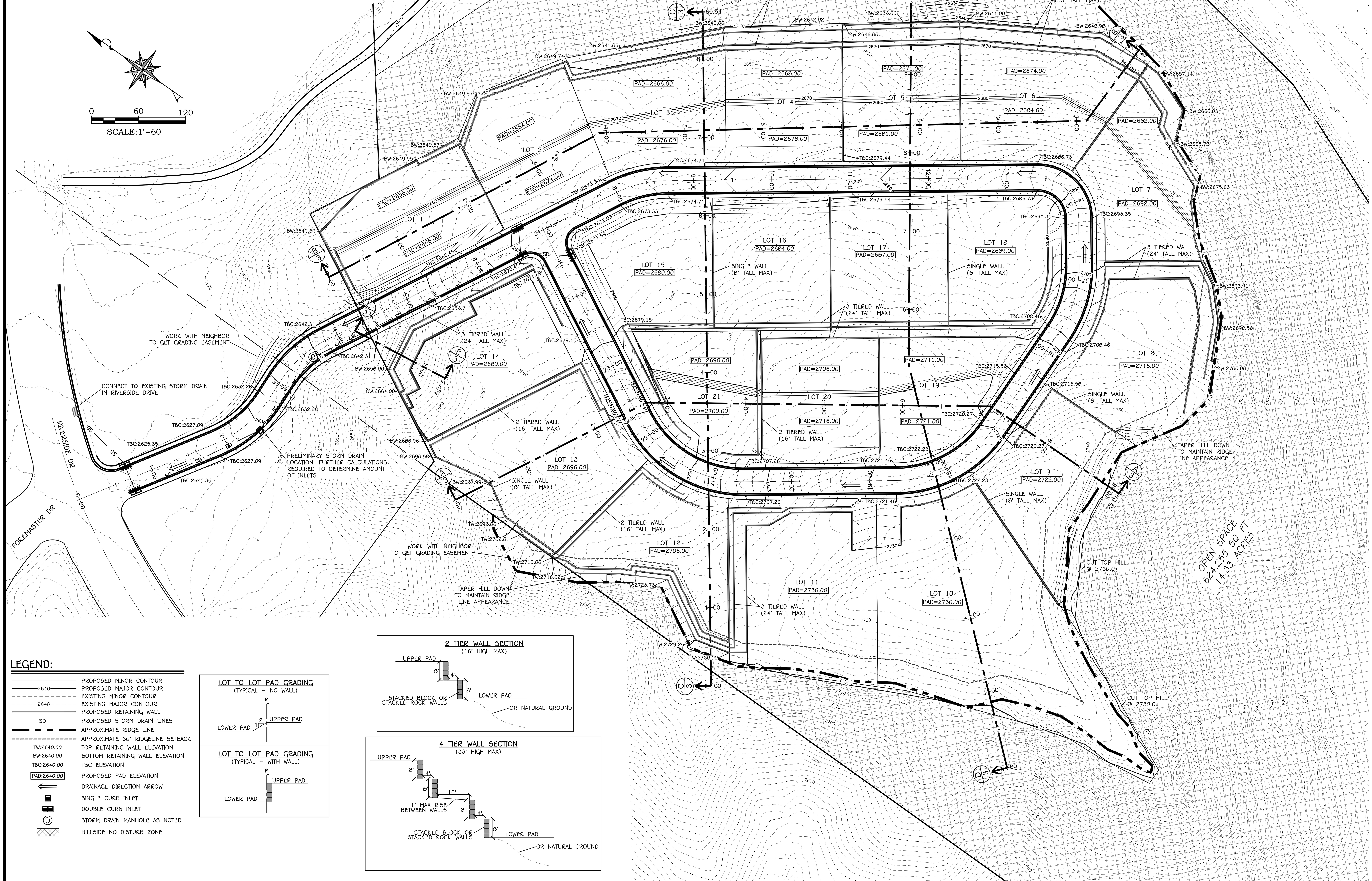
DATE: 4/28/2021
JOB # 21-001
FILE: Cut-Fill.dwg

SHEET 2 / 7 SHEETS

Exhibit C
Preliminary Grading Plan/Cross Sections/Plan& Profile

EARTHWORK QUANTITIES

154,452 CU. YDS. CUT
114,002 CU. YDS. FILL
40,152 CU. YDS. NET EXPORT
THESE QUANTITIES ARE **APPROXIMATE**, ARE TO **FINISHED GRADE** AND FOR **CONVENIENCE ONLY**. CONTRACTOR IS RESPONSIBLE FOR THEIR **OWN ESTIMATION** OF DIRT QUANTITIES.



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JASON L. TUTTLE No. 368642 4/28/21 LICENSED PROFESSIONAL ENGINEER STATE OF UTAH

REV.	DATE	NOTES:

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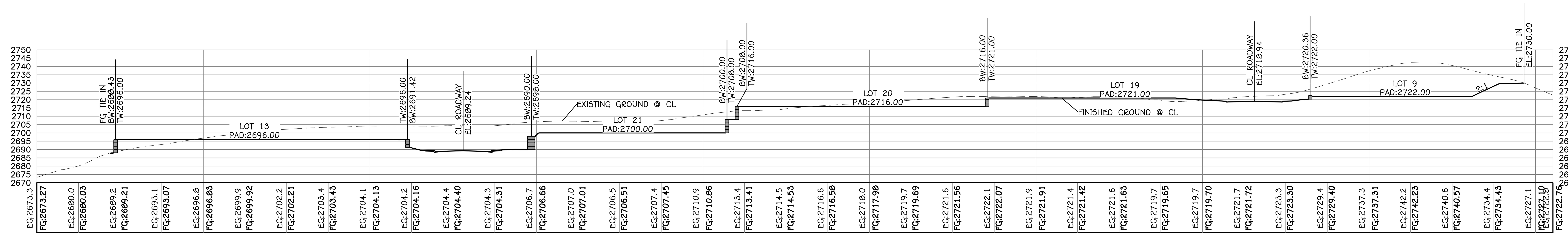
PRELIMINARY GRADING PLAN

KNETTA'S KNOLL
HILLSIDE REVIEW

ST. GEORGE CITY, WASHINGTON COUNTY, UTAH
SECTIONS 28 & 33, TOWNSHIP 43 SOUTH, RANGE 15 WEST, SLB&M

DATE: 4/28/2021
JOB # 21-001
FILE: Hillside Grading.dwg

SHEET 3 / 7 SHEETS



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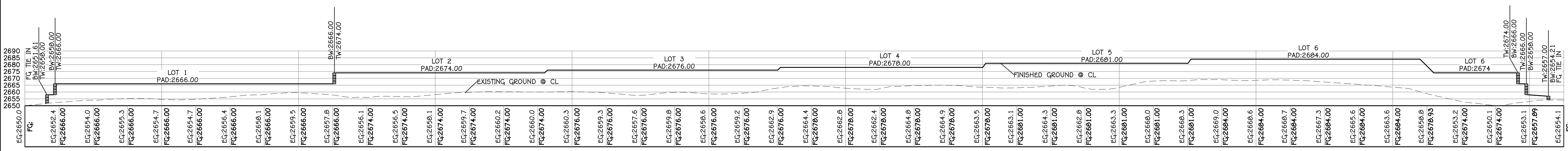

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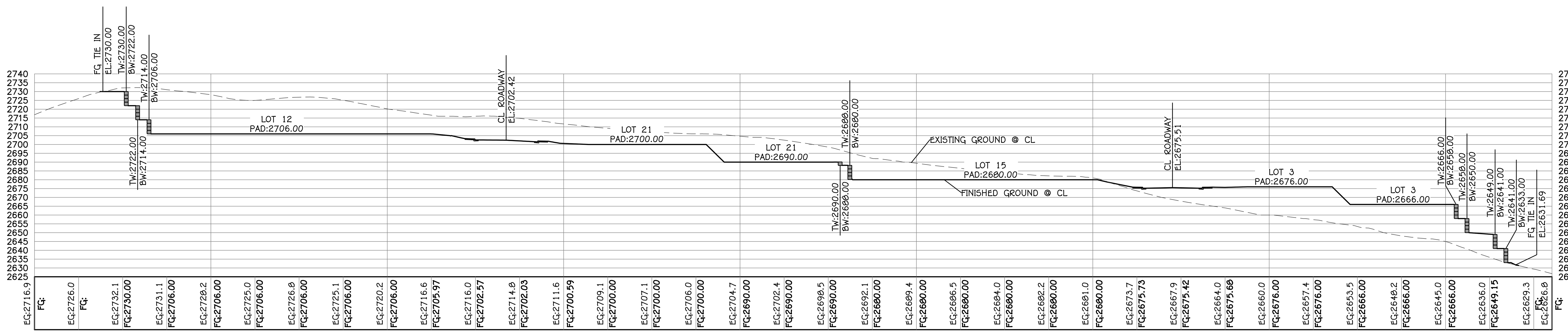

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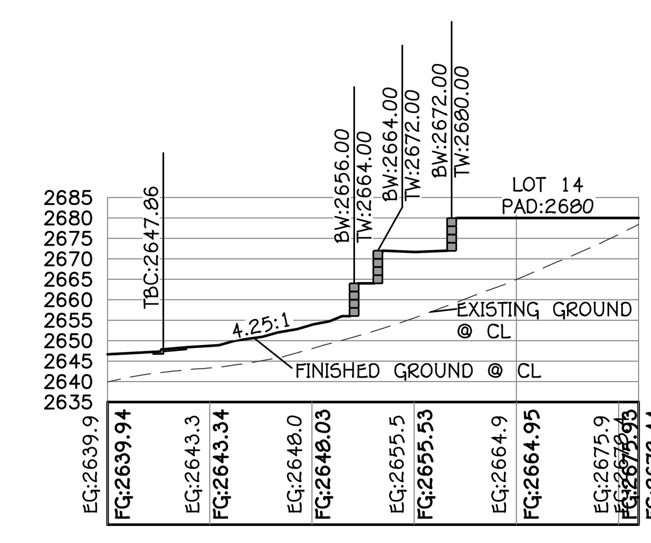

Section E

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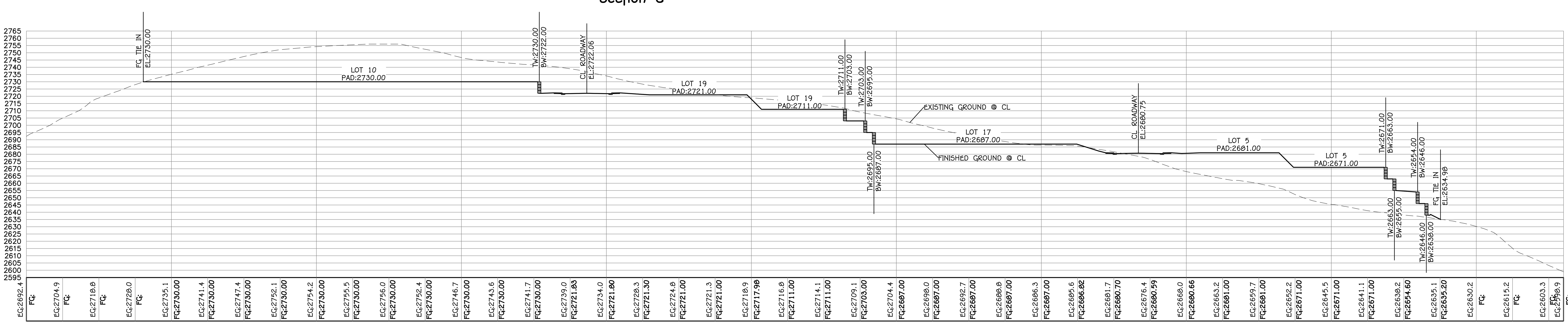


Section D

JASON L. TUTTLE
No. 363642
4/28/21
PROFESSIONAL ENGINEER
STATE OF UTAH

NOTES:

DATE

REV.

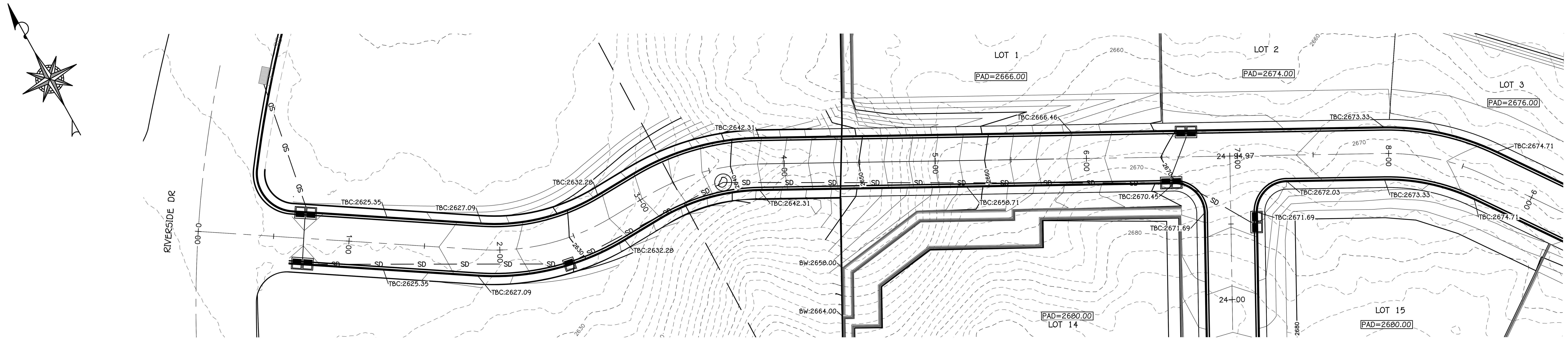
AMERICAN
LAND CONSULTING
1043 EAST 3740 SOUTH, WASHINGTON, UT 84780

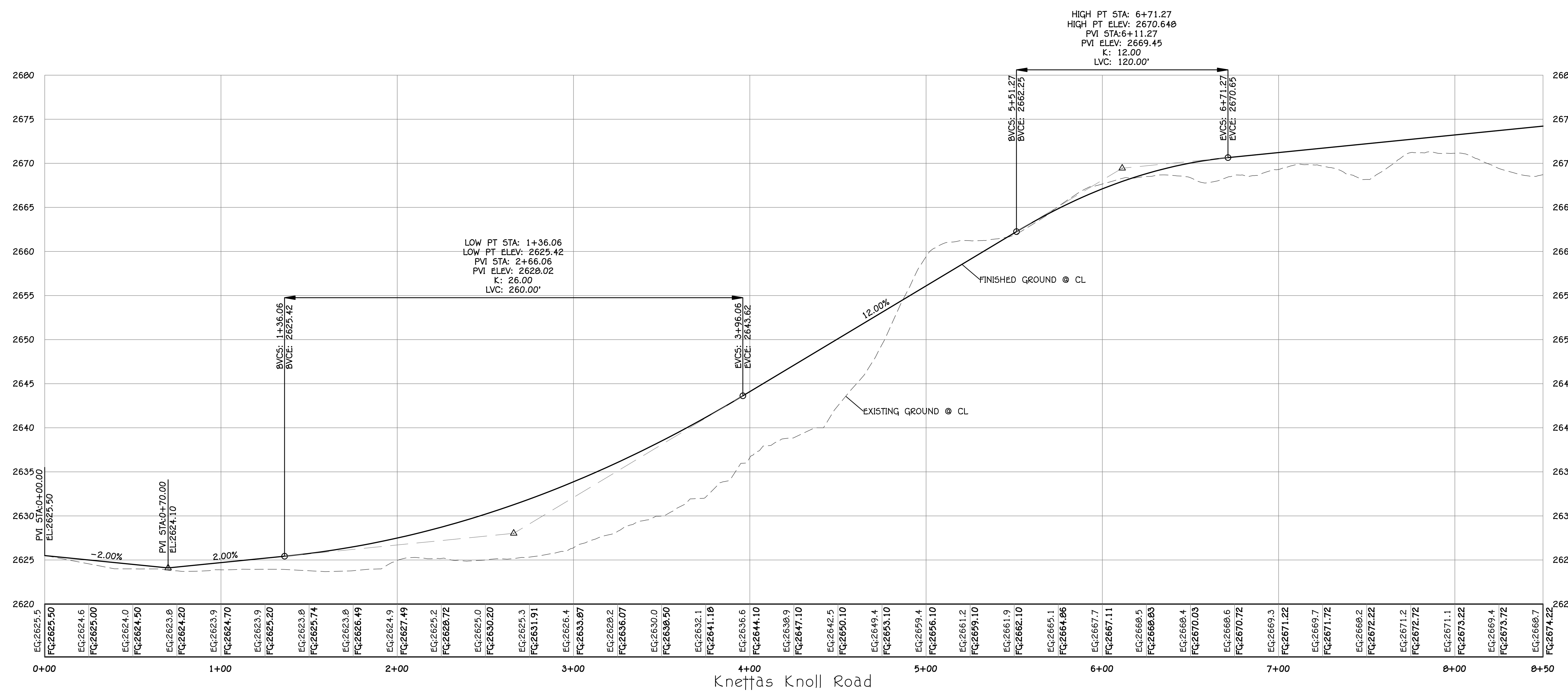
CROSS SECTIONS
KNETTA'S KNOLL
HILLSIDE REVIEW

ST. GEORGE CITY, WASHINGTON COUNTY, UTAH
SECTIONS 28 & 33, TOWNSHIP 43 SOUTH, RANGE 15 WEST, SLB&M

DATE: 4/28/2021
JOB # 21-001
FILE: Hillside Grading.dwg

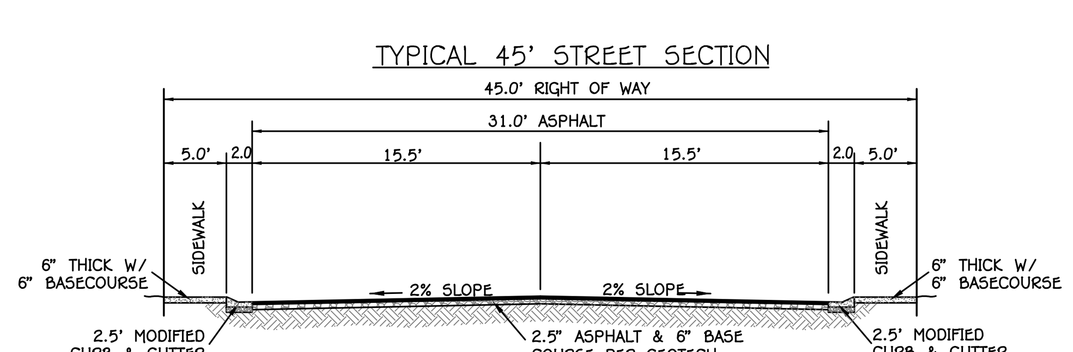
SHEET 4 / 7 SHEETS





LEGEND:

———	PROPOSED MINOR CONTOUR
—2640—	PROPOSED MAJOR CONTOUR
- - -	EXISTING MINOR CONTOUR
- -2640- -	EXISTING MAJOR CONTOUR
———	PROPOSED RETAINING WALL
— SD —	PROPOSED STORM DRAIN LINES
TW:2640.00	TOP RETAINING WALL ELEVATION
BW:2640.00	BOTTOM RETAINING WALL ELEVATION
TBC:2640.00	TBC ELEVATION
PAD:2640.00	PROPOSED PAD ELEVATION
⟸	DRAINAGE DIRECTION ARROW
	SINGLE CURB INLET
	DOUBLE CURB INLET
(D)	STORM DRAIN MANHOLE AS NOTED
	HILLSIDE NO DISTURB ZONE



0 40 80
SCALE:1"=40'
VERTICAL EXAGGERATION=5

JASON L. TUTTLE No. 368642 4/28/21 LICENSED PROFESSIONAL ENGINEER STATE OF UTAH

REV.	DATE	NOTES:

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PLAN & PROFILE SHEET
KNETTA'S KNOLL ROAD STA:0+00 TO STA:8+50
HILLSIDE SUBMITTAL

ST. GEORGE CITY, WASHINGTON COUNTY, UTAH
SECTIONS 28 & 33, TOWNSHIP 43 SOUTH, RANGE 15 WEST, SLB&M

DATE: 4/28/2021
JOB # 21-013
FILE: PNP's.dwg
SHEET 5 / 7 SHEETS

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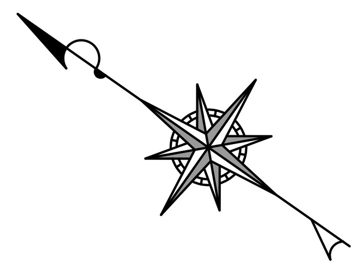

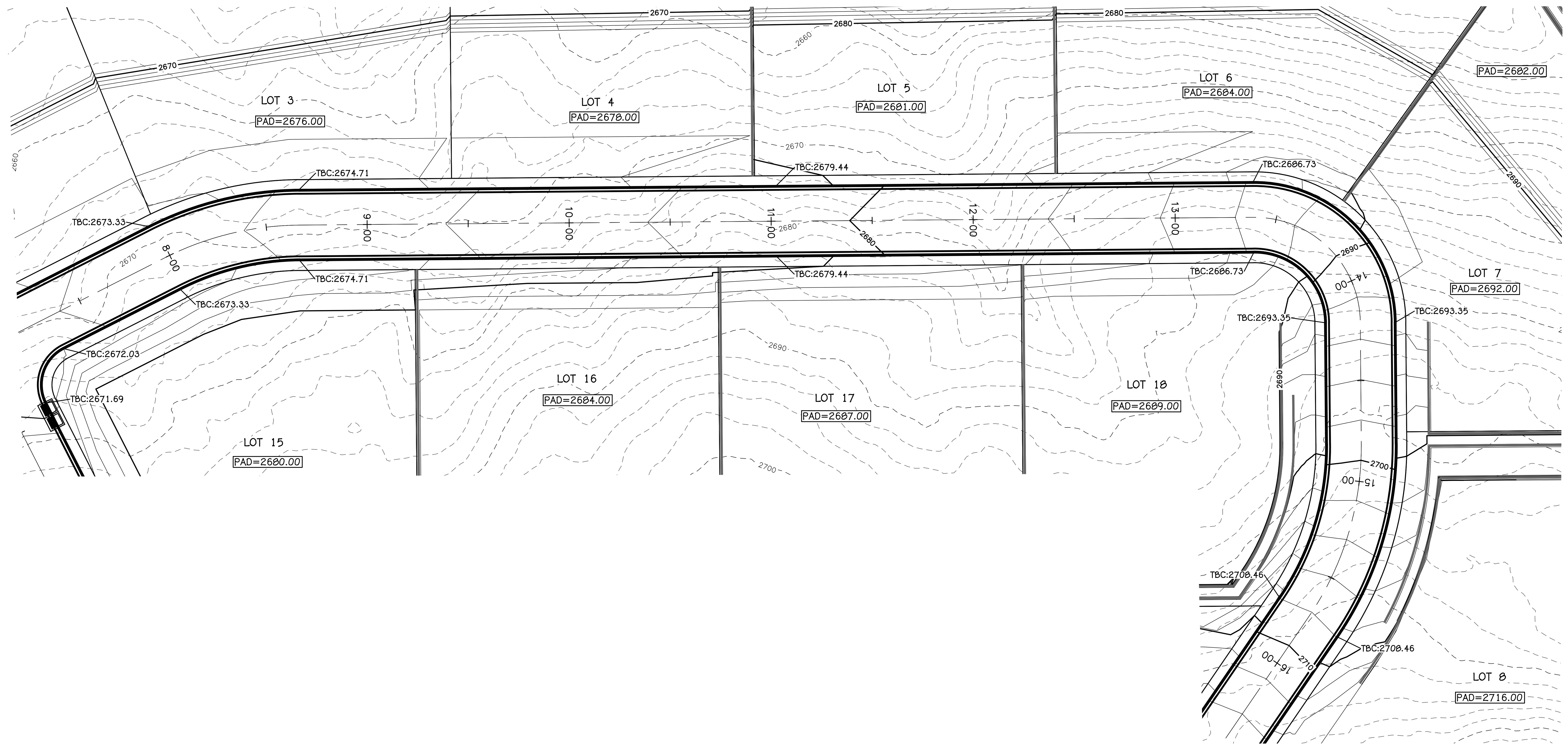

LEGEND:

	PROPOSED MINOR CONTOUR
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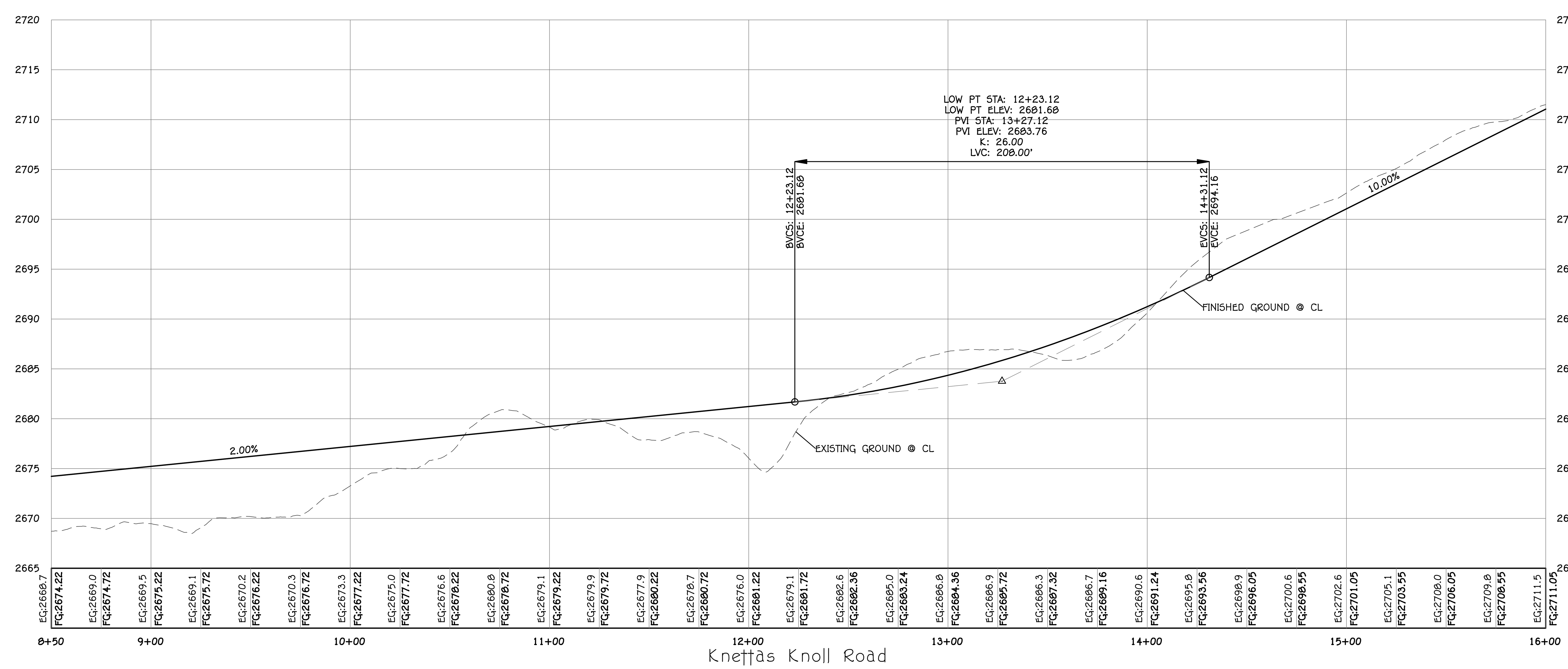

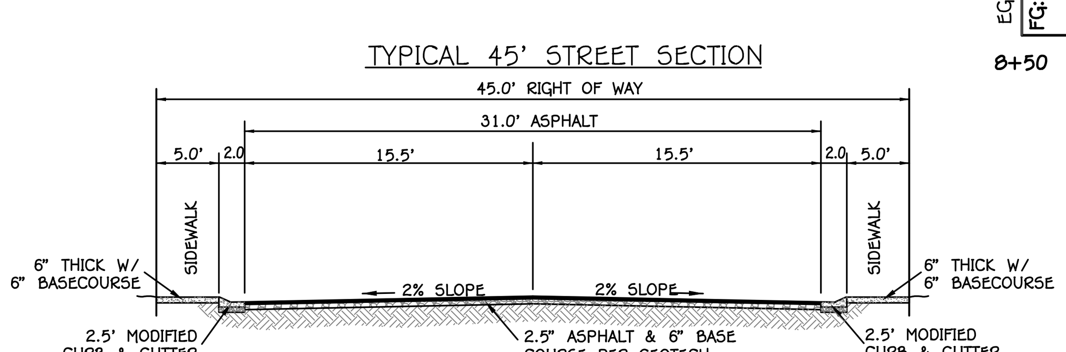

SCALE: 1"=40'
VERTICAL EXAGGERATION=5

0 40 80

PLAN & PROFILE SHEET

KNETTA'S KNOLL ROAD STA:8+50 TO STA:16+00
HILLSIDE SUBMITTAL

ST. GEORGE CITY, WASHINGTON COUNTY, UTAH
SECTIONS 28 & 33, TOWNSHIP 43 SOUTH, RANGE 15 WEST, SLB&M

AMERICAN LAND CONSULTING
1043 EAST 3740 SOUTH, WASHINGTON, UT 84780

LICENSED PROFESSIONAL ENGINEER — JASON L. TUTTLE No. 366642 — STATE OF UTAH — 4/28/21

REV.	DATE	NOTES:

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SHEET 6 / 7 SHEETS

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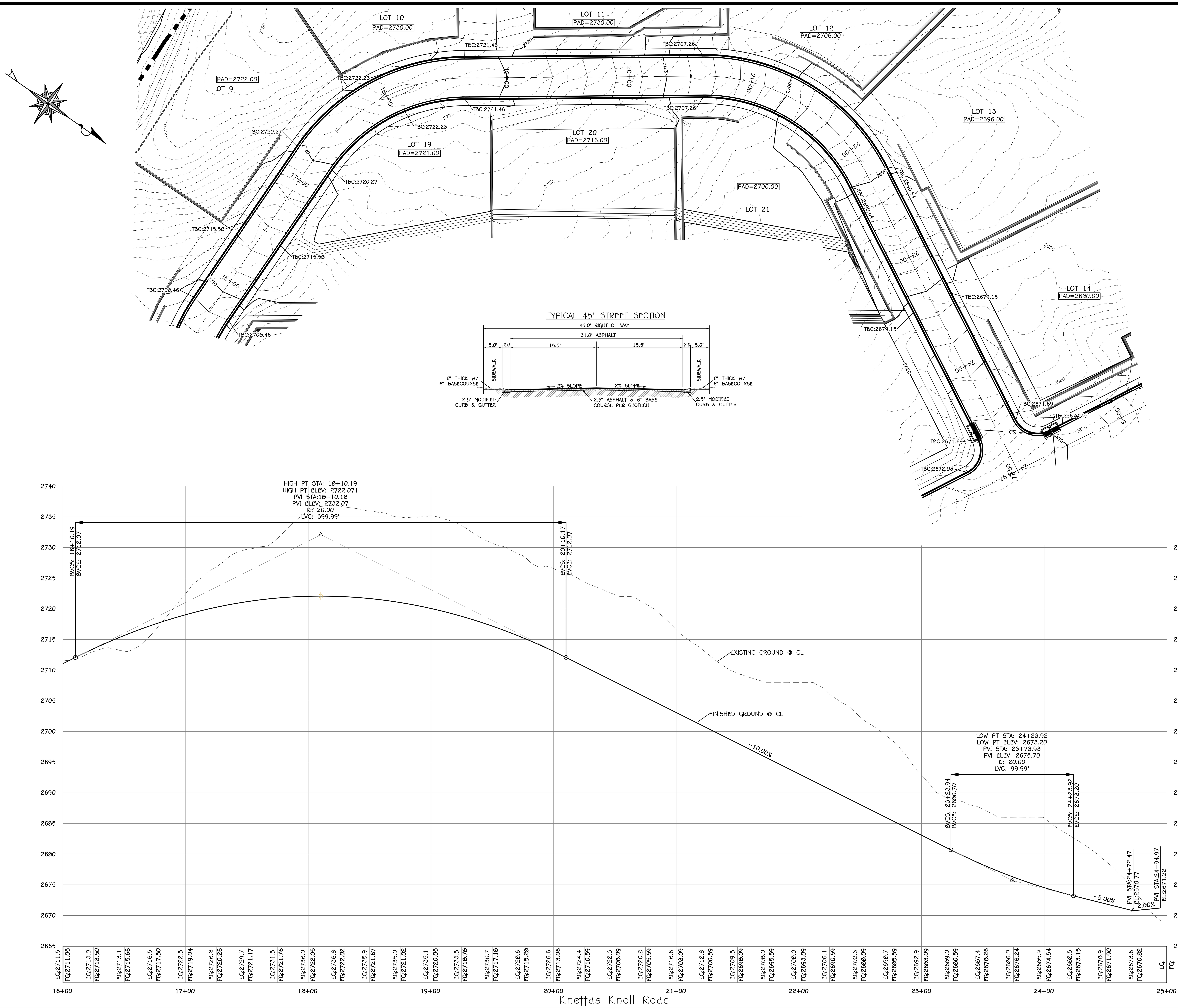

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- Ⓓ STORM DRAIN MANHOLE AS NOTED
- HILLSIDE NO DISTURB ZONE

0 40 80
SCALE:1"=40'
VERTICAL EXAGGERATION=5

REV. | DATE | NOTES:

AMERICAN LAND CONSULTING
1043 EAST 3740 SOUTH, WASHINGTON, UT 84780

PLAN & PROFILE SHEET

KNETTA'S KNOLL ROAD STA:16+00 TO END
HILLSIDE SUBMITTAL

ST. GEORGE CITY, WASHINGTON COUNTY, UTAH
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FILE: PNP's.dwg

SHEET 7 / 7 SHEETS

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Exhibit D
Geologic Hazard Study & Preliminary Geotechnical

Applied Geotechnical Engineering Consultants, Inc.

GEOLOGIC HAZARD ASSESSMENT AND PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

PROPOSED NETTAS KNOLL PLANNED DEVELOPMENT

ST. GEORGE, UTAH

PREPARED FOR:

MADISON COMPANY
JOINT VENTURE OF NETTAS KNOLL ASSOCIATION
C/O CRAIG HOPKINSON
335 EAST ST. GEORGE BOULEVARD
ST. GEORGE, UTAH 84770

ATTENTION: CRAIG HOPKINSON

PROJECT NO. 2030907

JANUARY 14, 2004
REVISED JULY 7, 2004

158 West 1600 South • St. George, Utah 84770 • (435) 673-6850 • FAX (435) 673-1044

TABLE OF CONTENTS

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SUMMARY

1. The site is suitable for the proposed development provided that grading and drainage recommendations within this report are followed. A geotechnical investigation will be required prior to design to provide a more detailed evaluation of the expansive mudstone elevation as well as to provide appropriate foundation, grading and drainage recommendations.

2. The subsurface soil profile observed across the site generally consists of alluvial soils composed of silty sand and gravel with cobbles and boulders underlain by a layer of conglomerate which is composed of highly cemented sand, gravel, and cobbles. The conglomerate is underlain by shale of the Moenave Formation which is further underlain by mudstone bedrock of the Chinle Formation. Both the shale and mudstone are expansive when wetted.

3. There are no map faults or evidence of significant fault activity located within the project area or in the proximity. The closest mapped fault is the St. George Fault located approximately 1 mile to the west.

4. No evidence of recent landslide movement was observed in the project area. There has been no historical movement in this area. Landsliding has occurred to the west of the subject site along the western portion of Foremaster Ridge Drive and is believed to have occurred in the Chinle Formation when the environment was significantly wetter. The Chinle Formation was likely in a near saturated condition at the time of failure and the topography was likely much steeper.

5. Based on field observation, rock fall hazard on the proposed site is very low. Some conglomerate boulders were observed along the slope of the western and southern portion of the site and are a result of the less resistant shale and mudstone weathering and the conglomerate breaking off and rolling or sliding down the hill. No conglomerate boulders were observed to have traveled to the base of the hill.

6. The existing slopes are currently stable in their existing geometry and moisture condition. Analysis also indicates the slopes would remain stable is the soil and bedrock were to become wetting following the proposed grading. Based on the proximity of the proposed building pad grades to the expansive mudstone bedrock, we anticipate that the proposed grading will change to allow for appropriate separation of foundations above expansive materials. A slope stability study should be conducted to provide detailed recommendations when final grading is known. To maintain stability of the slope following grading, proper drainage should be provided to reduce infiltration of surface water into the subsurface soil/mudstone. Drainage and grading recommendations within the recommendations section of this report should be followed. Site grading plans should be reviewed during the planning process by the geotechnical engineer. Guidance can be provided during planning to maintain appropriate slope stability.

7. As indicated above, a detailed geotechnical investigation will be required to determine the relative elevation of mudstone across the subject site and provide appropriate foundation recommendations. A representative of AGEC should observe the grading operations during construction to verify subsurface conditions are consistent with what was observed during this study as well as subsurface conditions which will be observed during the geotechnical investigation study.

SCOPE OF WORK

This report presents the results of the geologic hazard assessment and long-term slope stability evaluation for the area proposed for development of the Nettas Knoll Planned Development property located in St. George, Utah, as shown on Figures 1 and 3. The study consisted of a geologic site reconnaissance and review of geologic literature. The site reconnaissance included a general inspection of the site and its surrounding conditions and observation of geologic formations, bedrock, and potential hazards.

In addition to the site reconnaissance, a subsurface investigation was conducted which consisted of the drilling of six borings to a maximum depth of 39 feet below existing grade. In addition, three trenches were excavated at the approximate locations shown on the site plan, Figure 2, to assist in determining subsurface soil profile and specifically to determine the elevation of shale and mudstone bedrock on the western and eastern portion of the site. Samples were obtained during the subsurface investigation and were tested in the laboratory to determine the physical and engineering characteristics of the on-site soil and bedrock to assist in engineering analysis and slope stability evaluation.

Our conclusions and recommendations are based on the geologic study, subsurface information obtained and a detailed engineering analysis to determine the long term stability of the slope utilizing the proposed grading for the site.

PROPOSED CONSTRUCTION

Based on preliminary site plans, we understand that it is proposed to develop the top of the knoll into a planned development subdivision. The subdivision is currently planned to consist of 198 units. The development will require cuts along the southwestern portion of the site and fills along the north eastern portion of the site up to approximately 20 feet. We anticipate interior roadways will be constructed as part of the development.

We understand the building construction will generally consist of residential structures which will be three stories high.

SITE CONDITIONS

The proposed site is currently undeveloped property located at the top of an existing knoll to the east of Foremaster Ridge as shown on Figure 1. The site is covered with native vegetation consisting of brush and weeds. The general topography of the site is shown on the site plan, Figure 2. Generally, the site slopes down from the southwest to the northeast with an elevation change of approximately 150 to 200 feet. The proposed site is capped with alluvial material and conglomerate above the shale and mudstone bedrock which slopes down from the southwest to the northeast (see Photo Exhibit 5).

The site is bordered on the north by undeveloped land and Riverside Drive, to the west by undeveloped land and the proposed new construction of Riverside Drive with undeveloped land and the Virgin River to the south and undeveloped land to the east.

GEOLOGY

The geologic conditions at the site were evaluated based on a review of the geologic literature and a reconnaissance of the site.

A. **Geomorphology of the Study Area**

The proposed site is located along the top of an existing knoll. The conglomerate cap of the ridge is a retreating cliff face due to the undercutting of the underlying less competent Moenave and Chinle Formations. When the less competent underlying layers are eroded, tension cracks develop in the cliff-forming conglomerate and rock falls or slopes result (see Photo Exhibits 1 and 2). This erosional process is very slow.

The topography of the study area is dominated by sloping topography from the southwest to the northeast. The proposed hillside will be below the proposed development.

B. **Stratigraphy of the Area**

Geologic units exposed in the project area consist of Jurassic and Triassic bedrock and Quaternary alluvial deposits. The geology of the study area is presented on Figure 3.

Stream Terraced Deposits. Alluvial deposits of gravel and cobble sized clasts in a muddy to course sand matrix were observed along the majority of the top of the site. These clasts form a poorly sorted indurated pedogenic carbonate - cemented conglomerate at several levels above the present flood plain.

Dinosaur Canyon Member of the Moenave Formation. Shale bedrock exposed in the project area is the Jurassic-aged Dinosaur Canyon Member of the Moenave Formation. This unit consists of interbedded moderate-red-brown siltstone and fine grained thin bedded sandstone with laminated cross beds. This member is similar to the step-slope appearance of the middle member of the Kayenta Formation.

Petrified Forest Member of the Chinle Formation. The mudstone bedrock exposed in the project area is the Triassic-age Petrified Forest member of the Chinle Formation. The unit consists of bentonitic shale and siltstone with several interbeds of pale yellowish-brown sandstone up to 15 feet thick (Higgins and Willis, 1995). It is primarily a lacustrine deposit and exhibits a distinct variegated red-brown, purple and green color.

C. Structure of the Area

St. George is located between the Basin and Range province and the Colorado Plateau province in the St. George Basin section of the Colorado Plateau (Stokes, 1977). The rocks on the western edge of the Colorado Plateau are gently dipping and folded (Christenson and Deen, 1983). The St. George Basin is bordered on the east by the Hurricane Cliffs, on the west by the Beaver Dam Mountains, and on the north by the Pine Valley Mountains. The southern edge of the St. George Basin extends into Arizona (Christenson and Deen, 1983).

The St. George Basin is a downdropped fault block that has been displaced 6000-8000 feet along the Hurricane fault on the east (Hamblin, 1970). The area to the west has in turn been downdropped along the Grand Wash fault, which is the eastern boundary of the Basin and Range province in this area (Christenson and Deen, 1983).

The St. George Basin is characterized by basalt capped buttes and cuestas that were once stream channels along which lava flowed. Erosion of the surrounding softer sedimentary rocks over time has resulted in an inverted topography of old stream channels becoming resistant basalt ridges such as the distinct Washington, Middleton and West Black Ridges (Christenson and Deen, 1983). The site is located on the southeast flank of a basalt capped ridge adjacent to the West Black Ridge to the southeast.

GEOLOGIC HAZARDS

A. Landslides

Based on previous mapping and the site reconnaissance, no evidence of recent landslide movement was observed in the project area. Based on a landslide map of the St. George, Utah 30' x 60' Quadrangle, there has been no historical movement in this area (Harty, 1993).

No evidence of recent landslide movement was observed during our field reconnaissance. Long term slope stability concerns are further discussed in the geotechnical section of this report.

B. Rockfall

Based on field observation, rockfall onto the proposed building site is not a concern. However, rockfall as a result of weathering of the less resistant shale and mudstone bedrock below the conglomerate layer, has occurred along the western and southern portions of the site. The conglomerate cobbles and boulders appear to slide rather than roll and were not observed to have traveled to the base of the slope. Therefore, rockfall hazard along the subject site is very low.

C. Faults

Based on previous work by Christenson and Deen, 1983, there are no active faults or evidence of significant fault activity located within the project area or in the proximity. Field observations support these previous conclusions. The closest mapped fault is the St. George fault located approximately 1 mile to the west.

D. Flooding

The proposed site is not located in a flood plain, and no evidence of flood or debris flow hazards was identified at the site.

SUBSURFACE CONDITIONS

An engineer from AGEC observed the drilling/coring of 6 borings and the excavation of three trenches on the subject property on September 8, 12, 15, 24, and October 14, 30, and 31, 2003. The borings were drilled with a truck-mounted drill rig equipped with 7-inch diameter hollow stem augers and 5-inch diameter solid flight augers to practical refusal. The borings were advanced with a 2-inch NX diamond core barrel and tri-cone roller bit. The trenches were excavated utilizing a trackhoe. The borings were drilled and the trenches excavated at the approximate locations shown on Figure 2.

The subsurface soil profile observed in the borings drilled and in the trenches excavated generally consists of alluvial soils composed of silty sand and gravel with cobbles and boulders underlain by a layer of conglomerate which is composed of highly cemented sand, gravel, and cobbles. The conglomerate is underlain by shale bedrock of the Moenave Formation which is further underlain by mudstone bedrock of the Chinle Formation. A detailed description of each soil type encountered follows:

Silty sand with gravel - The silty sand with gravel contains occasional cobbles and boulders. It is medium dense to very dense, dry, and brown in color. The sand is fine to medium grained and calcareous. The cobbles and boulders are sub-rounded to sub-angular.

Silty gravel with sand - The silty gravel with sand contains occasional cobbles and boulders. It is very dense, slightly cemented, dry, and red to brown in color. The sand is fine to course grained. The cobbles and boulders are sub-angular to angular.

Conglomerate - The conglomerate is composed of highly cemented sands, gravel, cobbles and boulders. The conglomerate is very hard, dry, and gray to brown in color.

Shale bedrock - The shale bedrock is composed of lean to fat clay with varied amounts of sand. The shale is weathered to moderately hard, slightly moist, and red to brown in color.

Laboratory tests conducted on a sample of the shale indicates a natural moisture content of 19 percent, and in-place dry density of 107 pcf, and a fines content (percent passing the No. 200 sieve) of 93 percent. An Atterberg limit test conducted on a sample of the shale bedrock indicates a liquid limit of 67 percent and a plasticity index of 38 percent. A direct shear test conducted on a sample of the shale bedrock indicates a cohesion value of 360 psf and a friction angle of 26 degrees.

Mudstone bedrock - The mudstone bedrock is commonly known in the area as "blue clay" and is weathered to moderately hard, slightly moist, and purple to gray in color.

Laboratory tests conducted on samples of the mudstone bedrock indicate moisture contents ranging from 17 to 22 percent, natural dry densities ranging from 96 to 116 pcf, and fines contents (percent passing the No. 200 sieve) ranging from 91 to 99 percent. Atterberg limit tests conducted on samples of the mudstone bedrock indicate liquid limits ranging from 51 to 59 percent and plasticity indexes ranging from 27 to 38 percent.

A direct shear test conducted on a sample of the mudstone bedrock indicates a cohesion value of 190 psf and a friction angle of 37 degrees. A triaxial shear test conducted on a sample of the material indicates a cohesion value of 2,460 psf and a friction angle of 10 degrees.

The Boring Logs are shown on Figure 4 with the Legend and Notes of Exploratory Borings shown on Figure 5. Graphical logs of the excavated trenches are shown on Figures 6-8. A summary of laboratory test results are shown on the attached Table 1. Results of the direct and triaxial shear tests are shown graphically on Figures 13-15. The Core Logs are included in the Appendix of the report.

SUBSURFACE WATER

No groundwater was encountered during our subsurface investigation to the maximum depth investigated, approximately 39 feet. Further, no springs or seepages were observed on the site. Fluctuations of groundwater depth may occur over time. An evaluation of such fluctuations is beyond the scope of this report.

SLOPE ANALYSIS

The stability of the slope was evaluated by selecting representative cross sections across the property at the approximate locations shown on Figure 1. Soil and bedrock strengths were determined in a wet condition by laboratory testing.

The selected cross-sections of the slope were then evaluated both before and following proposed grading to determine factors of safety in a wet condition utilizing soil/bedrock strengths found in the laboratory by AGEC. Generally accepted factors of safety for static in seismic conditions are 1.5 and 1.1, respectively.

The cross-sections were analyzed using a circular type failure which assumes the mudstone bedrock is wet through the entire profile depth. This is highly unlikely to occur with current precipitation conditions. The cross-sections were also analyzed using a sliding block type failure. This method assumes the slope becomes wetted to 20 to 40 feet below the existing grade creating a weak interface through the weathered zone of the shale and mudstone bedrock. This creates a more realistic failure, but wetting the mudstone bedrock to depths of 20 to 40 feet for the entire profile is also highly unlikely to occur since no springs or seepages are present on the hillside. Factors of safety obtained in a wet condition during the analysis both before and after grading under static and seismic conditions are listed below:

Circular Failure

Cross Section	(0.1g) Earthquake	Factors of Safety	
		Before Grading	After Grading
A-A	No	3.2	2.9
A-A	Yes	1.9	1.9
B-B	No	2.1	1.5
B-B	Yes	1.3	1.2

Block Failure

Cross Section	(0.1g) Earthquake	Factors of Safety	
		Before Grading	After Grading
A-A	No	6.5	5.4
A-A	Yes	1.9	3.3
B-B	No	4.0	1.8
B-B	Yes	2.6	1.4

Acceptable factors of safety were generated during the analysis in the saturated condition indicating a relatively safe slope for cross-sections A-A and B-B before and after grading for both failure modes.

It should be noted that the soil profiles were analyzed in a wet condition which significantly reduces the strength of the soils. It is highly unlikely that the existing mudstone would be wetted to significant depths which would affect the global stability of the slope.

It is our opinion that the slope will remain stable following the currently proposed grading in the existing moisture condition. We anticipate that the grading will most likely change due to the close proximity of the proposed pad grades to expansive mudstone bedrock elevation which will require special foundation considerations. A more detailed geotechnical analysis should be conducted to further evaluate the depth to expansive mudstone below proposed pads as well as to provide foundation, grading, and drainage recommendations. An additional slope stability analysis should also be conducted following determination of proposed final grading if it changes significantly from the current proposed grading.

RECOMMENDATIONS

Based on subsurface soil conditions, laboratory test results, engineering analysis, and the proposed construction, the following recommendations are provided.

A. Site Grading

1. Subgrade Preparation

   Prior to placing fill, the exposed subgrade should be scarified to a depth of 8 inches and recompacted to at least 95 percent of the maximum dry density as determined by ASTM D-1557. Scarification will not be required in areas where the exposed subgrade consists of conglomerate. Fill should be moisture conditioned and placed in lift thicknesses suitable for the compaction equipment used. The density of the fill should be tested frequently to verify compaction.

2. Slope Stability

To maintain suitable factors of safety against landslide movements, the grading plans should be reviewed by the geotechnical engineer. To maintain the long term stability of the slope, drainage recommendations provided within the report should followed to reduce the infiltration of surface water into the subsurface soil or bedrock.

3. Excavation/Earthwork

Based on our site investigation and experience with similar material, very difficult conditions will exist when excavating through the conglomerate. Blasting will most likely be required for excavations which extend into the conglomerate. Excavations into the alluvial material as well as shale and mudstone bedrock can be accomplished with typical excavation equipment.

4. Grading Slopes

Based on the proposed grading plans cut slopes on the order of 10 to 20 feet in height may be constructed between lots. Cut slopes into the non-cemented alluvial materials may be cut as steep as 2 to 1 (horizontal to vertical). Cut slopes into the conglomerate, and competent shale and mudstone bedrock may be cut as steep as ½:1 (horizontal to vertical) provided adequate site drainage is provided.

We also understand fill slopes up to approximately 20 feet in height will be placed along the northeastern portion of the site. Fill slopes should be placed at a maximum slope of 2:1 (horizontal to vertical) provided the fill is properly moisture conditioned and compacted. Fill placed on existing natural slopes steeper than 3:1 should be benched into the natural slope. Horizontal benches should be cut into natural slopes to provide an adequate surface for compaction and to assure proper stability of the slope. We further recommend over-filling slopes and cutting them to design grades to assure appropriate compaction at the edge of the slopes and to reduce erosion.

Horizontal benches should be constructed in fill and cut slopes at not more than 30 foot intervals to control drainage, erosion and debris. The benches should be at least 6 feet in width. If only one bench is required, it should be constructed at the midheight of the slope.

5. Compaction

Compaction of fill materials placed at the site should equal or exceed the following percentages:

Area	Percent Compaction
Subgrade	90
Footings/foundations	95
Building pad/Mass grading	95
Roadways/parking grading fill	95
Utility trench backfill	95

Granular fill tested should be compared to the maximum dry density as determined by ASTM D-1557. Fill should be compacted with a moisture content ± of 2 percent optimum. Fill placed at the site should be tested to verify proper compaction and moisture.

Base course in roadway areas should be compacted to at least 95 percent of the maximum dry density as determined to ASTM D-1557.

6. Materials

The on-site sand, gravel, and conglomerate free of organics and debris, may be used as site grading fill, structural fill, and utility trench backfill (above the pipe zone) provided the material is processed such that the maximum size particle is 8 inches and at least 50 percent of the material passes the No. 4 sieve. The on-site expansive shale and mudstone bedrock are not suitable for use as site grading or structural fill, but may be used in non-structural areas.

The soil at the site is generally below optimum moisture content and will require wetting prior to placement. Fill should be placed in the appropriate lift thicknesses which do not exceed the capability of the equipment used. Generally 8 to 10 inch lift thicknesses are adequate.

Preliminary grading recommendations have been provided for the current pad construction. Additional recommendations will be provided in a detailed geotechnical investigation when final proposed pad grading is known.

B. Rock Fall Recommendations

Rockfall protection is not necessary due to the very low likelihood of rockfall on the subject site.

C. Foundations

The site is suitable for the proposed construction provided that grading recommendations and appropriate foundation recommendations are followed. We anticipate deep foundations will be required to support the structures due to the expansive characteristics of the mudstone bedrock if the building pads are constructed such that less than 15 feet of non expansive soil is provided between the foundation and the expansive mudstone bedrock. Deep foundations consist of drilled concrete piers in conjunction with grade beams and a structural wood floor. We understand that the owners wish to construct building pads such that deep foundations are not required. Therefore, it will be necessary to drill additional borings on the subject site to provide appropriate pad grading recommendations and appropriate foundation recommendations.

D. **Drainage Recommendations**

Positive site drainage should be maintained through the course of construction. After construction has been completed, positive drainage of the surface water away from each building and off of the project must be maintained. In no case should water be allowed to pond adjacent the existing buildings. Additionally, infiltration beds are not an option for control of on-site surface water. We further recommend that landscaping be kept to a minimum to reduce the amount of moisture infiltration into the underlying soils.

Roof drains should be utilized on buildings and roof downspouts should discharge out away from foundations to collection gutters which discharge water off site or to closed storm sewers.

LIMITATIONS

Findings presented in this report represent conditions encountered on the subject parcel at the time of the investigation. Findings presented herein may be rendered invalid by changes which may occur as a result of natural processes or the influence and activities of man, over which Applied Geotechnical Engineering Consultants, Inc., has no control. Variations in the subsurface conditions may not become evident until additional exploration or excavation is conducted. If the subsurface soil, bedrock, or groundwater conditions are found to be different than what is described in this report, we should be notified to reevaluate the recommendations given.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

Jared Hanks, P.E.

Reviewed by: Arnold DeCastro, P.E.

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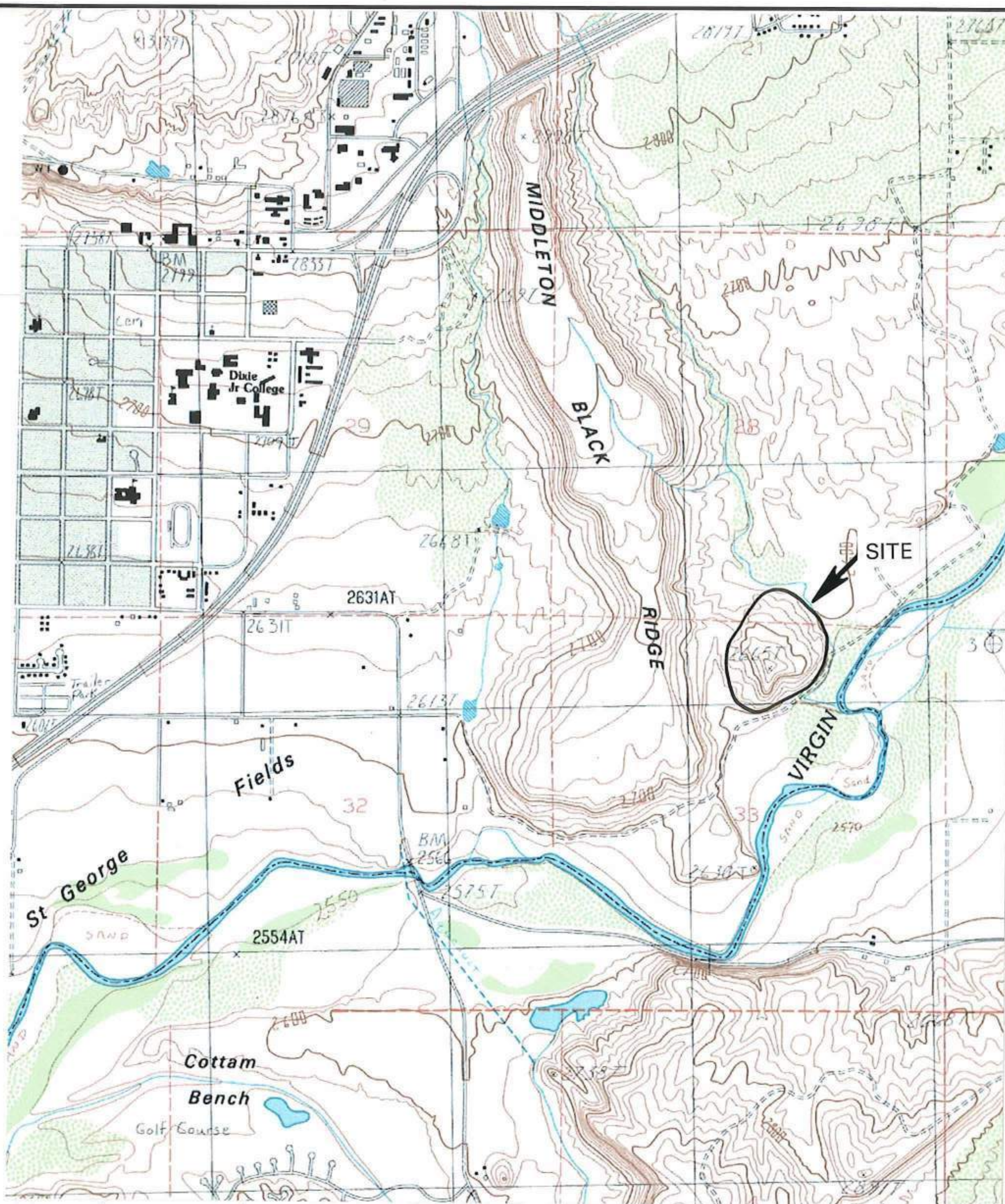
enclosures

REFERENCES CITED

Christenson, G. E., and Deen, R. D., 1983, Engineering Geology of the St. George Area, Washington County, Utah; Utah Geological Survey, Special Studies 58.

Harty, K. M., 1993, Landslide Map of the St. George 30' x 60' Quadrangle, Utah; Utah Geological Survey, Open-File Report 292.

Higgins, J. M. and Willis, G. C., 1995, Interim Geologic Map of the St. George Quadrangle, Washington County, Utah; Utah Geological Survey, Open-File Report 323.



7.5 Minute USGS Map
St. George Quadrangle

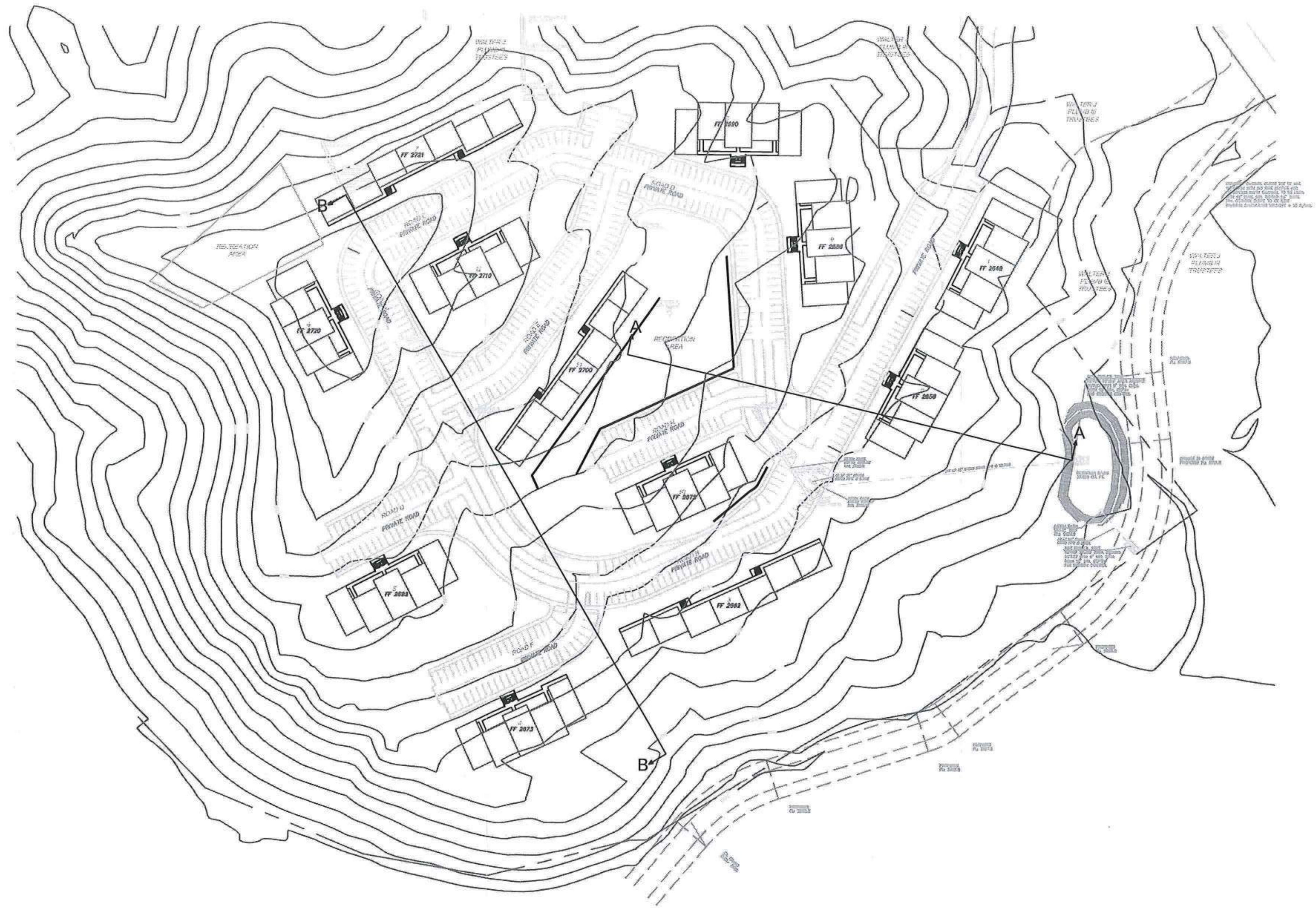
N

Scale 1:24,000

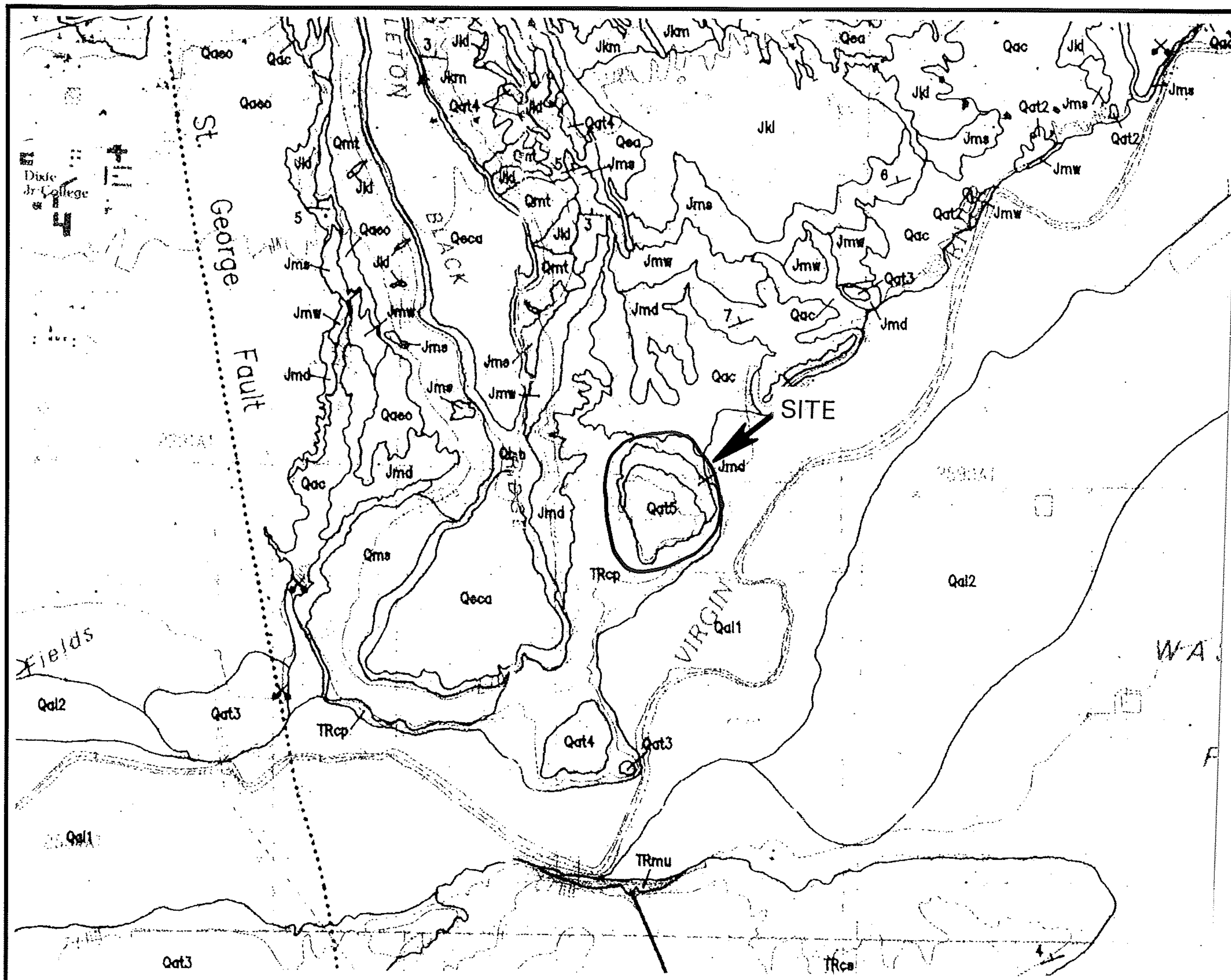
NETTAS KNOLL TOWNHOMES
ST. GEORGE, UTAH

2030907	AGEC	Topography/Vicinity Map of Study Area	Figure 1

NETTLAS KNOLL PLANNED DEVELOPMENT
ST. GEORGE, UTAH



2030907	AGEC	Site Plan	Figure 2



Quaternary Alluvial Deposits

Qat_5 - Stream-terrace deposits - Gravel to cobble size clasts in a muddy to course sand matrix; form a poorly sorted, indurated pedogenic carbonate-cemented conglomerate at several levels above the present floodplain; clasts are well-rounded and may are exotic to the quadrangle, indicating a source several miles upstream; pedogenic carbonate (caliche) thicker in older depositsl subscripts denote relative heights above the current drainage (and approximate ages); level 3 deposits are 440-90 feet (12-27 m); level 4 are 90-140 feet (27-42 m); and level 5 are 140-190 feet (42-57 m) above present channels; typically 0-40 feet (12m) thick; near Fort Pearce Wash may exceed 100 feet (30 m) thick.

Jurrasic

Jmd - Dinosaur Canyon Member of the Moenave Formation - Interbedded moderate-red-brown siltstone and fine-grained, thin-bedded, pale-reddish-brown to grayish-red sandstone with laminated crossbeds; very similar to the step-slope appearance of the middle member of the Kayenta Formation; 250 feet (76 m) thick.

Triassic

TRcp - Petrified Forest Member of the Chinle Formation - Light-brownish-gray to grayish-purple bentonitic shale and siltstone with several interbeds of pale-yellowish-brown, crossbedded sandstone up to 10 feet (10 m) thick; petrified wood is common; shales weather to a "popcorn" surface with abundant mudcracks due to bentonitic clay swelling and shrinking with moisture; forms well-developed strike valleys adjacent to the more resistant cliffs of the Shinarump Conglomerate Member, 700 feet (215 m) thick.

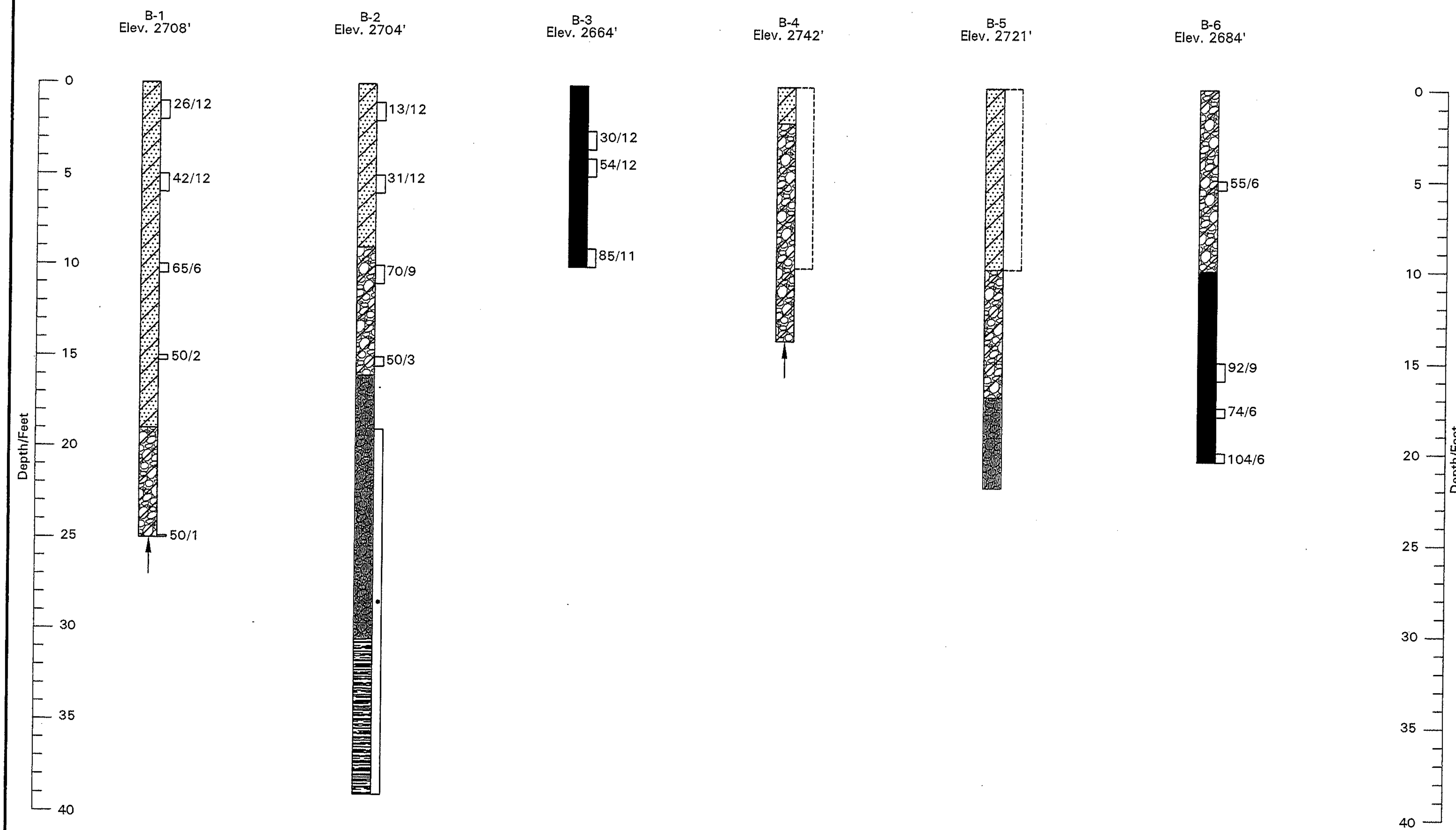
7.5 Minute USGS Map
St. George Quadrangle
Source: Higgins and Willis (1995)

N

Scale 1:24,000

NETTAS KNOLL TOWNHOMES
ST. GEORGE, UTAH

2030907	AGEC	Topography/Vicinity Map of Study Area	Figure 3



Approximate Vertical Scale 1" = 8'

See Figure 4 for Legend and Notes

2030907 | AGEC | Logs of Exploratory Borings | Figure 4

LEGEND:

Silty sand with gravel (SM); contains occasional cobbles and boulders. It is medium dense to very dense, dry and brown. The sand is fine to medium grained and calcareous. The cobbles and boulders were subrounded to subangular.

Silty gravel with sand (GM); contains occasional cobbles and boulders. It is very dense, slightly cemented, dry, and red to brown in color. The sand is fine to course grained. The cobbles and boulders are subangular to angular.

Conglomerate; composed of highly cemented sands, gravels, cobbles and boulders. The conglomerate is very hard, dry, and gray to brown in color.

Shale bedrock; composed of lean to fat clay with varied amounts of sand. The shale is weathered to moderately hard, slightly moist, and red to brown in color.

Mudstone bedrock; composed of fat clay and is commonly known as "blue clay". It is weathered to moderately hard, slightly moist, and purple to gray in color.

10/12 California Drive sample taken. The symbol 10/12 indicates that 10 blows from a 140 pound automatic hammer falling 30 inches were required to drive the sampler 12 inches.

Indicates core sample taken.

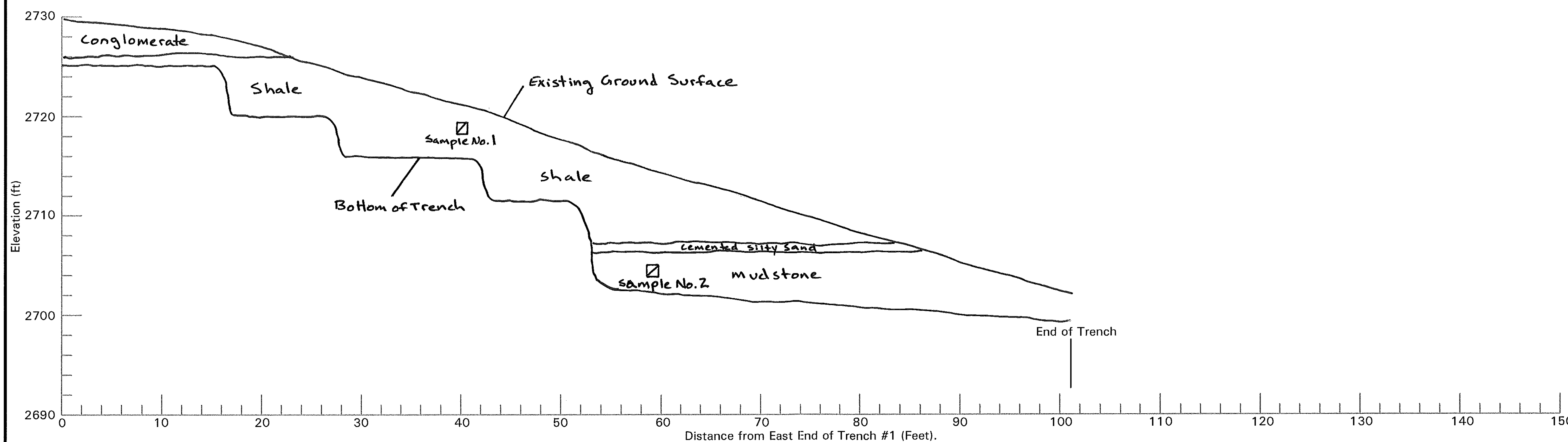
Indicates disturbed sample taken.

Indicates practical auger or core barrel refusal on conglomerate.

NOTES:

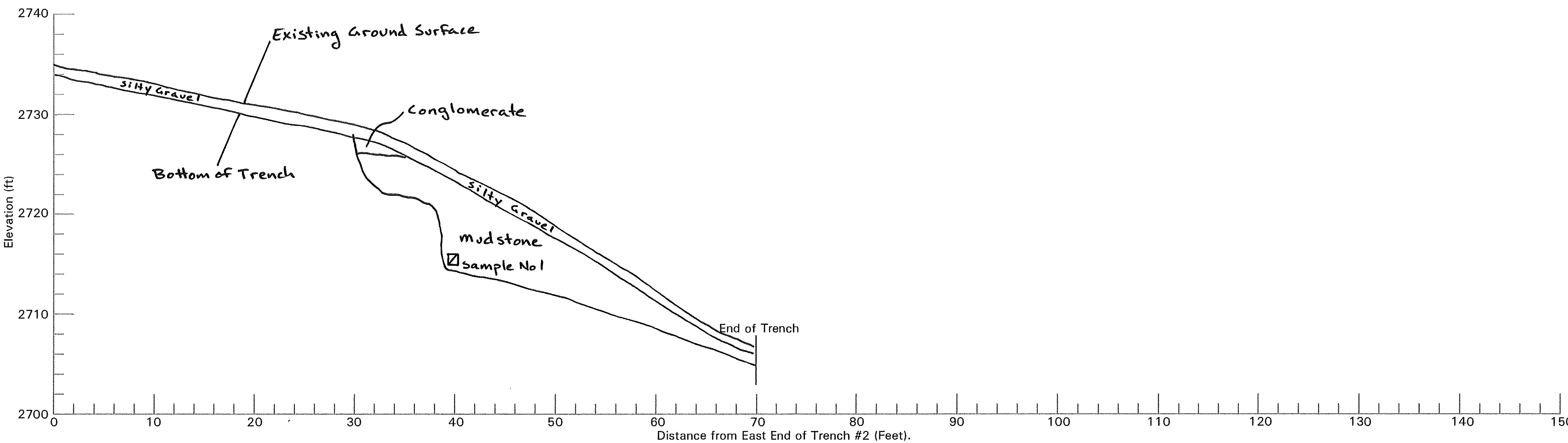
1. The borings and trenches were drilled/excavated on September 8, 12, 15, and 24, October 14, 30, and 31, 2003 with 7-inch diameter hollow-stem augers, 5-inch solid flight augers, 2-inch NX core barrel using air and a tri-cone roller bit using air. The trenches were excavated with a trackhoe.
2. The locations of the borings and trenches were determined by L.R. Pope Engineers using a Global Positioning System (GPS).
3. The elevations of the borings were determined by L.R. Pope Engineers using a Global Positioning System (GPS).
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. No free water was encountered in the borings at the time of drilling.

Approximate Vertical and Horizontal Scale 1" = 10'



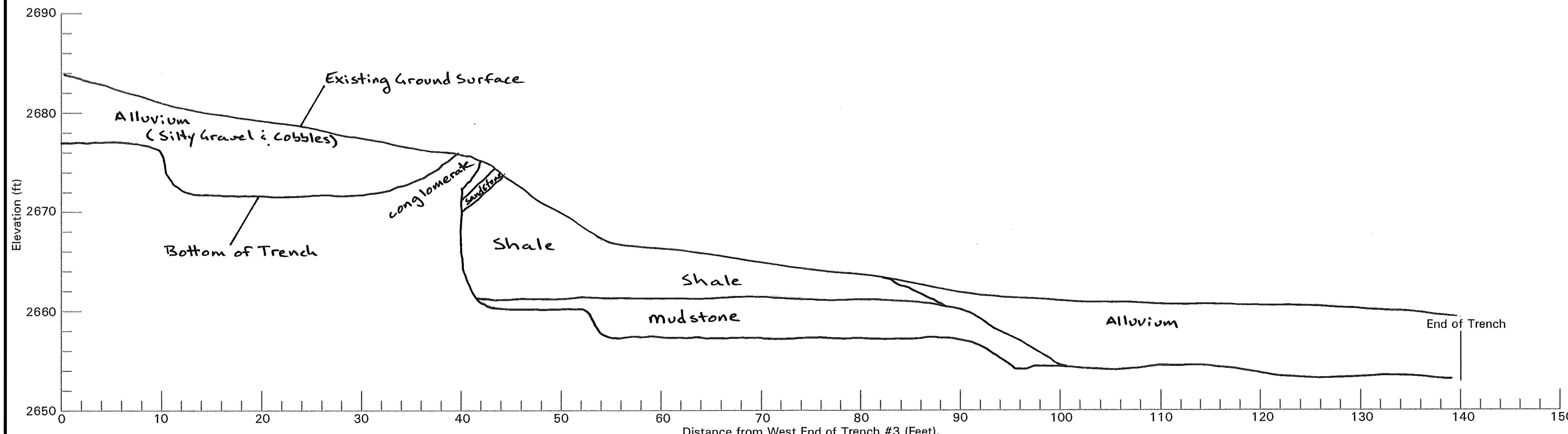
2030907	AGEC	Trench No. 1 Profile	Figure 6

Approximate Vertical and Horizontal Scale 1" = 10'

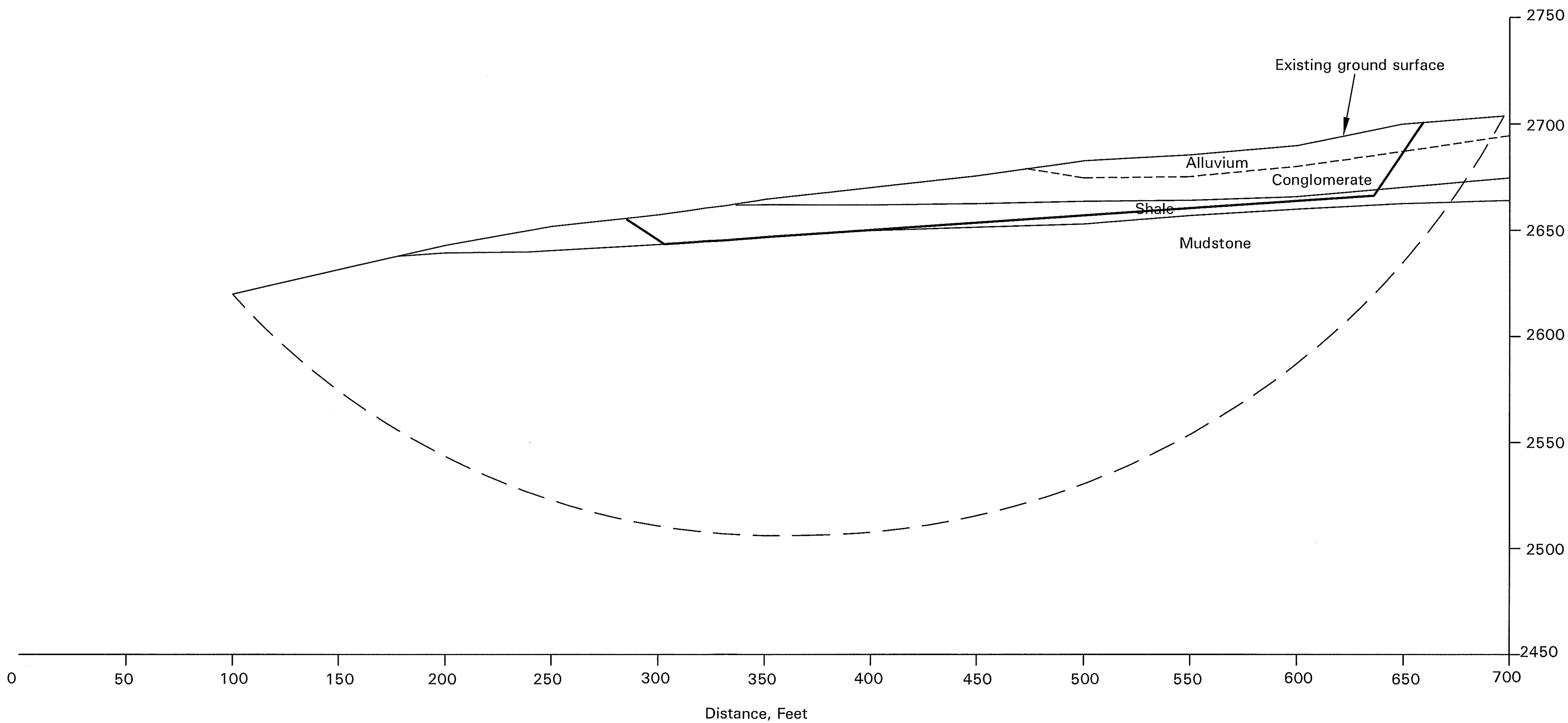


2030907	AGEC	Trench No. 2 Profile	Figure 7

Approximate Vertical and Horizontal Scale 1" = 10'



2030907	AGEC	Trench No. 3 Profile	Figure 8



Key:

—— Projected Block Failure Surface
FS = 6.5 static
FS = 1.9 seismic

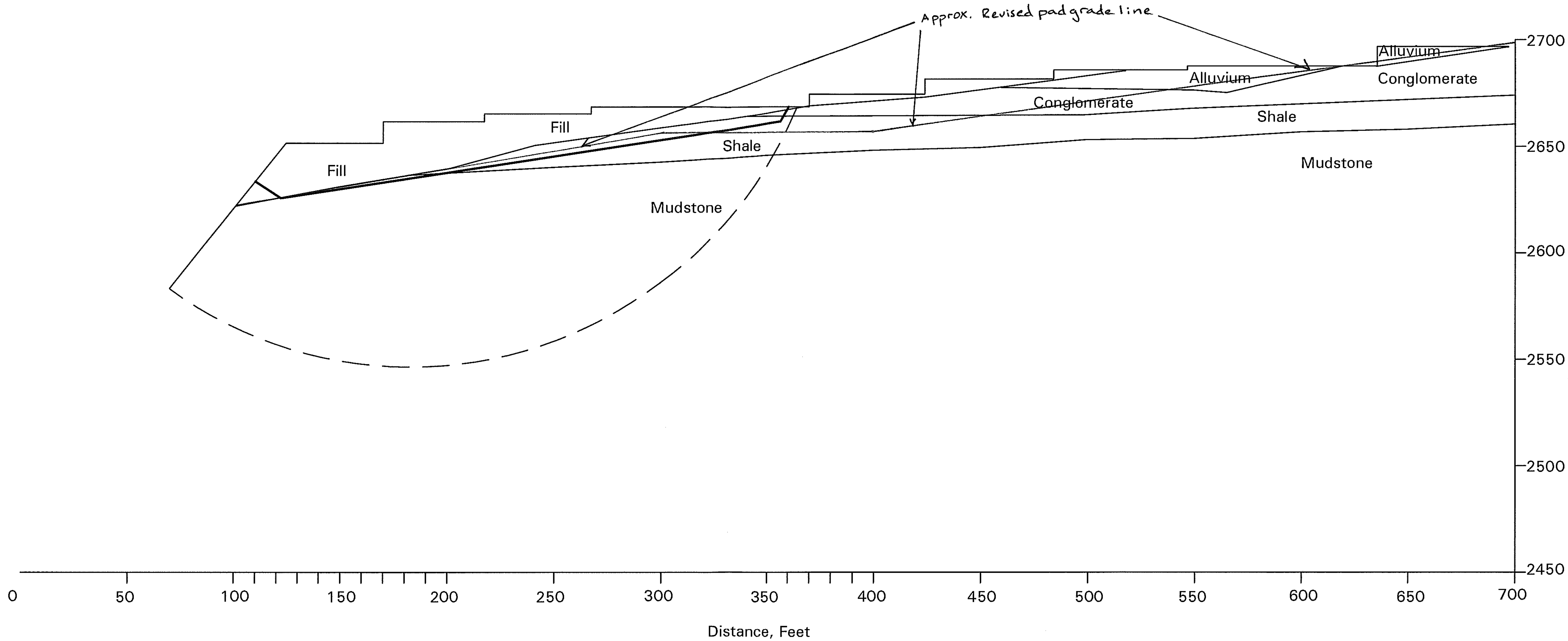
— — Projected Circular Failure Surface
FS = 3.2 static
FS = 1.9 seismic

Note: Circular Failure Surface assumes a saturated condition for the full depth of the slope.

Block Failure Surface assumes a shallower wet depth (approximately 20 to 40 feet) resulting in a weak faulure surface between the weathered shale and mudstone and the unweathered mudstone.

Scale 1" = 50'

2030907	AGEC	Cross Section A-A' Existing Contours	Figure 9



Key:
Projected Block Failure Surface
FS = 5.4 static
FS = 3.3 seismic

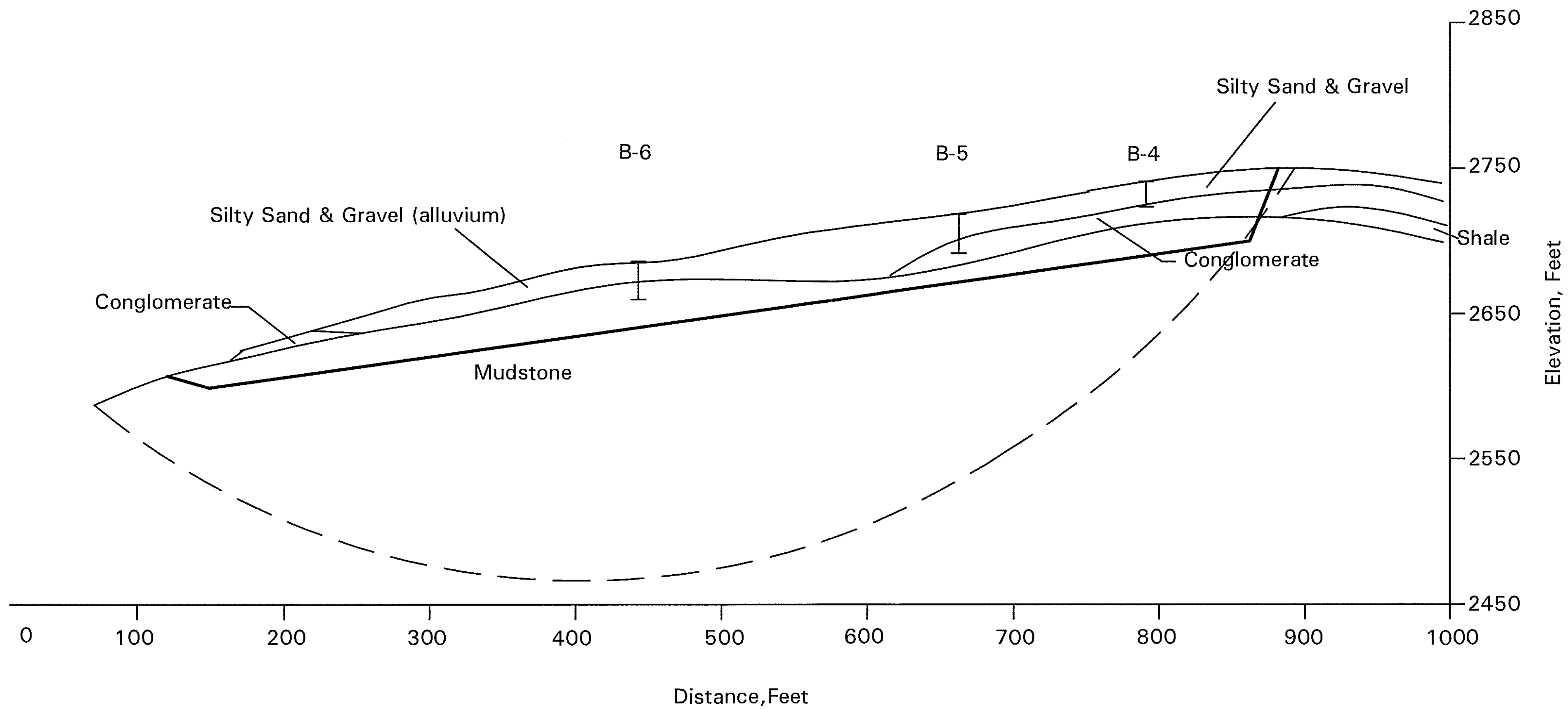
Projected Circular Failure Surface
FS = 2.9 static
FS = 1.9 seismic

Note: Circular Failure Surface assumes a saturated condition for the full depth of the slope.

Block Failure Surface assumes a shallower wet depth (approximately 20 to 40 feet) resulting in a weak faulure surface between the weathered shale and mudstone and the unweathered mudstone.

Scale 1" = 50'

2030907	AGES	Cross Section A-A' Proposed Ground Surface after Grading	Figure 10



Key:

—— Projected Block Failure Surface
FS = 4.0 static
FS = 2.6 seismic

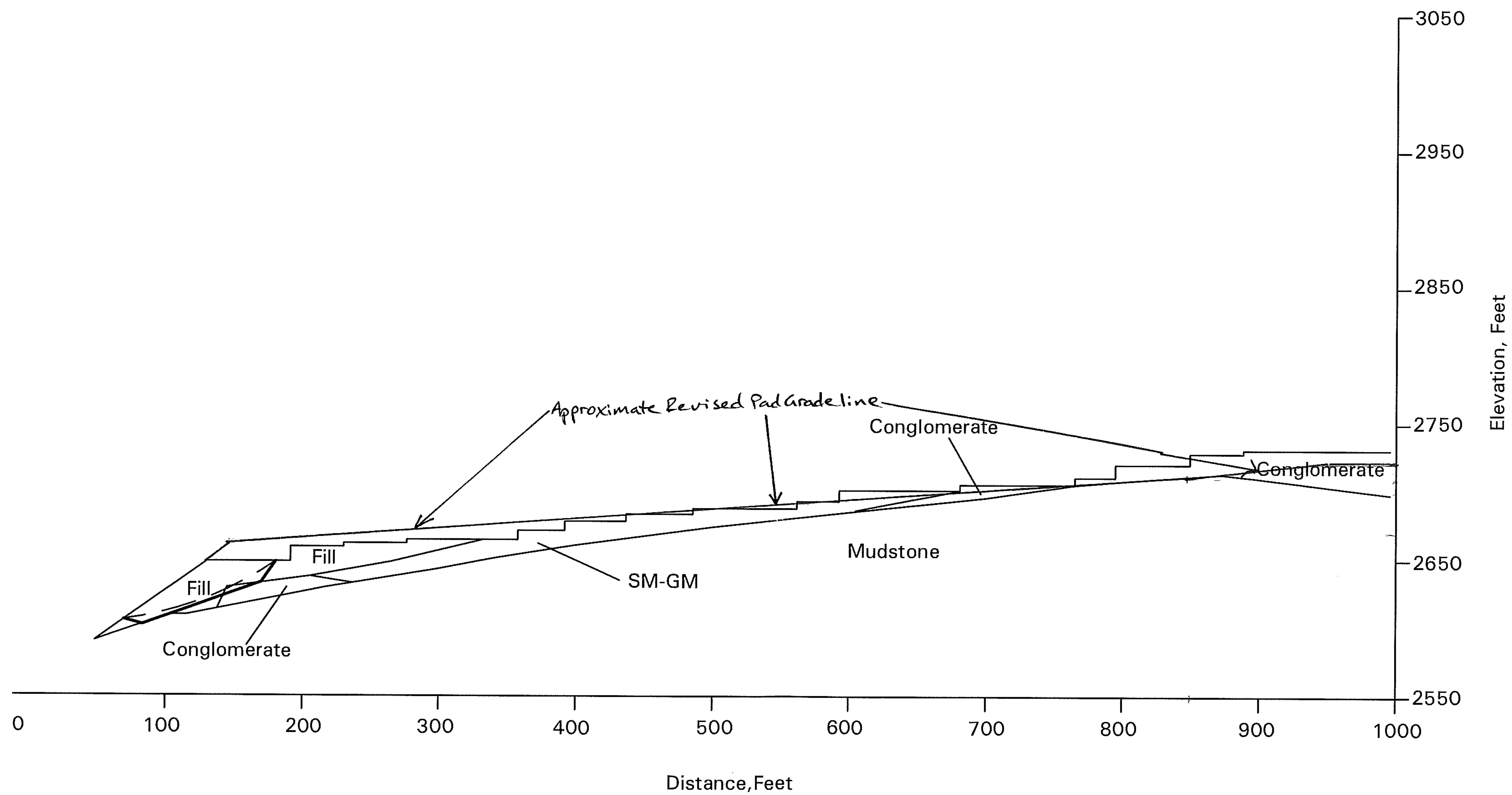
— — Projected Circular Failure Surface
FS = 2.1 static
FS = 1.3 seismic

Note: Circular Failure Surface assumes a saturated condition for the full depth of the slope.

Block Failure Surface assumes a shallower wet depth (approximately 20 to 40 feet) resulting in a weak faulure surface between the weathered shale and mudstone and the unweathered mudstone.

Scale 1" = 100'

2030907	AGES	Cross Section B-B' Existing Contours	Figure 11



Key:

- Projected Block Failure Surface
  - FS = 1.8 static
  - FS = 1.4 seismic
- Projected Circular Failure Surface
  - FS = 1.5 static
  - FS = 1.2 seismic

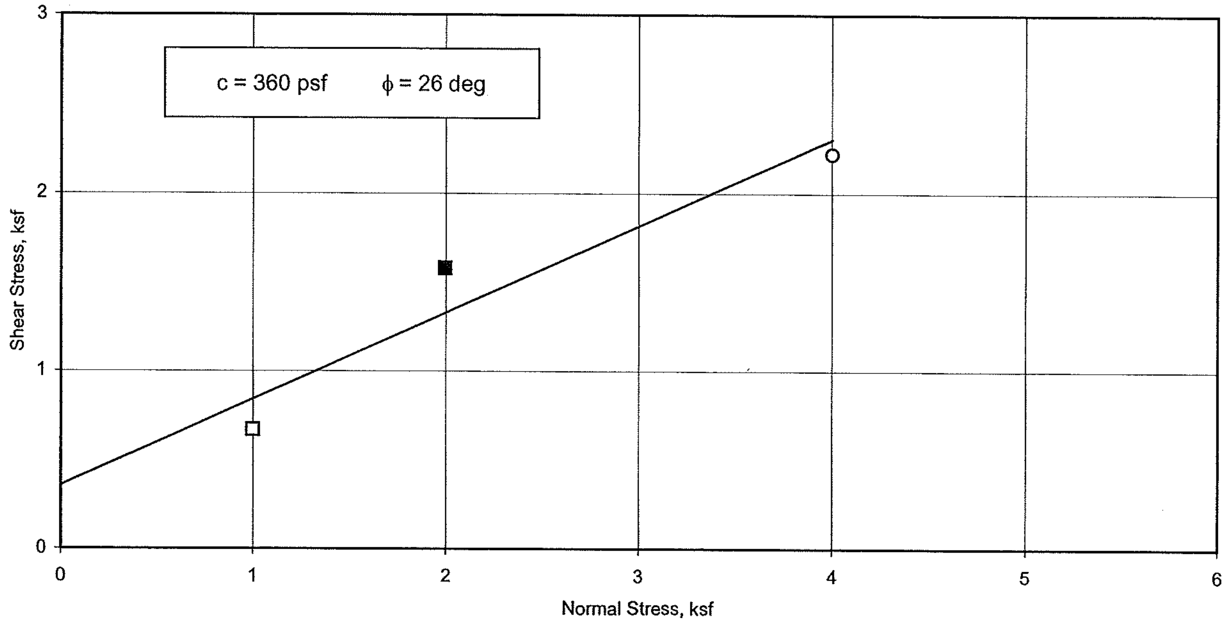
Note: Circular Failure Surface assumes a saturated condition for the full depth of the slope.

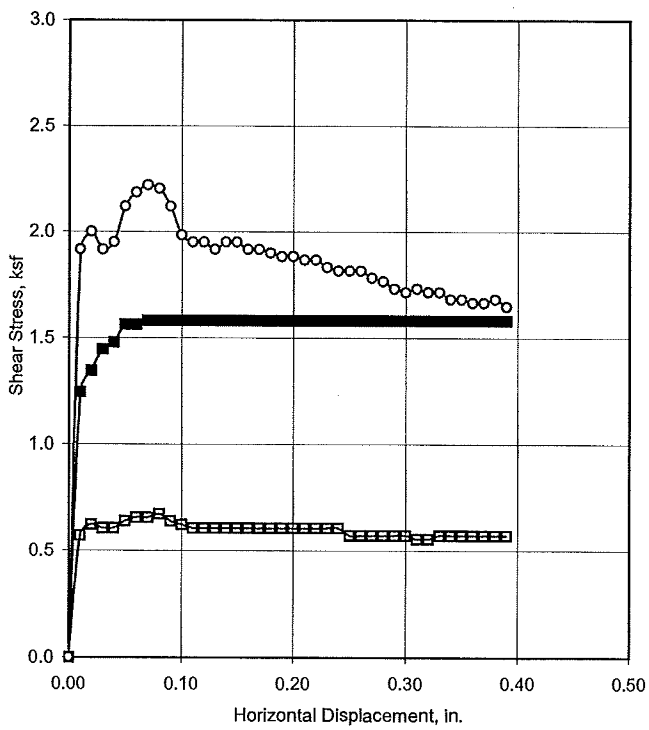
Block Failure Surface assumes a shallower wet depth (approximately 20 to 40 feet) resulting in a weak faulure surface between the weathered shale and mudstone and the unweathered mudstone.

Scale 1" = 100'

2030907	AGEC	Cross Section B-B' Proposed Ground Surface after Grading	Figure 12

Applied Geotechnical Engineering Consultants, Inc.





Test No. (Symbol)	1(□)	2(■)	3(○)
Sample Type	Undisturbed		
Length, in.	1.00	1.00	1.00
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	N/A	N/A	N/A
Moisture Content, %	N/A	N/A	N/A
Consolidation Load, ksf	1.0	2.0	4.0
Normal Load, ksf	1.0	2.0	4.0
Shear Stress, ksf	0.67	1.58	2.22
Remarks	Strain Rate 0.05 in/min.		

Sample Index Properties	
Dry Density, pcf	107
Moisture Content, %	19
Liquid Limit, %	67
Plasticity Index, %	38
Percent Gravel	0
Percent Sand	7
Percent Passing No. 200 Sieve	93

Type of Test: Consolidated, Wetted

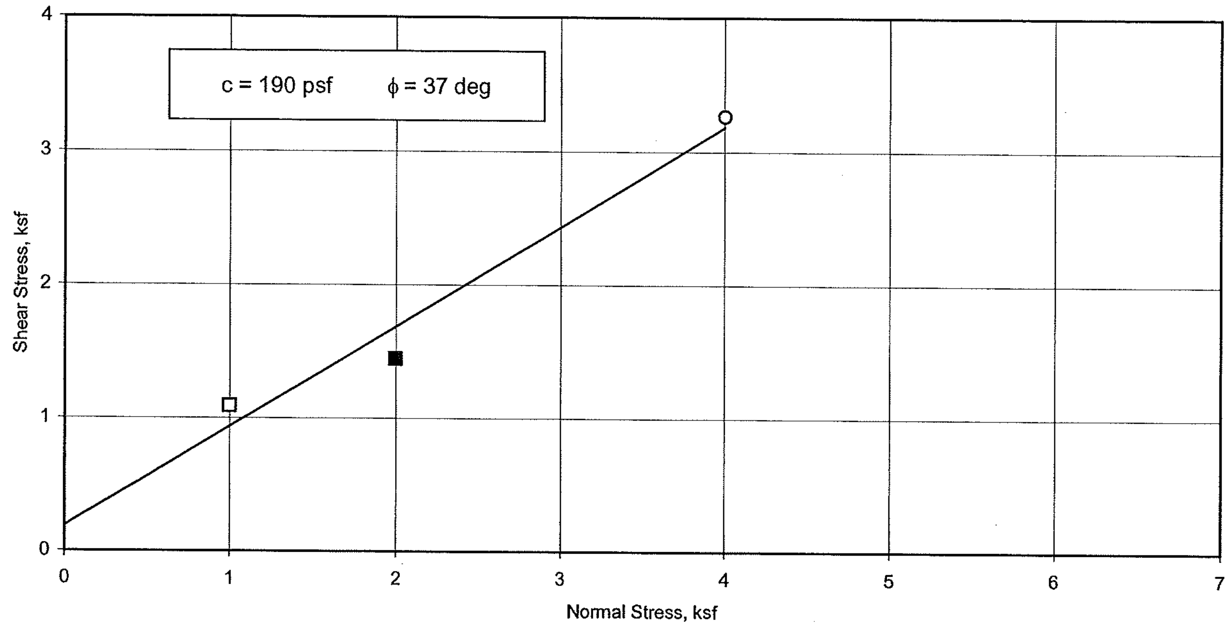
Sample Description: Red Shale (Fat Clay) From Trench 1 @ Sample 1

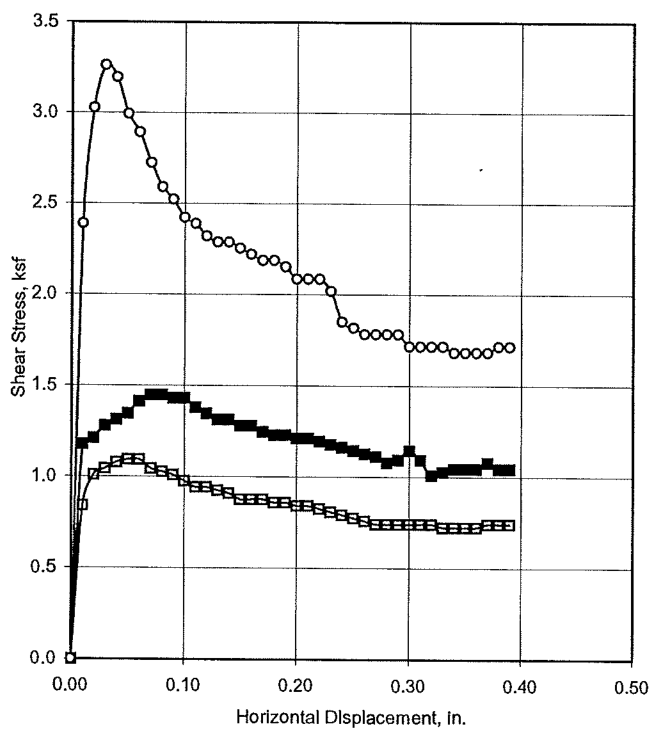
Project No. 2030907

Direct Shear Test Results

Figure 13

Applied Geotechnical Engineering Consultants, Inc.





Test No. (Symbol)	1(□)	2(■)	3(○)
Sample Type	Undisturbed		
Length, In.	1.00	1.00	1.00
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	N/A	N/A	N/A
Moisture Content, %	N/A	N/A	N/A
Consolidation Load, ksf	1.0	2.0	4.0
Normal Load, ksf	1.0	2.0	4.0
Shear Stress, ksf	1.09	1.45	3.26
Remarks	Strain Rate 0.05 in/min.		

Sample Index Properties	
Dry Density, pcf	96
Moisture Content, %	22
Liquid Limit, %	59
Plasticity Index, %	38
Percent Gravel	0
Percent Sand	9
Percent Passing No. 200 Sieve	91

Type of Test: Consolidated, Wetted

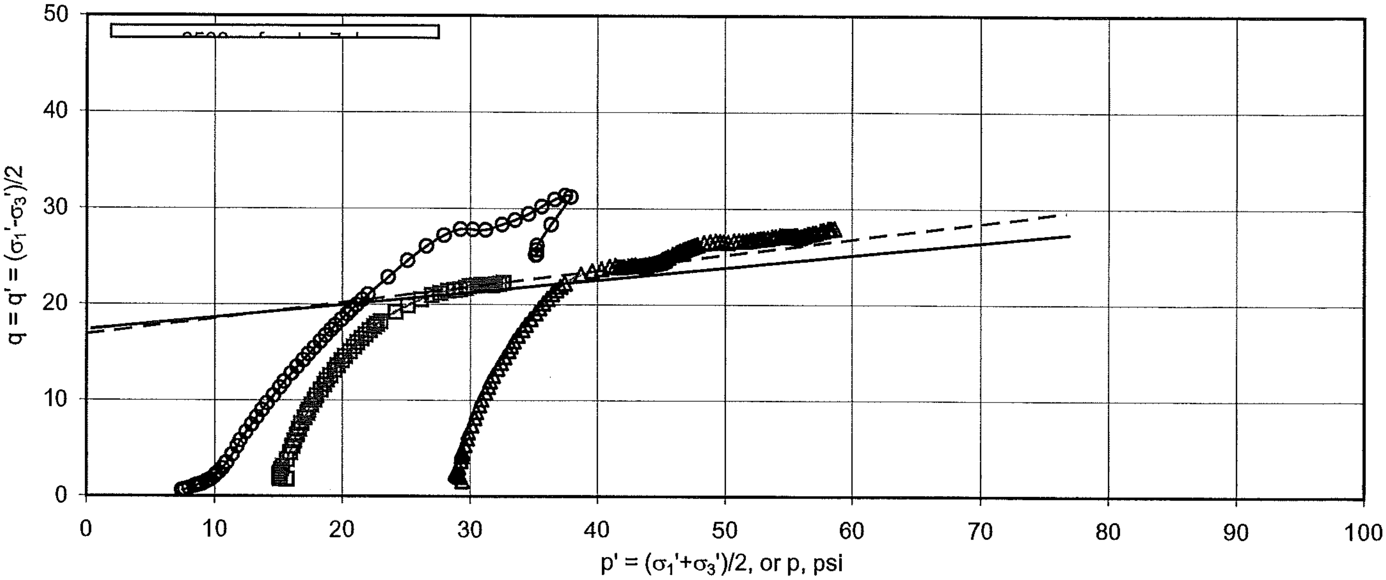
Sample Description: Purple Mudstone (Fat Clay) From Trench 1 @ Sample No. 2

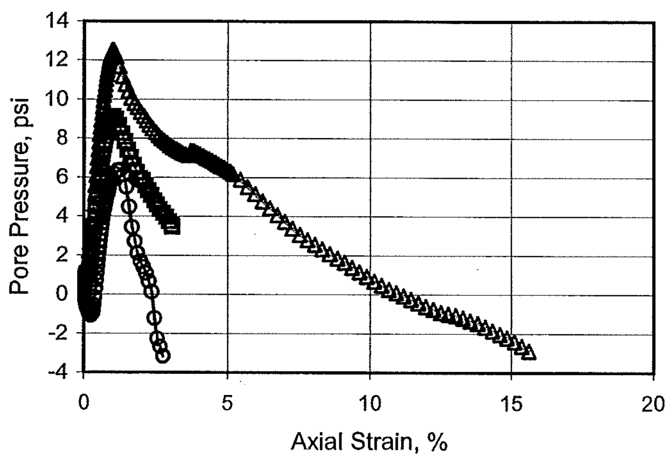
Project No. 2030907

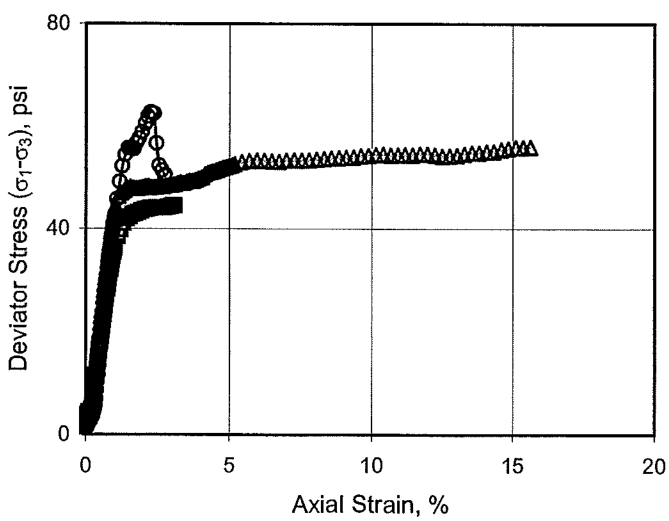
Direct Shear Test Results

Figure 14

Applied Geotechnical Engineering Consultants, Inc.







Test No. (Symbol)	○	□	△
Sample Type	undisturbed		
Length, in.	4.00	3.88	3.80
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	116	N/A	N/A
Moisture Content, %	17	N/A	N/A
Consolidation Pressure, psi	6.9	13.9	27.8
"B" Parameter	0.98	0.98	0.98
Total Confining Stress (σ_3), psi	6.9	13.9	27.8
Total Axial Stress (σ_1), psi	63.5	57.9	76.0
Deviator Stress (σ_1-σ_3), psi	56.6	44.0	48.2
Effective Lateral Stress (σ_3'), psi	8.1	9.1	19.5
Effective Axial Stress (σ_1'), psi	64.8	53.1	67.7
Pore Pressure (μ), psi	-1.24	4.8	8.3
Strain, %	2.5	2.5	2.5
Remarks			

Sample Index Properties	
Natural Dry Density, pcf	116
Natural Moisture Content, %	17
Liquid Limit, %	51
Plasticity Index, %	27
Percent Gravel	0
Percent Sand	1
Percent Passing No. 200 Sieve	99

Sample Description Purple Mudstone (Fat Clay)

Sample Location Trench 2 @ Sample 1

Project No. 2030907

Figure 15

Applied Geotechnical Engineering Consultants, Inc.

Table 1 - Summary of Laboratory Test Results

KETTAS KNOLL TOWNHOMES

Project No. 2030907

Sample Location				Gradation			Atterberg Limits		Direct Shear		Triaxial Shear		
Trench No.	Sample No.	Natural Moisture Content (%)	Natural Dry Density (pcf)	Gravel (%)	Sand (%)	Silt/Clay (%)	Liquid Limit (%)	Plastic Index (%)	Cohesion (psf)	Friction Angle (°)	Cohesion (psf)	Friction Angle (°)	Soil Type
1	1	19	107			93	67	38	360	26			Red shale (fat clay)
1	2	22	96			91	59	38	190	37			Purple mudstone (fat clay)
2	1	17	116			99	51	27			2,460	10	Purple Mudstone (fat clay)

Photo Exhibit 1: View of subject site looking east from Foremaster Drive.

Photo Exhibit 2 - View of conglomerate rockfall on western hillside looking east.

Photo Exhibit 3 - View of southern portion of the site looking northeast. Some conglomerate boulders have broken off and rolled or slid down the slope (see arrows).

Photo Exhibit 4 - View of northern portion of the site looking south.

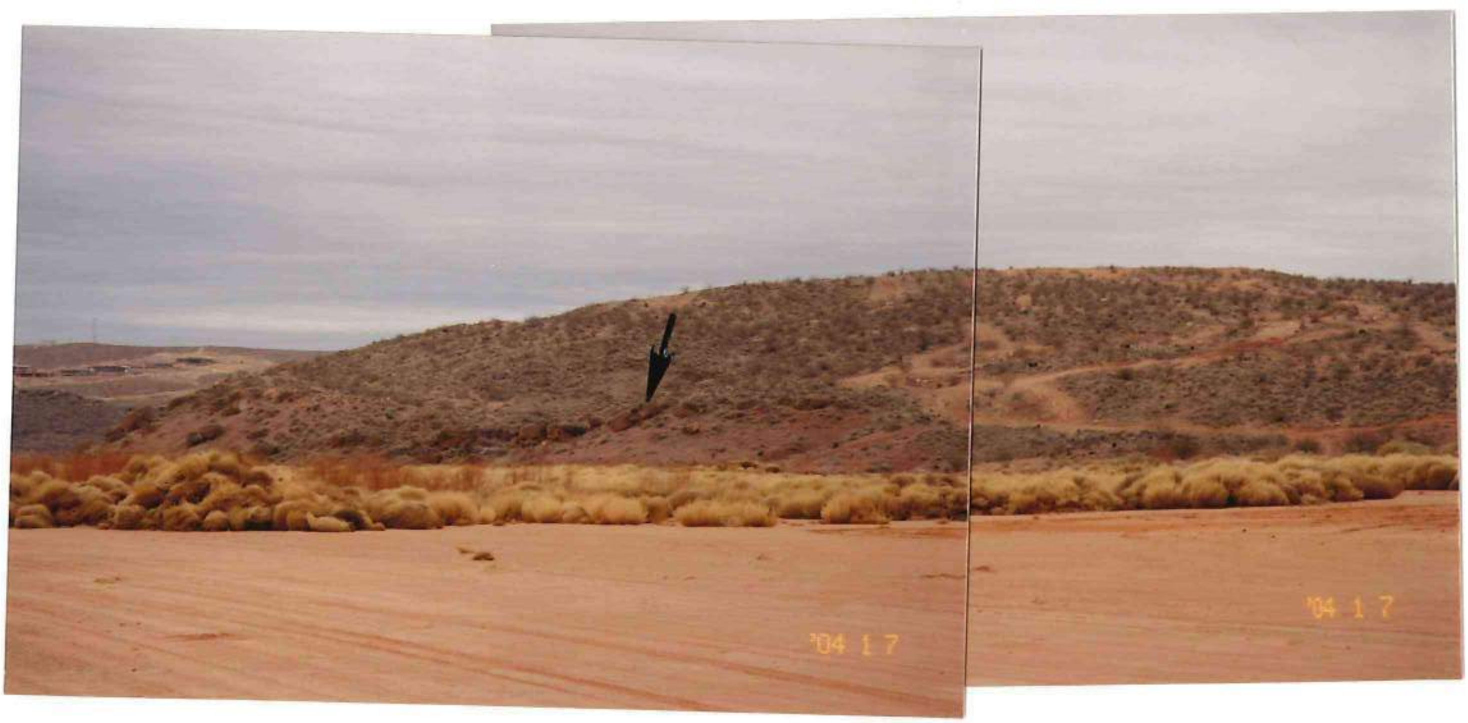


Photo Exhibit 5 - View of the eastern portion of the site looking southwest from the old 3H Turf Farm area. Arrows indicate location of conglomerate outcroppings.

APPENDIX

AGEC FIELD CORE LOG

PROJECT NO. 2030907

PROJECT Nettas Knoll | CORE SIZE 2" NX | DATE Sept. 8, 12 & 15, 2003

LOCATION Surveyed by L. R. Pope Eng. | ELEVATION 2704 | PAGE 1 of 2

FIELD ENG. ST | DRILLER Mountain States | BORING NO. B-2

DEPTH (ft)	ALTERATION	HARDNESS	CORE DESCRIPTION	WATER	PACKER TESTS	GRAPHIC LOG	DISCONTINUITY LOG: ORIENT.	TYPE	ROUGH.	PLAN.	FILLING	CORE RUN (FT)	RECOVERY (FT)	RQD (%)	FRAC./FT.	PROGRESS	DRILLING COMMENTS
0–9			Silty Sand (SM); some gravel, occasional cobbles, medium dense to dense, dry, slightly calcareous, fine to medium grained, granular, light brown.														Boring cased with 7" diameter hollow-stem augers to 19'.
9–16			Silty Gravel with Sand (GM); occasional cobbles, very dense, dry, fine to coarse-grained, sub-rounded, light brown to red.														
16–19	S	H	Conglomerate, hard to very hard, dry, fine to coarse-grained clasts, gray.														
19–	U	V													NR	39	Boring advanced with 2" NX core barrel and diamond impregnated bit using air.

AGEC FIELD CORE LOG

PROJECT NO. 2030907

PROJECT Nettas Knoll | CORE SIZE 2" NX | DATE Sept. 8, 12 & 15, 2003

LOCATION Surveyed by L. R. Pope Eng. | ELEVATION 2704 | PAGE 2 of 2

FIELD ENG. ST | DRILLER Mountain States | BORING NO. B-2

DEPTH (ft)	ALTERATION	HARDNESS	CORE DESCRIPTION	WATER	PACKER TESTS	GRAPHIC LOG	DISCONTINUITY LOG: ORIENT.	TYPE	ROUGH.	PLAN.	FILLING	CORE RUN (FT)	RECOVERY (FT)	RQD (%)	FRAC./FT.	PROGRESS	DRILLING COMMENTS
20–21												5	3	0	NR	36	
21–22															I	8	
22–23															I	29	
23–24															I	60	
24–25												2	2	100	0	20	
25–26															0	65	
26–27												3	3	100	0	44	
27–28															0	30	
28–29															0	38	
29–30												5	4	80	0	74	
30–31	U	S	Shale; soft, slightly moist, medium plastic, red-brown.												NR	16	Drilling pressure reduced to prevent plugging of bit.
31–32															0	19	
32–33															0	9	
33–34															0	8	
34–35												5	1	20	0	10	
35–36															NR	10	
36–37															NR	16	
37–38															NR	15	
38–39															NR	9	
39																	End of Boring at 39'.

AGEC FIELD CORE LOG

PROJECT NO. 2030907

PROJECT Nettas Knoll | CORE SIZE 2" NX | DATE Oct. 14, 2003

LOCATION 20' N. 20' W. of Survey Line | ELEVATION 2723' | PAGE 1 of 2

FIELD ENG. BS | DRILLER Mountain States | BORING NO. B-5

DEPTH (ft)	ALTERATION	HARDNESS	CORE DESCRIPTION	WATER	PACKER TESTS	GRAPHIC LOG	DISCONTINUITY LOG: ORIENT.	TYPE	ROUGH.	PLAN.	FILLING	CORE RUN (FT)	RECOVERY (FT)	RQD (%)	FRAC./FT.	PROGRESS	DRILLING COMMENTS
0–10			Silty Sand with gravel and boulders, medium dense to very dense, dry, subrounded gravels, fine-grained, brown.														Boring cased with 7" diameter hollow-stem augers.
10–17			Silty Gravel with Sand; occasional cobbles and boulders, very dense, slightly cemented, subangular, brown to red.														Boring advanced using tricone with air to pilot, followed by 7" HSA.
17–20	S	H	Conglomerate, very hard, dry, brown.														(from 19) Boring advanced using Tricone with air.

AGEC FIELD CORE LOG

PROJECT NO. 2030907

PROJECT Nettas Knoll | CORE SIZE 2" NX | DATE Oct. 14, 2003

LOCATION 20' W. 20' N. of Survey Line | ELEVATION 2723' | PAGE 2 of 2

FIELD ENG. BS | DRILLER Mountain States | BORING NO. B-5

DEPTH (ft)	ALTERATION	HARDNESS	CORE DESCRIPTION	WATER	PACKER TESTS	GRAPHIC LOG	DISCONTINUITY LOG: ORIENT.	TYPE	ROUGH.	PLAN.	FILLING	CORE RUN (FT)	RECOVERY (FT)	RQD (%)	FRAC./FT.	PROGRESS	DRILLING COMMENTS
20–21.5	U	V															Boring advanced using tricon bit with air.
21.5–22												½	0	NA	NA	30	Boring advanced using 2" NX core barrel with diamond bit and air, end @ 22', bit worn.

Depth scale: 20–39 ft

LEGEND AND NOTES TO CORE LOGS

Alteration

Log Symbol	Description	Field Identification
E	Extremely altered	The material is discolored and the original minerals of the rock have been almost entirely altered to secondary minerals, even though the original fabric may be intact.
H	Highly altered	The rock is weakened to such an extent that a 2-inch diameter core can be broken readily by hand across the rock fabric.
M	Moderately altered	Rock is discolored and noticeably weakened, but a 2-inch diameter core cannot usually be broken by hand across the rock fabric.
S	Slightly altered	Rock is slightly discolored but not noticeably lower in strength than fresh rock.
U	Unaltered	Rock shows no discoloration, loss of strength, or any other effect of weathering or alteration.

Hardness

Log Symbol	Description	Field Identification
S	Soft	Fingernail: Can be scratched with a fingernail.
M	Moderately hard	Knife: Can be readily scratched with a pocket knife blade. The scratch leaves a trace of dust and is readily visible after the dust is blown away. Pick: Shallow indentation under a firm blow from the point of a geology pick.
H	Hard	Knife: Can be scratched with difficulty with a pocket knife blade. The scratch leaves little dust and is often only faintly visible. Pick: A hand-held sample breaks with one firm blow with the hammer end of a geology pick.
V	Very hard	Knife: Cannot be scratched with a pocket knife blade. Pick: Requires many blows from the hammer end of a geology pick.

Joint Type

Log Symbol	Description	Field Identification
B	Bedding	Joint associated with bedding plane.
H	Healed	Joint is healed closed.
O	Open	Joint is open and sides do not fit together.
S	Shear	Joint is due to shear.

Joint Surface Roughness

Log Symbol	Description	Field Identification
VR	Very rough	Near vertical steps and ridges occur on the discontinuity surface.
R	Rough	Some ridges and side-angle steps are evident. Asperities are clearly visible, and discontinuity surface feels very abrasive.
SR	Slightly rough	Asperities on the discontinuity surface are distinguishable and can be felt.
S	Smooth	Surface appears smooth and feels smooth to the touch.
SLK	Slickensided	Visual evidence of polishing exists.

LEGEND AND NOTES TO CORE LOGS

Joint Surface Planarity

Log Symbol	Description	Field Identification
W	Wavy	A moderately undulating surface.
PL	Planar	A flat surface.
ST	Stepped	A surface with asperities or steps.

Joint Filling Material

Log Symbol	Description	Field Identification
CL	Clay	Joint filled with clay-sized particles.
Sd	Sand	Joint filled with sand-sized particles.
G	Gypsum	Joint filled with gypsum.
Ca	Calcite	Joint filled with calcite.
Fe	Iron oxide	Joint surfaces coated with iron oxide stains.
C	Clean	No surface coating or joint filling.
Q	Quartz	Joint filled with quartz

Other

Log Symbol	Description
RQD (Rock Quality Designation)	Percent of intact core which is 4 inches or greater in length.
Fractures Per Foot	Number of fractures per foot of core. "I" indicates intensely fractured.
Progress	Time to advance boring (minutes per foot).

Exhibit E
Storm Water Analysis

Preliminary Storm Water Analysis for Knetta's Knoll

A Residential Subdivision located in
St. George City, UT

Prepared for:
Adam Allen
American Land Consulting, LLC
1043 East 3740 South
Washington, UT 84780

LICENSED PROFESSIONAL ENGINEER
JASON L. TUTTLE
No. 368642
4/24/21
STATE OF UTAH

Prepared by:
Jason Tuttle PE, PLS

April 24, 2021

Engineering & Land Surveying P.C.
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(801)358-5297

Table of Contents

Preface

This report is a preliminary analysis of the pre and post development storm water runoff flow rates and quantities. Without design grades and final detail, many parameters of the post-development scenarios had to be estimated or assumed. Curve numbers and lag times could change as the design is finalized. This will result in flow rates and detention volumes varying slightly from the results presented herein. Furthermore, no hydraulic analysis of gutters, inlets, pipes, or outlets can be performed without final design grades.

Description of Development

Knetta's Knoll is a proposed single family residential development located just southeast of the intersection of Riverside Drive and Foremaster Ridge Road. It is bordered by Riverside Drive on the north and west, Middleton Wash on the north and east, and the Virgin River on the east and south.

Existing Drainage Facilities

There are no existing drainage improvements on site. There appears to be a storm drain system in Riverside Drive that presumably discharges to Middleton Wash. Middleton Wash flows into the Virgin River.

General Description of Property

The development encompasses 18.5 acres, but only 12.4 acres will see new impervious area and contribute to the storm drain system. The developable area is the northeast face of a knoll covered with desert shrub and crisscrossed with off-road vehicle trails. There are no irrigation facilities or any structures on the site. There are only small local channels in a few areas along the east where the site drains to Middleton Wash.

Off-site Drainage

Upstream

Because it is an elevated knoll, the site is largely unaffected by upstream runoff. Middleton Wash drains the largest upstream area and passes along the north and east boundaries of the property.

The access road will be affected by runoff from riverside drive and the west, undeveloped side of the knoll. This can be channeled into the storm drain in Riverside Drive or let under the access road in a culvert to stay in the natural drainage ditch leading to Middleton Wash.

Downstream

The site drains directly to Middleton Wash just north of the confluence with the Virgin River. The only improvement between the site and these large natural drainages is a pedestrian and bike path on the west side of Middleton Wash near the northeast corner of the property. The path then crosses over to the east side of the wash.

Along Riverside Drive, there is a parcel between the Knetta's Knoll access road and Middleton Wash. Knetta's Knoll and the two Parcels flanking the access road would do well to coordinate drainage improvements.

Known Drainage Problems

There are no known drainage problems affecting the site.

FEMA Floodplains

The site is within the limits of FEMA floodplain map number 49053C1031G. The map shows floodplains in Middleton Wash and the Virgin River, but the site itself is in Zone X. A portion of the map is shown in the appendix.

On –Site Drainage

Once developed, the runoff from the area will increase compared to undeveloped conditions but will be relatively small due to the small size of the site with no upstream areas to consider. The calculations show that predeveloped runoff from the site is almost non-existent. This is because the soil is Type A and the curve number is very low. This is corroborated by the fact that there is little erosion and very insignificant washes on the property despite it being crisscrossed with off road vehicle trails.

Potential Drainage Problems

Development will bring impervious areas and will cut off historical drainage paths. Impervious areas will increase and concentrate runoff which will have to be conveyed to Middleton Wash. The access road will be relatively steep and capturing the runoff in low points is easier than on steep grades. The path to Middleton Wash could be straight down between lot lines, but that will cause maintenance and possible erosion problems. Based on the small runoff numbers, and the steeper grades, it is likely that storm drain inlets in the access road near the intersection with Riverside Drive will be sufficient to collect runoff before gutter capacity is exceeded. It will then need to be conveyed to Middleton wash in either a pipe or ditch or combination thereof. The flow rates in this report can be used in evaluating the best path.

Another potential problem is the issue of detention. Typically, developments are required to provide storm water detention to reduce developed flow rated to pre-development levels. This is required to prevent flooding downstream. For this property, however, Middleton Wash and the Virgin River have more than sufficient capacity for the increased flows from a tiny development and the peak runoff will happen hours or days after the site has stopped contributing. Therefore, it is proposed that detention is not required for this site.

Master Planned Drainage Facilities

There are no master planned drainage facilities affecting the site. There could be something planned on Riverside Drive in the vicinity of Middleton Wash and any plans should be considered while evaluating the best path for conveying storm water from the site to Middleton Wash.

Preliminary Hydrology Calculations

HEC-HMS was used to model site hydrology. Runoff from the site was evaluated for both pre- and post-developed conditions.

Design Precipitation

Both the SCS type 2 and the Farmer-Fletcher distributions were modeled for both the 10-year and 100-year events. The following rainfall totals were used in the appropriate models and come from Table 2-1 in the St. George Drainage Manual:

10 Year 3 Hour: 1 Inch (FF10)

10 Year 24 Hour: 1.68 Inches (SCS10)

100 Year 3 Hour: 1.64 Inches (FF100)

100 Year 24 Hour: 2.51 Inches (SCS100)

Interception and Infiltration

The SCS Curve Number method was used to model interception and infiltration. Post Development conditions were evaluated using both the pervious curve number and composite curve number methods. The composite curve number method yielded extremely low flow rates, so result for it are not included and any references to it in the calculations are there only to compare SCS lag time to the primary routing method.

Impervious area in the developed condition was estimated at 30%. This could be a little lower according to Table 2-3 in the St. George Hydrology Manual, but many back yards will not make it to the streets and will drain down the sides of the Knoll.

Sub-basin Lag Time

The Kinematic Wave Flow Path Components Method was used to calculate the basin lag time.

Routing

No routing between sub basins or through any detention ponds was evaluated at this time. As a hydraulically isolated site near the Virgin River, no sub-basin routing should be required.

Drainage Facility Hydraulic Calculations

No gutters, inlets, pipes, channels, culverts, detention outlets, or energy dissipation facilities were evaluated at this time. Runoff will be directed to the gutters, intercepted by inlets, fed into storm drain pipes and conveyed to Middleton wash where rip rap or other energy dissipation methods will prevent erosion.

Results Summary

Flow Rates from the modeled watersheds for the various precipitation events are summarized in Table 1.

Table 1. Watershed Flow Rate Summary

	Peak Flow Rate (cfs)			
Watershed	10 Year FF	10 Year SCS	100 Year FF	100 Year SCS
Pre-Developed Site	0	0.06	0.42	1.53
Developed Site	0.63	3.41	5.21	9.91
Upstream	1.09	2.62	3.8	5.19
Downstream	0.57	1.41	2	2.77

Required Easements

If the drainage system is kept within the public right of way, no easements will be required. If the best route is more directly to Middleton Wash, of course easements will be required.

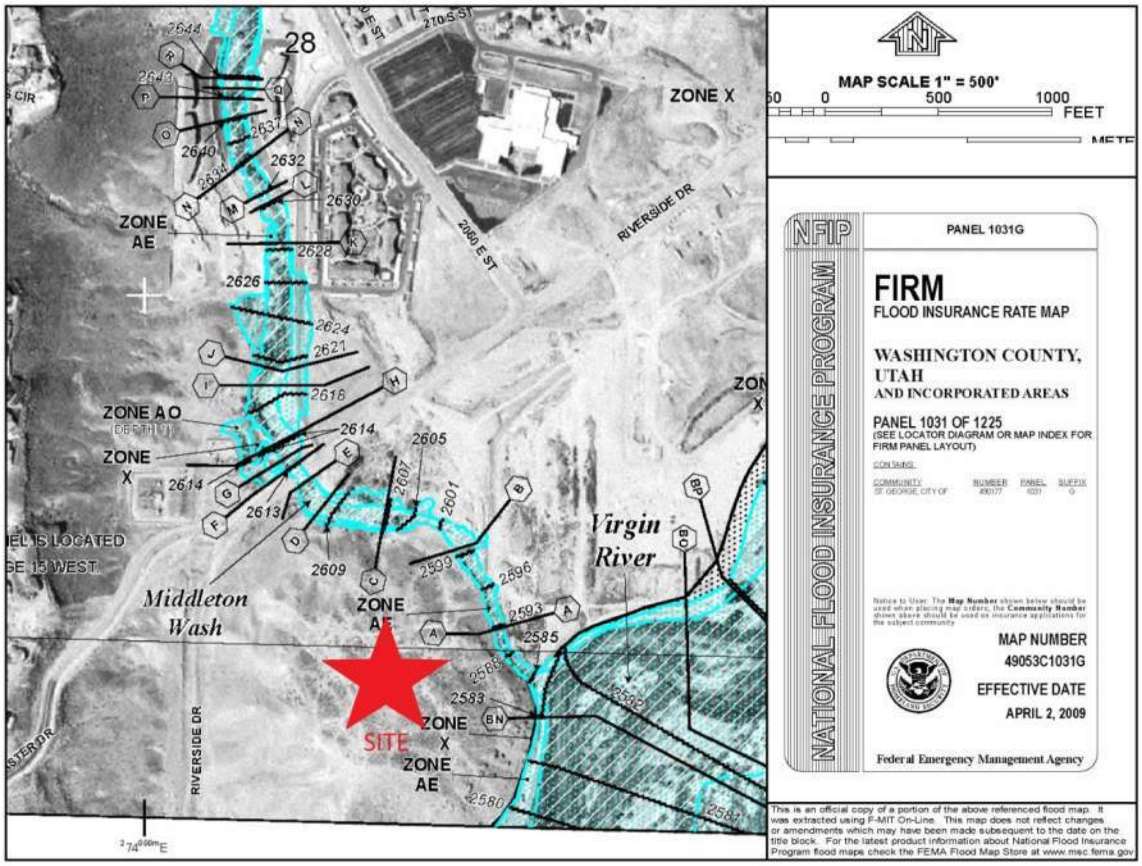
APPENDIX

Vicinity Map

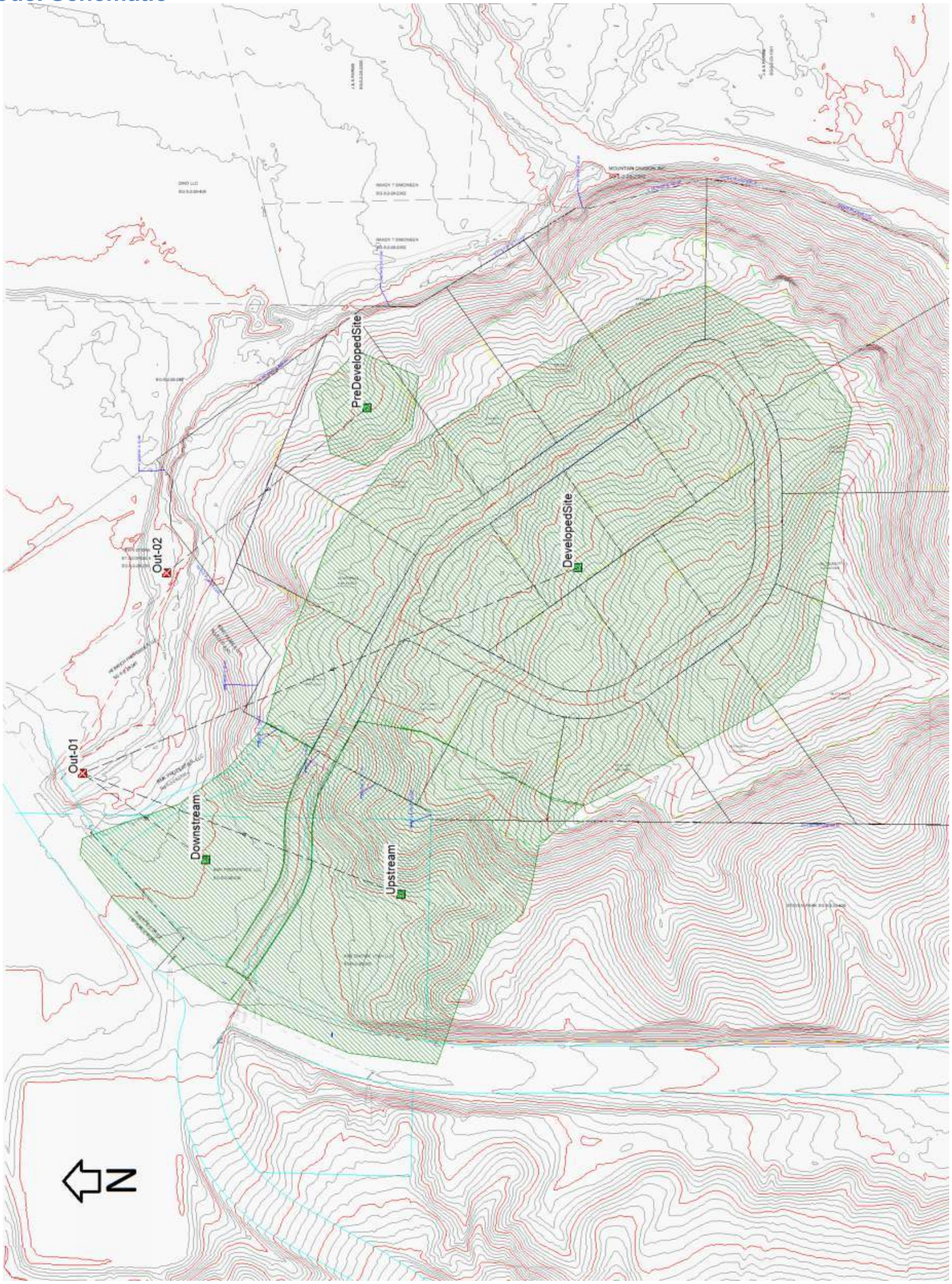
Soil Map

Hydrologic Soil Group and Surface Runoff–Washington County Area, Utah			
Map symbol and soil name	Pct. of map unit	Surface Runoff	Hydrologic Soil Group
FA—Fluvaquents and torrifluvents, sandy			
Fluvaquents	55	Negligible	A/D
Torrifluvents	35	Very low	A
IAF—Isom cobbly sandy loam, 3 to 30 percent slopes			
Isom	90	Low	A
Sd—St. George silty clay loam, moderately saline			
St. george, moderately saline	80	Low	C
Se—St. George silty clay loam, shallow water table			
St. george, shallow water table	85	Very high	C/D
SY—Stony colluvial land			
Stony colluvial land	100	—	—
Tc—Tobler fine sandy loam			
Tobler	85	Very low	A
Td—Tobler silty clay loam			
Tobler	90	Low	C
W—Water			
Water	100	—	—
WBD—Winkel gravelly fine sandy loam, 1 to 8 percent slopes			
Winkel	85	Medium	D

FEMA Map


MAP SCALE 1" = 500'
PANEL 1031G
FIRM
FLOOD INSURANCE RATE MAP
WASHINGTON COUNTY, UTAH
AND INCORPORATED AREAS
PANEL 1031 OF 1225
(SEE LOCATOR DIAGRAM OR MAP INDEX FOR FIRM PANEL LAYOUT)
NATIONAL FLOOD INSURANCE PROGRAM
MAP NUMBER
49053C1031G
EFFECTIVE DATE
APRIL 2, 2009
Federal Emergency Management Agency
ZONE X
ZONE AE
ZONE AO
Virgin River
Middleton Wash
RIVERSIDE DR
SITE

Model Schematic



FF10 Results

Project Description

File Name	Knetta's Knoll Preliminary Drainage.SPF

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Apr 24, 2021	00:00:00
End Analysis On	Apr 25, 2021	00:00:00
Start Reporting On	Apr 24, 2021	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	4
Subbasins	4
Nodes	2
Junctions	0
Outfalls	2
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	FF10	Cumulative	inches				0.00	

Subbasin Summary

SN	Subbasin ID	Area (ac)	Peak Rate Factor	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	DevelopedSite	12.86	484.00	78.45	1.00	0.06	0.81	0.63	0 00:24:12
2	Downstream	1.89	484.00	88.00	1.00	0.25	0.48	0.57	0 00:21:54
3	PreDevelopedSite	12.86	484.00	63.00	1.00	0.00	0.00	0.00	0 00:25:55
4	Upstream	4.16	484.00	88.00	1.00	0.25	1.05	1.09	0 00:29:13

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	Out-01	Outfall	0.00					0.00	0.00					
2	Out-02	Outfall	0.00					0.00	0.00					

Subbasin Hydrology

Subbasin : DevelopedSite

Input Data

Area (ac) 12.86
Peak Rate Factor 484.00
Weighted Curve Number 78.45
Rain Gage ID ....

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/2 acre lots, 25% impervious	5.46	A	54.00
Paved roads with curbs & sewers	1.93	A	98.00
Artificial desert landscape	5.46	A	96.00
Composite Area & Weighted CN	12.85		78.45

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	50	0.00	0.00
Slope (%) :	2	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.05	0.00	0.00
Computed Flow Time (min) :	17.10	0.00	0.00

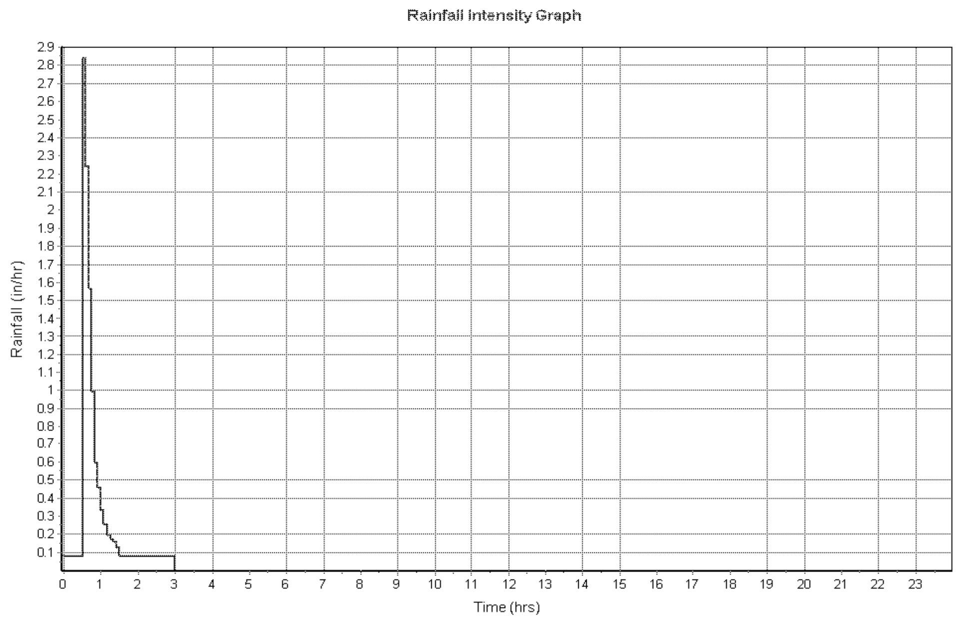
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	1942.86	0.00	0.00
Channel Slope (%) :	6	0.00	0.00
Cross Section Area (ft^2) :	.15	0.00	0.00
Wetted Perimeter (ft) :	1.85	0.00	0.00
Velocity (ft/sec) :	4.56	0.00	0.00
Computed Flow Time (min) :	7.10	0.00	0.00

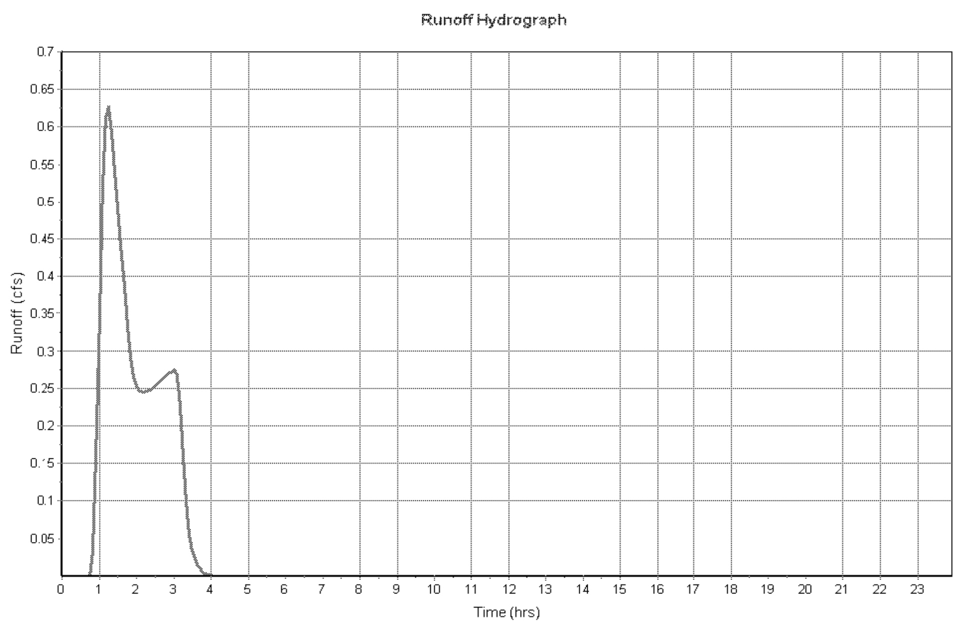
Total TOC (min) 24.21

Subbasin Runoff Results

Total Rainfall (in) 1.00
Total Runoff (in) 0.06
Peak Runoff (cfs) 0.63
Weighted Curve Number 78.45
Time of Concentration (days hh:mm:ss) 0 00:24:13

Subbasin : DevelopedSite





Subbasin : Downstream

Input Data

Area (ac) 1.89
Peak Rate Factor 484.00
Weighted Curve Number 88.00
Rain Gage ID FF10

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Natural western desert	1.89	D	88.00
Composite Area & Weighted CN	1.89		88.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	172.66	0.00	0.00
Slope (%) :	18	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.15	0.00	0.00
Computed Flow Time (min) :	19.14	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	306.09	0.00	0.00
Slope (%) :	8	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	4.56	0.00	0.00
Computed Flow Time (min) :	1.12	0.00	0.00

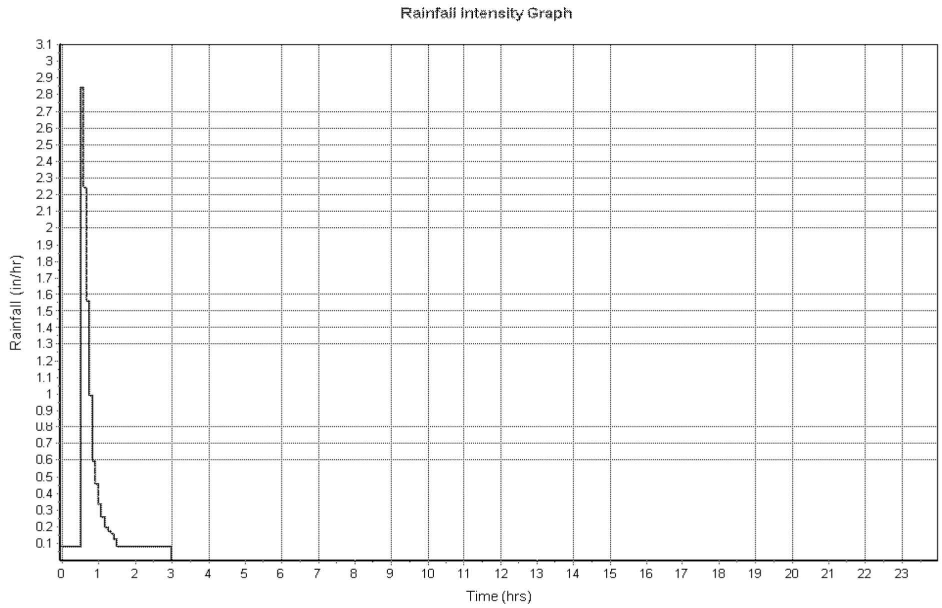
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	259.02	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	.15	0.00	0.00
Wetted Perimeter (ft) :	1.85	0.00	0.00
Velocity (ft/sec) :	2.63	0.00	0.00
Computed Flow Time (min) :	1.64	0.00	0.00

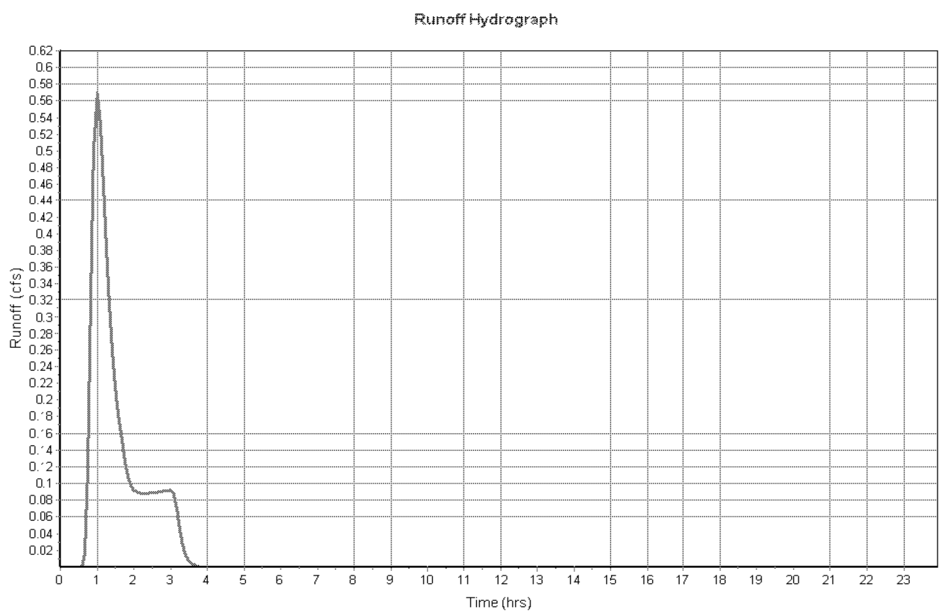
Total TOC (min) 21.90

Subbasin Runoff Results

Total Rainfall (in) 1.00
Total Runoff (in) 0.25
Peak Runoff (cfs) 0.57
Weighted Curve Number 88.00
Time of Concentration (days hh:mm:ss) 0 00:21:54

Subbasin : Downstream





Subbasin : PreDevelopedSite

Input Data

Area (ac) 12.86
Peak Rate Factor 484.00
Weighted Curve Number 63.00
Rain Gage ID ....

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Natural western desert	12.86	A	63.00
Composite Area & Weighted CN	12.86		63.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	185.22	0.00	0.00
Slope (%) :	12	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.13	0.00	0.00
Computed Flow Time (min) :	23.81	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	298.26	0.00	0.00
Slope (%) :	12	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	5.59	0.00	0.00
Computed Flow Time (min) :	0.89	0.00	0.00

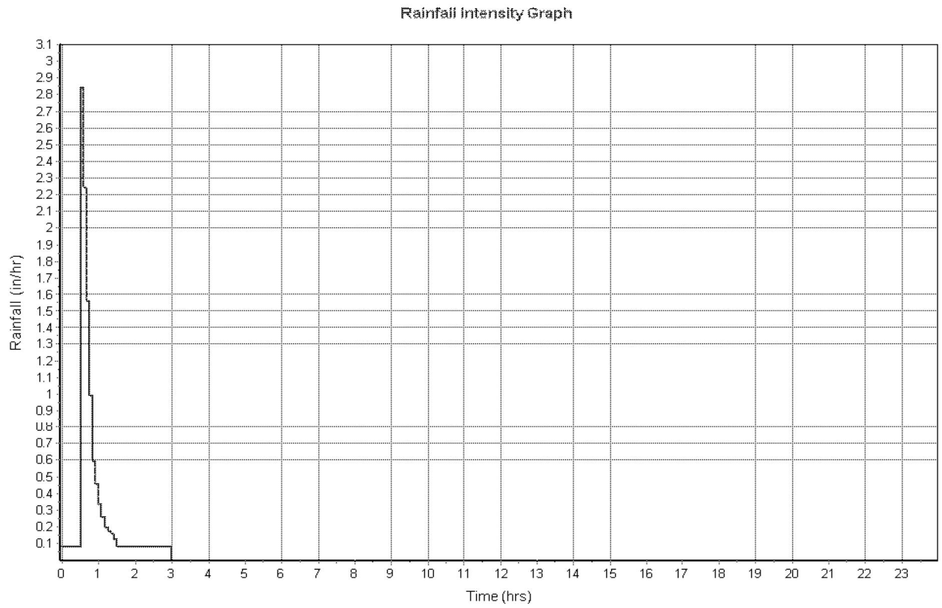
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.023	0.00	0.00
Flow Length (ft) :	654.28	0.00	0.00
Channel Slope (%) :	12	0.00	0.00
Cross Section Area (ft²) :	.5	0.00	0.00
Wetted Perimeter (ft) :	2	0.00	0.00
Velocity (ft/sec) :	8.91	0.00	0.00
Computed Flow Time (min) :	1.22	0.00	0.00

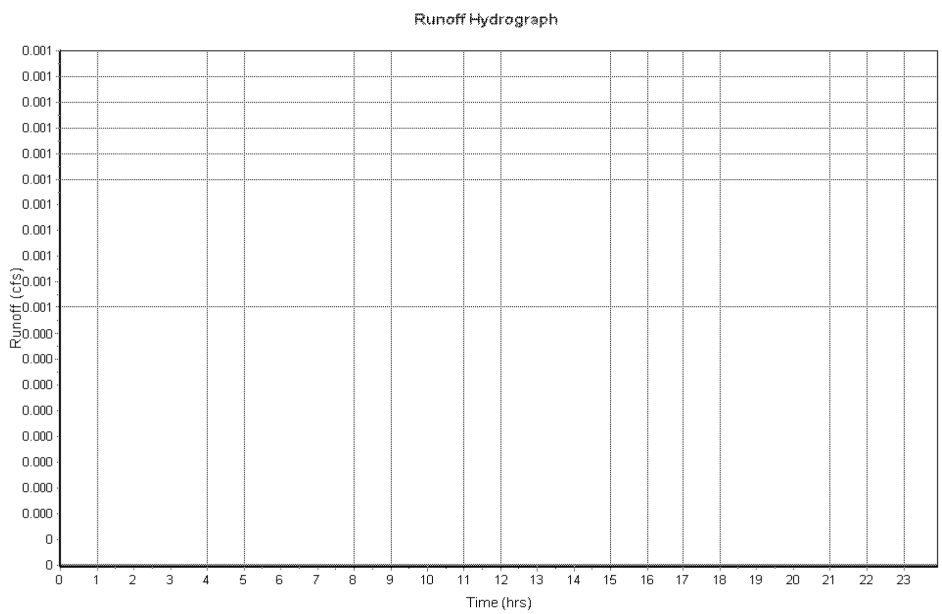
Total TOC (min) 25.93

Subbasin Runoff Results

Total Rainfall (in) 1.00
Total Runoff (in) 0.00
Peak Runoff (cfs) 0.00
Weighted Curve Number 63.00
Time of Concentration (days hh:mm:ss) 0 00:25:56

Subbasin : PreDevelopedSite





Subbasin : Upstream

Input Data

Area (ac) 4.16
Peak Rate Factor 484.00
Weighted Curve Number 88.00
Rain Gage ID ....

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Natural western desert	4.16	D	88.00
Composite Area & Weighted CN	4.16		88.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	241.27	0.00	0.00
Slope (%) :	20	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.17	0.00	0.00
Computed Flow Time (min) :	23.99	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	151.97	0.00	0.00
Slope (%) :	10	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	5.10	0.00	0.00
Computed Flow Time (min) :	0.50	0.00	0.00

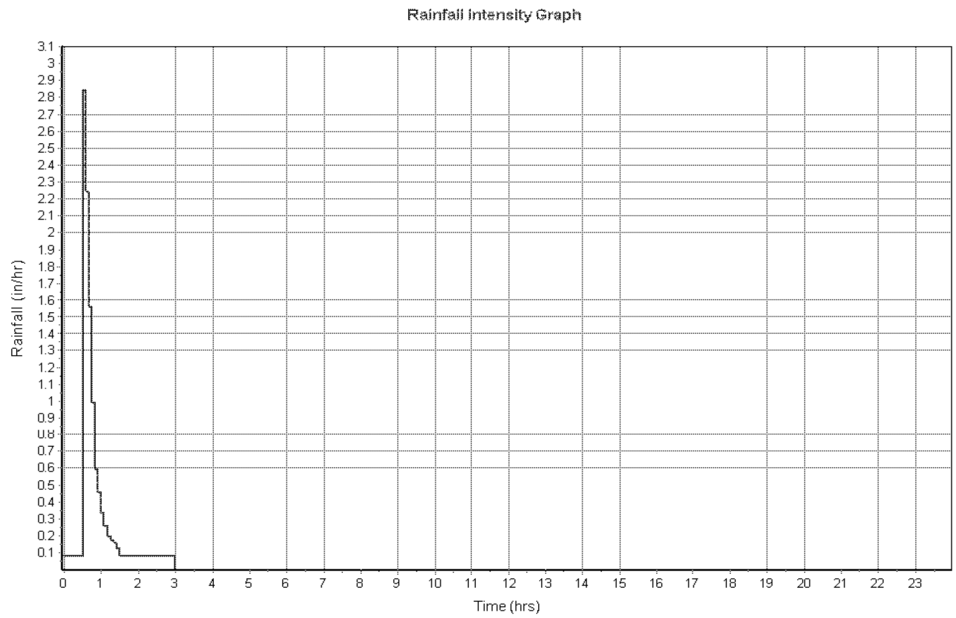
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	747.90	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	.15	0.00	0.00
Wetted Perimeter (ft) :	1.85	0.00	0.00
Velocity (ft/sec) :	2.63	0.00	0.00
Computed Flow Time (min) :	4.74	0.00	0.00

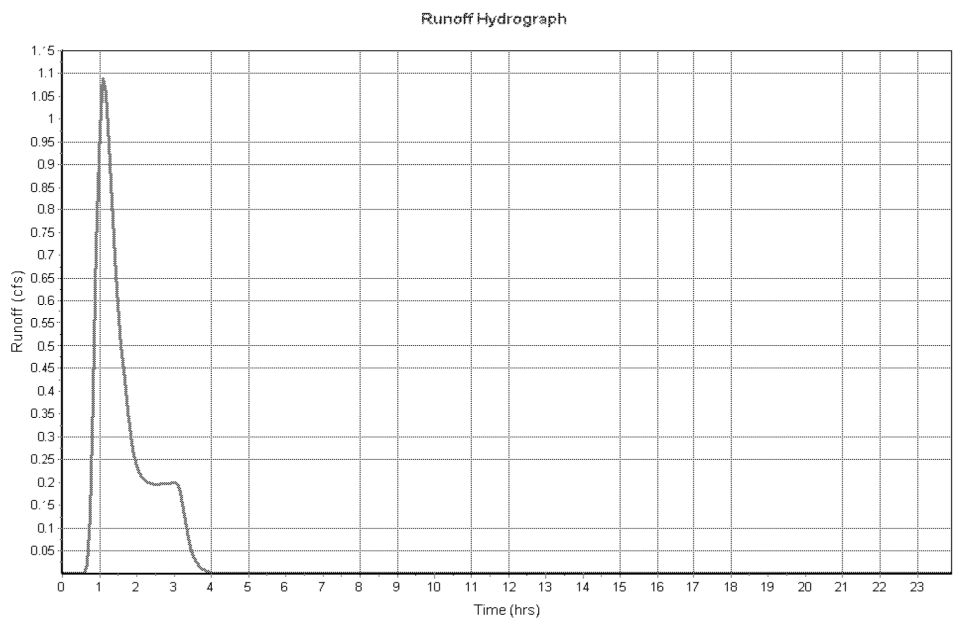
Total TOC (min) 29.22

Subbasin Runoff Results

Total Rainfall (in) 1.00
Total Runoff (in) 0.25
Peak Runoff (cfs) 1.09
Weighted Curve Number 88.00
Time of Concentration (days hh:mm:ss) 0 00:29:13

Subbasin : Upstream





SCS10 Results

Project Description

File Name .... Knetta's Knoll Preliminary Drainage.SPF

Project Options

Flow Units .... CFS
Elevation Type .... Elevation
Hydrology Method .... SCS TR-55
Time of Concentration (TOC) Method .... SCS TR-55
Link Routing Method .... Kinematic Wave
Enable Overflow Ponding at Nodes .... YES
Skip Steady State Analysis Time Periods .... NO

Analysis Options

Start Analysis On	Apr 24, 2021	00:00:00
End Analysis On	Apr 25, 2021	00:00:00
Start Reporting On	Apr 24, 2021	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	4
Subbasins	4
Nodes	2
Junctions	0
Outfalls	2
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	SCS10	Cumulative	inches				0.00	

Subbasin Summary

SN	Subbasin ID	Area (ac)	Peak Rate Factor	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	DevelopedSite	12.86	484.00	78.45	1.68	0.33	4.24	3.41	0 00:24:12
2	Downstream	1.89	484.00	88.00	1.68	0.72	1.35	1.41	0 00:21:54
3	PreDevelopedSite	12.86	484.00	63.00	1.68	0.04	0.51	0.06	0 00:25:55
4	Upstream	4.16	484.00	88.00	1.68	0.72	2.98	2.62	0 00:29:13

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	Out-01	Outfall	0.00					0.00	0.00					
2	Out-02	Outfall	0.00					0.00	0.00					

Subbasin Hydrology

Subbasin : DevelopedSite

Input Data

Area (ac) 12.86
Peak Rate Factor 484.00
Weighted Curve Number 78.45
Rain Gage ID ....

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/2 acre lots, 25% impervious	5.46	A	54.00
Paved roads with curbs & sewers	1.93	A	98.00
Artificial desert landscape	5.46	A	96.00
Composite Area & Weighted CN	12.85		78.45

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	50	0.00	0.00
Slope (%) :	2	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.05	0.00	0.00
Computed Flow Time (min) :	17.10	0.00	0.00

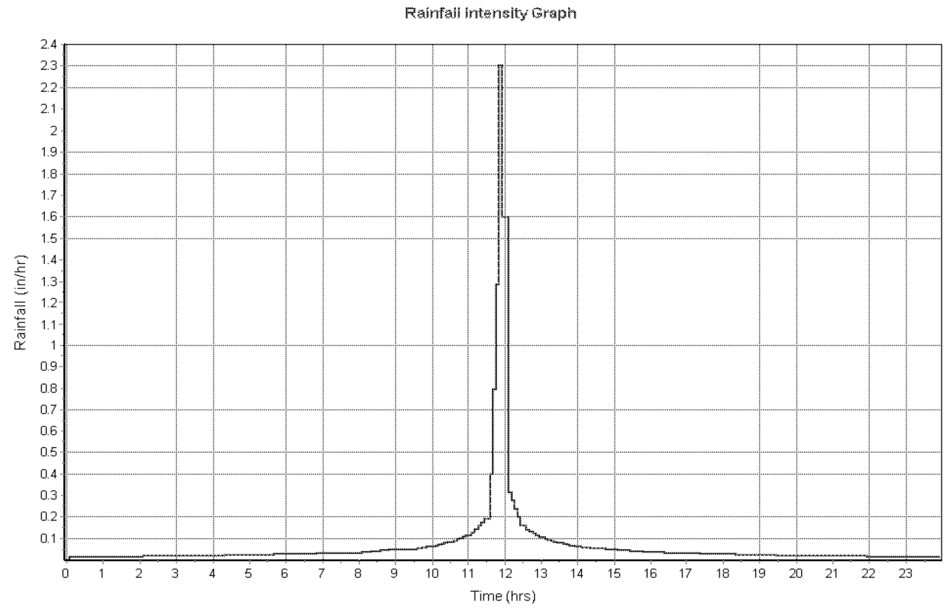
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	1942.86	0.00	0.00
Channel Slope (%) :	6	0.00	0.00
Cross Section Area (ft^2) :	.15	0.00	0.00
Wetted Perimeter (ft) :	1.85	0.00	0.00
Velocity (ft/sec) :	4.56	0.00	0.00
Computed Flow Time (min) :	7.10	0.00	0.00

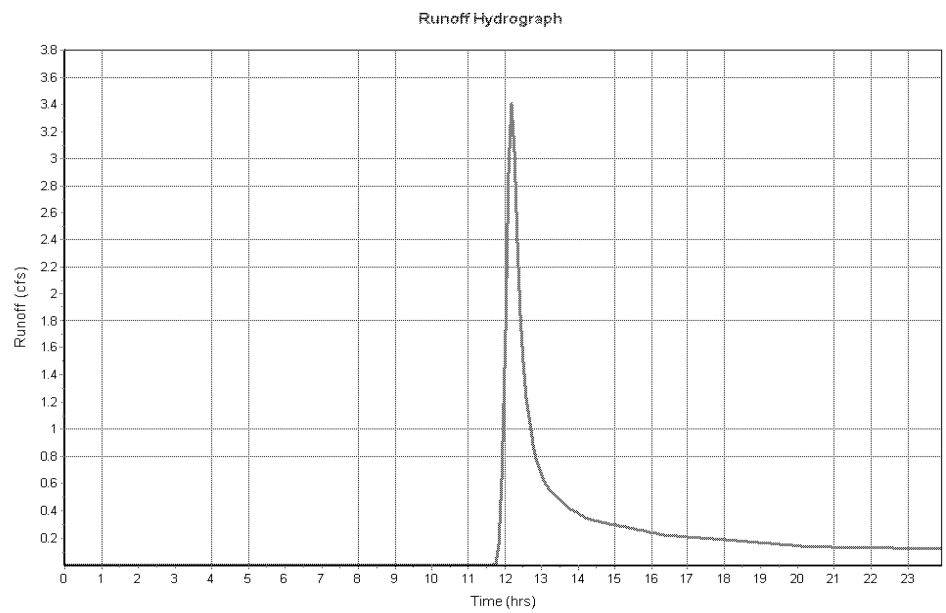
Total TOC (min) 24.21

Subbasin Runoff Results

Total Rainfall (in) 1.68
Total Runoff (in) 0.33
Peak Runoff (cfs) 3.41
Weighted Curve Number 78.45
Time of Concentration (days hh:mm:ss) 0 00:24:13

Subbasin : DevelopedSite





Subbasin : Downstream

Input Data

Area (ac) 1.89
Peak Rate Factor 484.00
Weighted Curve Number 88.00
Rain Gage ID FF10

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Natural western desert	1.89	D	88.00
Composite Area & Weighted CN	1.89		88.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	172.66	0.00	0.00
Slope (%) :	18	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.15	0.00	0.00
Computed Flow Time (min) :	19.14	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	306.09	0.00	0.00
Slope (%) :	8	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	4.56	0.00	0.00
Computed Flow Time (min) :	1.12	0.00	0.00

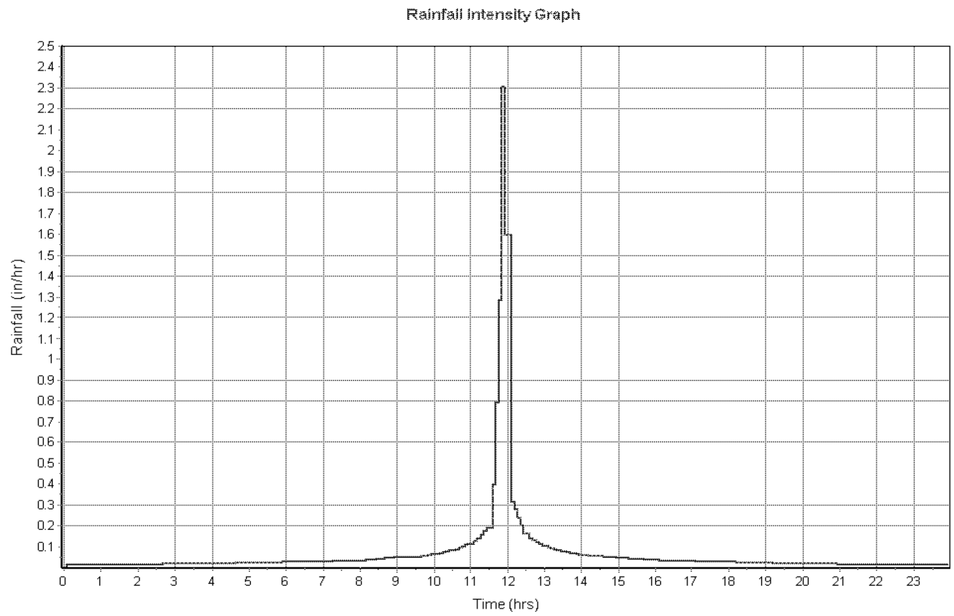
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	259.02	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	.15	0.00	0.00
Wetted Perimeter (ft) :	1.85	0.00	0.00
Velocity (ft/sec) :	2.63	0.00	0.00
Computed Flow Time (min) :	1.64	0.00	0.00

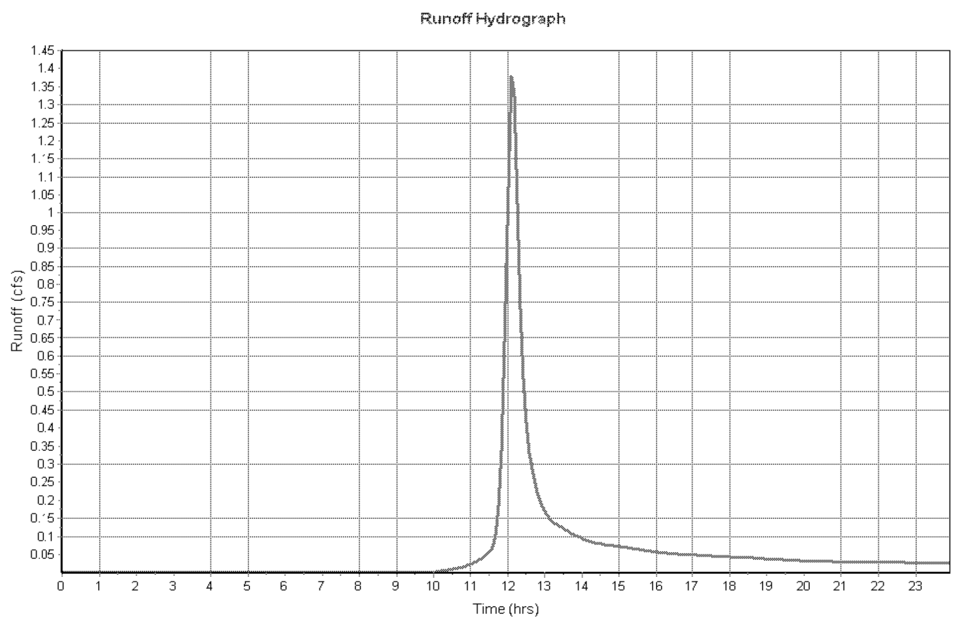
Total TOC (min) 21.90

Subbasin Runoff Results

Total Rainfall (in) 1.68
Total Runoff (in) 0.72
Peak Runoff (cfs) 1.41
Weighted Curve Number 88.00
Time of Concentration (days hh:mm:ss) 0 00:21:54

Subbasin : Downstream





Subbasin : PreDevelopedSite

Input Data

Area (ac) 12.86
Peak Rate Factor 484.00
Weighted Curve Number 63.00
Rain Gage ID ....

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Natural western desert	12.86	A	63.00
Composite Area & Weighted CN	12.86		63.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	185.22	0.00	0.00
Slope (%) :	12	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.13	0.00	0.00
Computed Flow Time (min) :	23.81	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	298.26	0.00	0.00
Slope (%) :	12	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	5.59	0.00	0.00
Computed Flow Time (min) :	0.89	0.00	0.00

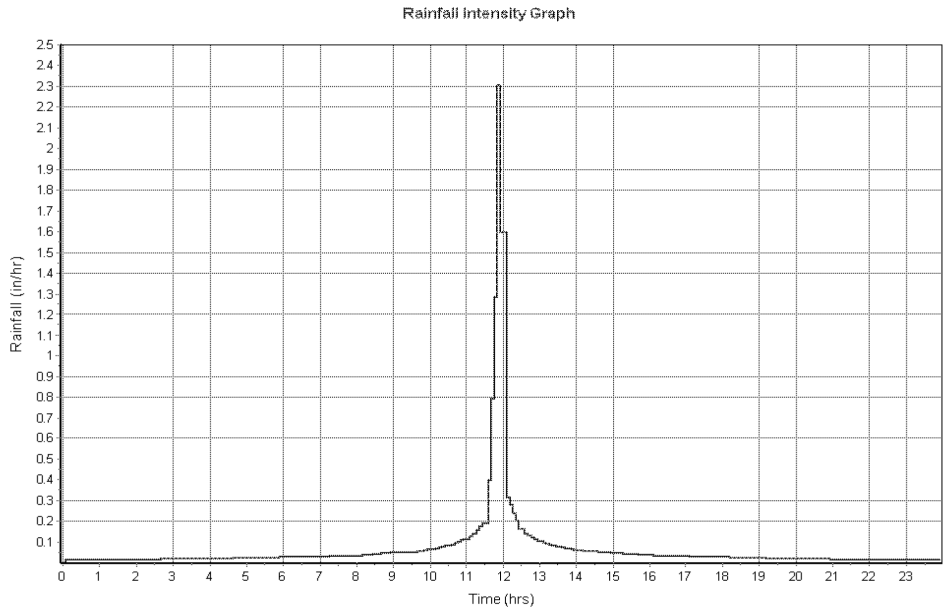
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.023	0.00	0.00
Flow Length (ft) :	654.28	0.00	0.00
Channel Slope (%) :	12	0.00	0.00
Cross Section Area (ft²) :	.5	0.00	0.00
Wetted Perimeter (ft) :	2	0.00	0.00
Velocity (ft/sec) :	8.91	0.00	0.00
Computed Flow Time (min) :	1.22	0.00	0.00

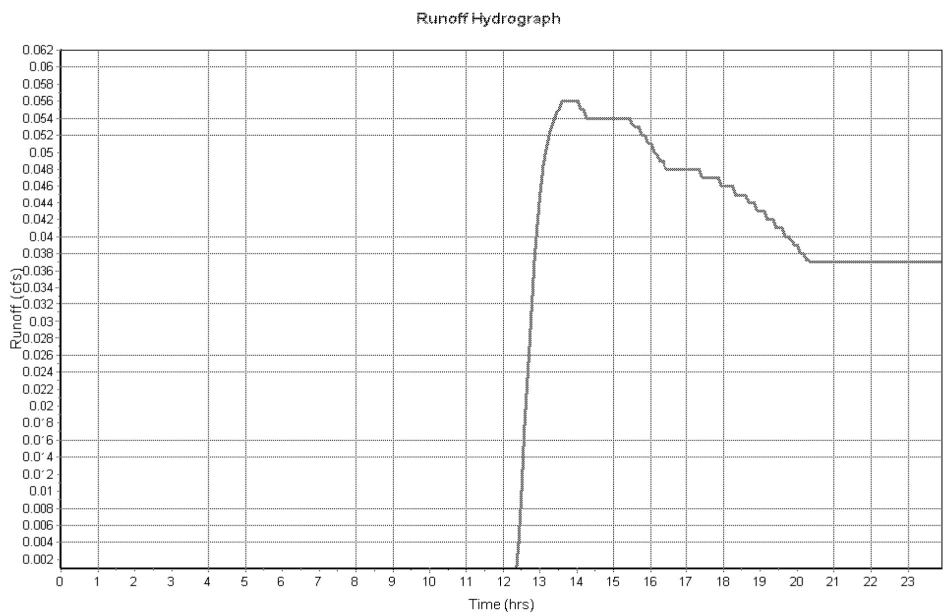
Total TOC (min) 25.93

Subbasin Runoff Results

Total Rainfall (in) 1.68
Total Runoff (in) 0.04
Peak Runoff (cfs) 0.06
Weighted Curve Number 63.00
Time of Concentration (days hh:mm:ss) 0 00:25:56

Subbasin : PreDevelopedSite





Subbasin : Upstream

Input Data

Area (ac) 4.16
Peak Rate Factor 484.00
Weighted Curve Number 88.00
Rain Gage ID ....

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Natural western desert	4.16	D	88.00
Composite Area & Weighted CN	4.16		88.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	241.27	0.00	0.00
Slope (%) :	20	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.17	0.00	0.00
Computed Flow Time (min) :	23.99	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	151.97	0.00	0.00
Slope (%) :	10	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	5.10	0.00	0.00
Computed Flow Time (min) :	0.50	0.00	0.00

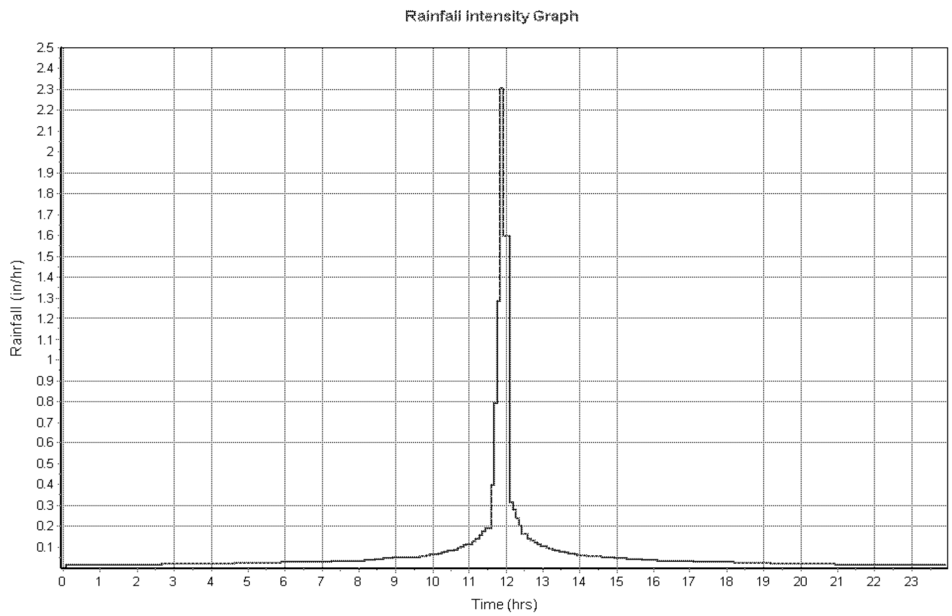
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	747.90	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	.15	0.00	0.00
Wetted Perimeter (ft) :	1.85	0.00	0.00
Velocity (ft/sec) :	2.63	0.00	0.00
Computed Flow Time (min) :	4.74	0.00	0.00

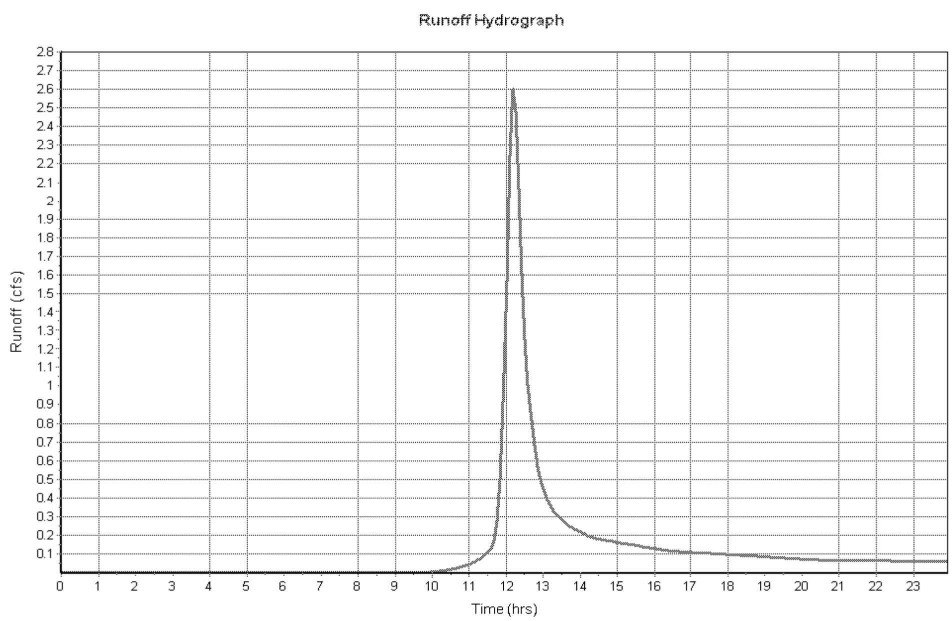
Total TOC (min) 29.22

Subbasin Runoff Results

Total Rainfall (in) 1.68
Total Runoff (in) 0.72
Peak Runoff (cfs) 2.62
Weighted Curve Number 88.00
Time of Concentration (days hh:mm:ss) 0 00:29:13

Subbasin : Upstream





FF100 Results

Project Description

File Name	Knetta's Knoll Preliminary Drainage.SPF

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Apr 24, 2021	00:00:00
End Analysis On	Apr 25, 2021	00:00:00
Start Reporting On	Apr 24, 2021	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	4
Subbasins	4
Nodes	2
Junctions	0
Outfalls	2
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	FF100	Cumulative	inches					User Defined

Subbasin Summary

SN	Subbasin ID	Area (ac)	Peak Rate Factor	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	DevelopedSite	12.86	484.00	78.45	1.64	0.31	3.99	5.21	0 00:24:12
2	Downstream	1.89	484.00	88.00	1.64	0.68	1.29	2.00	0 00:21:54
3	PreDevelopedSite	12.86	484.00	63.00	1.64	0.03	0.44	0.42	0 00:25:55
4	Upstream	4.16	484.00	88.00	1.64	0.69	2.85	3.80	0 00:29:13

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft²)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	Out-01	Outfall	0.00					0.00	0.00					
2	Out-02	Outfall	0.00					0.00	0.00					

Subbasin Hydrology

Subbasin : DevelopedSite

Input Data

Area (ac) 12.86
Peak Rate Factor 484.00
Weighted Curve Number 78.45
Rain Gage ID ....

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/2 acre lots, 25% impervious	5.46	A	54.00
Paved roads with curbs & sewers	1.93	A	98.00
Artificial desert landscape	5.46	A	96.00
Composite Area & Weighted CN	12.85		78.45

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	50	0.00	0.00
Slope (%) :	2	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.05	0.00	0.00
Computed Flow Time (min) :	17.10	0.00	0.00

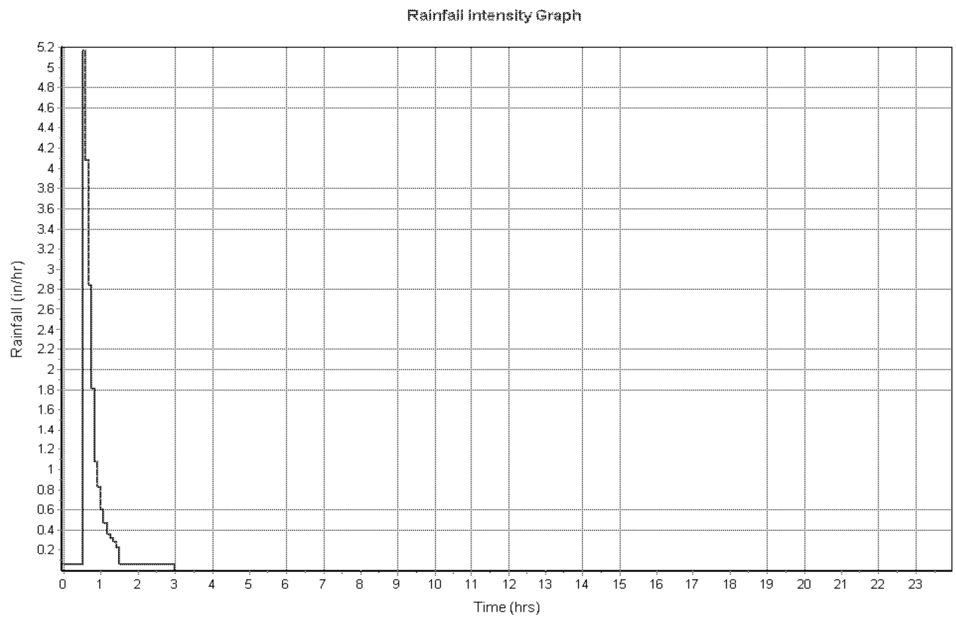
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	1942.86	0.00	0.00
Channel Slope (%) :	6	0.00	0.00
Cross Section Area (ft²) :	.15	0.00	0.00
Wetted Perimeter (ft) :	1.85	0.00	0.00
Velocity (ft/sec) :	4.56	0.00	0.00
Computed Flow Time (min) :	7.10	0.00	0.00

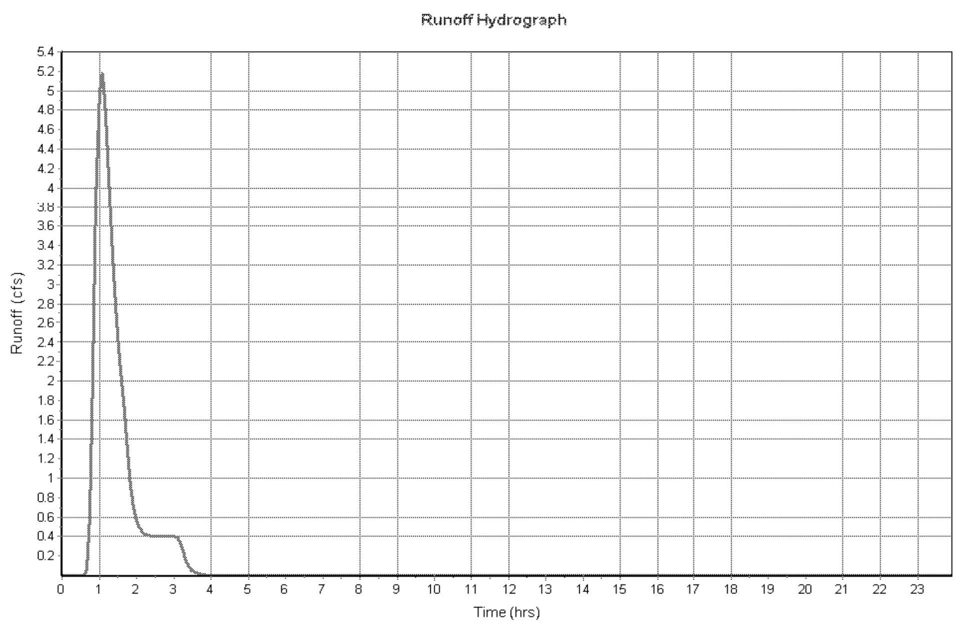
Total TOC (min) 24.21

Subbasin Runoff Results

Total Rainfall (in) 1.64
Total Runoff (in) 0.31
Peak Runoff (cfs) 5.21
Weighted Curve Number 78.45
Time of Concentration (days hh:mm:ss) 0 00:24:13

Subbasin : DevelopedSite





Subbasin : Downstream

Input Data

Area (ac) 1.89
Peak Rate Factor 484.00
Weighted Curve Number 88.00
Rain Gage ID FF10

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Natural western desert	1.89	D	88.00
Composite Area & Weighted CN	1.89		88.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	172.66	0.00	0.00
Slope (%) :	18	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.15	0.00	0.00
Computed Flow Time (min) :	19.14	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	306.09	0.00	0.00
Slope (%) :	8	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	4.56	0.00	0.00
Computed Flow Time (min) :	1.12	0.00	0.00

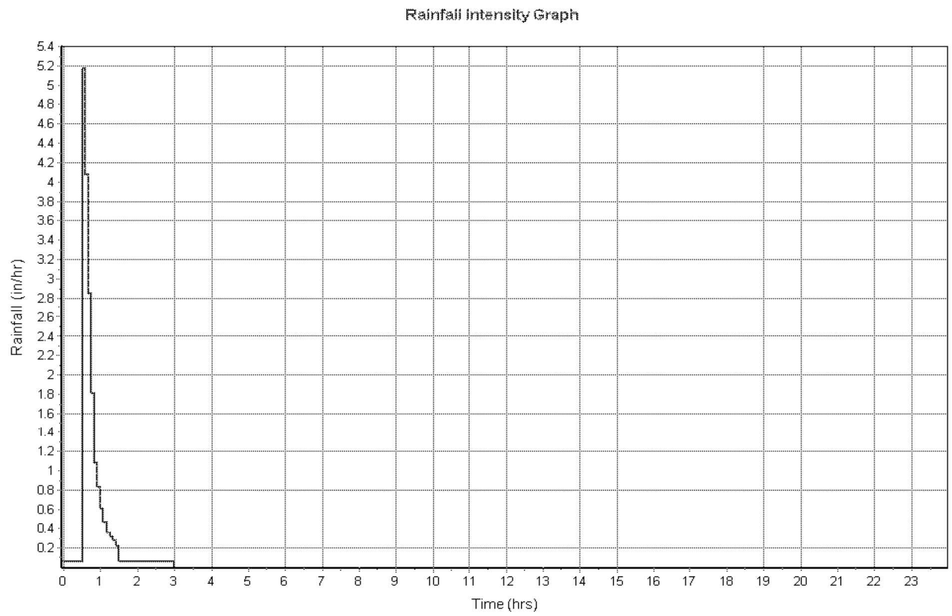
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	259.02	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	.15	0.00	0.00
Wetted Perimeter (ft) :	1.85	0.00	0.00
Velocity (ft/sec) :	2.63	0.00	0.00
Computed Flow Time (min) :	1.64	0.00	0.00

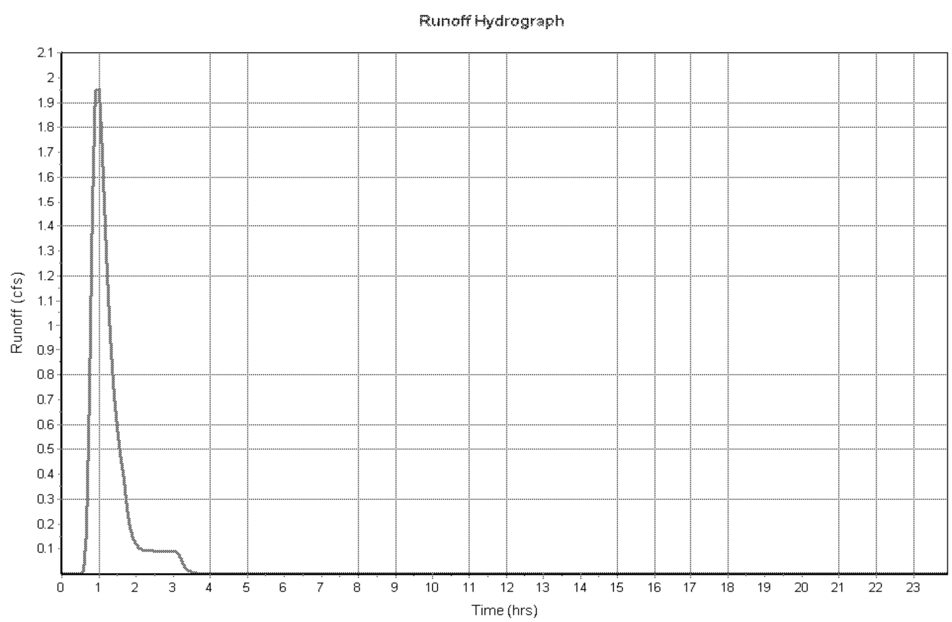
Total TOC (min) 21.90

Subbasin Runoff Results

Total Rainfall (in) 1.64
Total Runoff (in) 0.68
Peak Runoff (cfs) 2.00
Weighted Curve Number 88.00
Time of Concentration (days hh:mm:ss) 0 00:21:54

Subbasin : Downstream





Subbasin : PreDevelopedSite

Input Data

Area (ac) 12.86
Peak Rate Factor 484.00
Weighted Curve Number 63.00
Rain Gage ID ....

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Natural western desert	12.86	A	63.00
Composite Area & Weighted CN	12.86		63.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	185.22	0.00	0.00
Slope (%) :	12	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.13	0.00	0.00
Computed Flow Time (min) :	23.81	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	298.26	0.00	0.00
Slope (%) :	12	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	5.59	0.00	0.00
Computed Flow Time (min) :	0.89	0.00	0.00

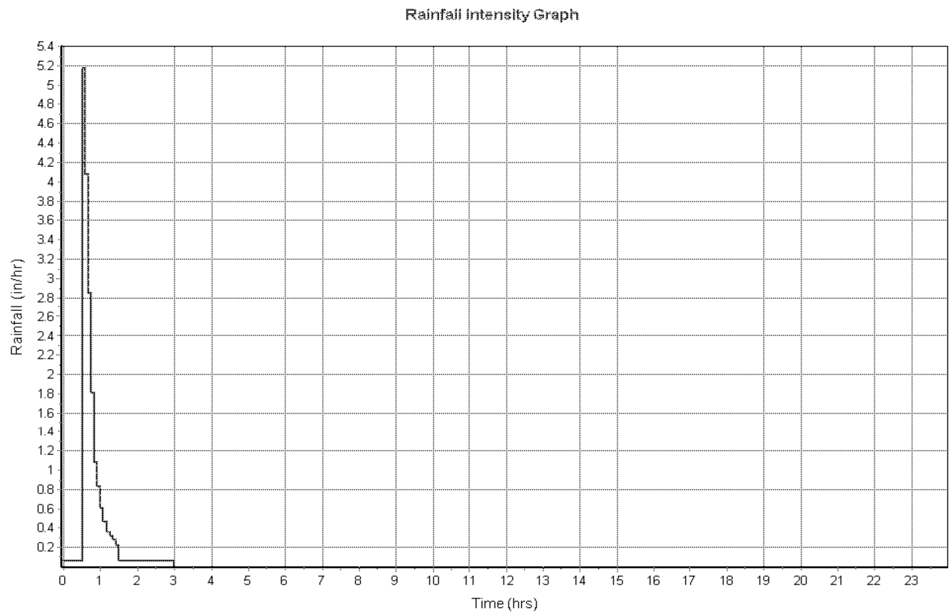
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.023	0.00	0.00
Flow Length (ft) :	654.28	0.00	0.00
Channel Slope (%) :	12	0.00	0.00
Cross Section Area (ft²) :	.5	0.00	0.00
Wetted Perimeter (ft) :	2	0.00	0.00
Velocity (ft/sec) :	8.91	0.00	0.00
Computed Flow Time (min) :	1.22	0.00	0.00

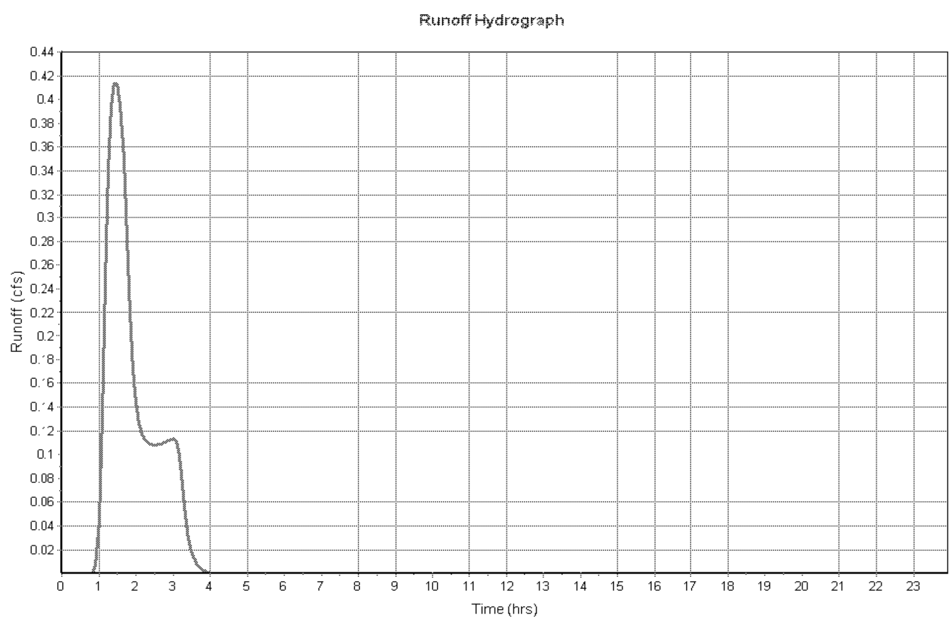
Total TOC (min) 25.93

Subbasin Runoff Results

Total Rainfall (in) 1.64
Total Runoff (in) 0.03
Peak Runoff (cfs) 0.42
Weighted Curve Number 63.00
Time of Concentration (days hh:mm:ss) 0 00:25:56

Subbasin : PreDevelopedSite





Subbasin : Upstream

Input Data

Area (ac) 4.16
Peak Rate Factor 484.00
Weighted Curve Number 88.00
Rain Gage ID ....

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Natural western desert	4.16	D	88.00
Composite Area & Weighted CN	4.16		88.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	241.27	0.00	0.00
Slope (%) :	20	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.17	0.00	0.00
Computed Flow Time (min) :	23.99	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	151.97	0.00	0.00
Slope (%) :	10	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	5.10	0.00	0.00
Computed Flow Time (min) :	0.50	0.00	0.00

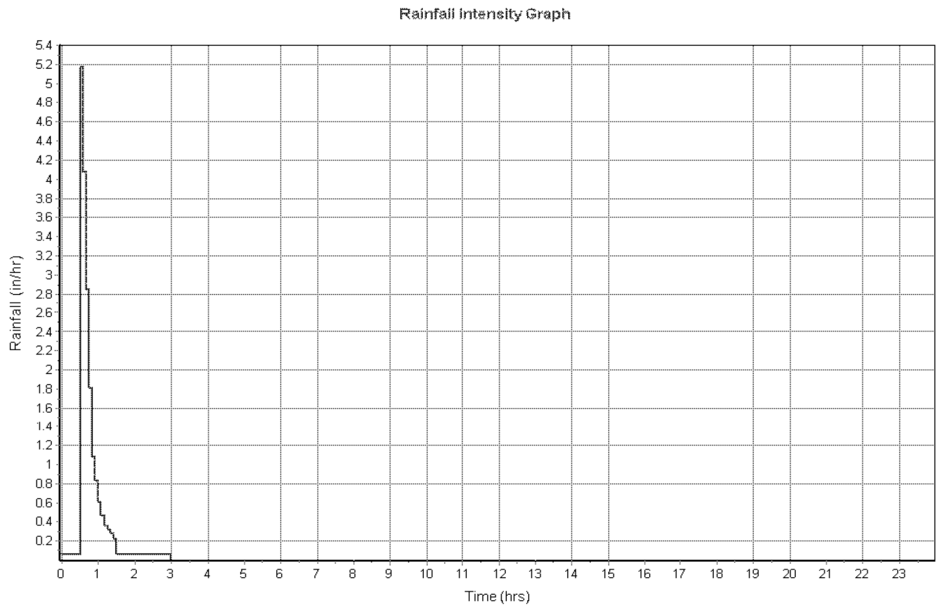
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	747.90	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	.15	0.00	0.00
Wetted Perimeter (ft) :	1.85	0.00	0.00
Velocity (ft/sec) :	2.63	0.00	0.00
Computed Flow Time (min) :	4.74	0.00	0.00

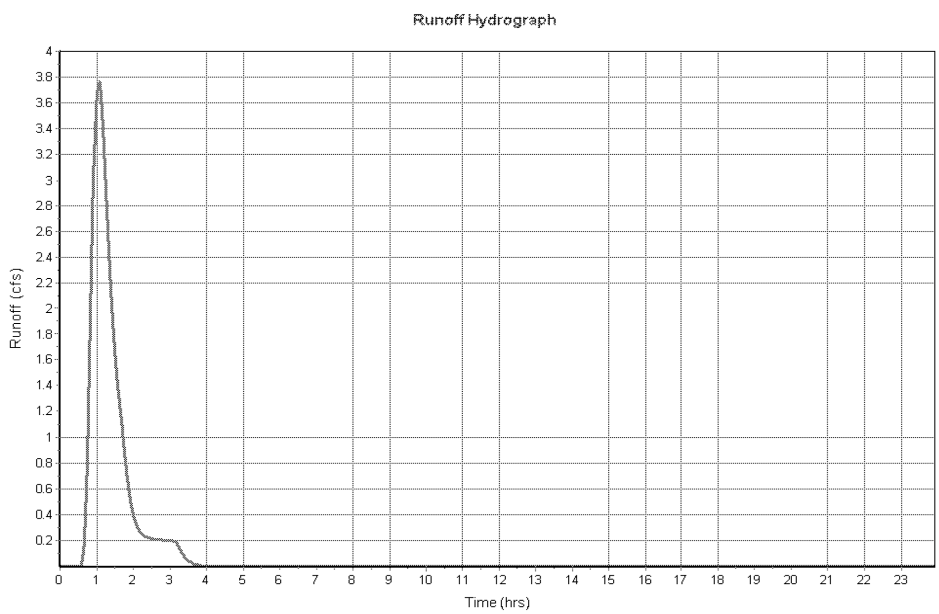
Total TOC (min) 29.22

Subbasin Runoff Results

Total Rainfall (in) 1.64
Total Runoff (in) 0.69
Peak Runoff (cfs) 3.80
Weighted Curve Number 88.00
Time of Concentration (days hh:mm:ss) 0 00:29:13

Subbasin : Upstream





SCS100 Results

Project Description

File Name	Knetta's Knoll Preliminary Drainage.SPF

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Apr 24, 2021	00:00:00
End Analysis On	Apr 25, 2021	00:00:00
Start Reporting On	Apr 24, 2021	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	4
Subbasins	4
Nodes	2
Junctions	0
Outfalls	2
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	SCS100	Cumulative	inches					User Defined

Subbasin Summary

SN	Subbasin ID	Area (ac)	Peak Rate Factor	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	DevelopedSite	12.86	484.00	78.45	2.51	0.82	10.50	9.91	0 00:24:12
2	Downstream	1.89	484.00	88.00	2.51	1.39	2.63	2.77	0 00:21:54
3	PreDevelopedSite	12.86	484.00	63.00	2.51	0.25	3.18	1.53	0 00:25:55
4	Upstream	4.16	484.00	88.00	2.51	1.39	5.78	5.19	0 00:29:13

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	Out-01	Outfall	0.00					0.00	0.00					
2	Out-02	Outfall	0.00					0.00	0.00					

Subbasin Hydrology

Subbasin : DevelopedSite

Input Data

Area (ac) 12.86
Peak Rate Factor 484.00
Weighted Curve Number 78.45
Rain Gage ID ....

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/2 acre lots, 25% impervious	5.46	A	54.00
Paved roads with curbs & sewers	1.93	A	98.00
Artificial desert landscape	5.46	A	96.00
Composite Area & Weighted CN	12.85		78.45

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft^2)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	50	0.00	0.00
Slope (%) :	2	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.05	0.00	0.00
Computed Flow Time (min) :	17.10	0.00	0.00

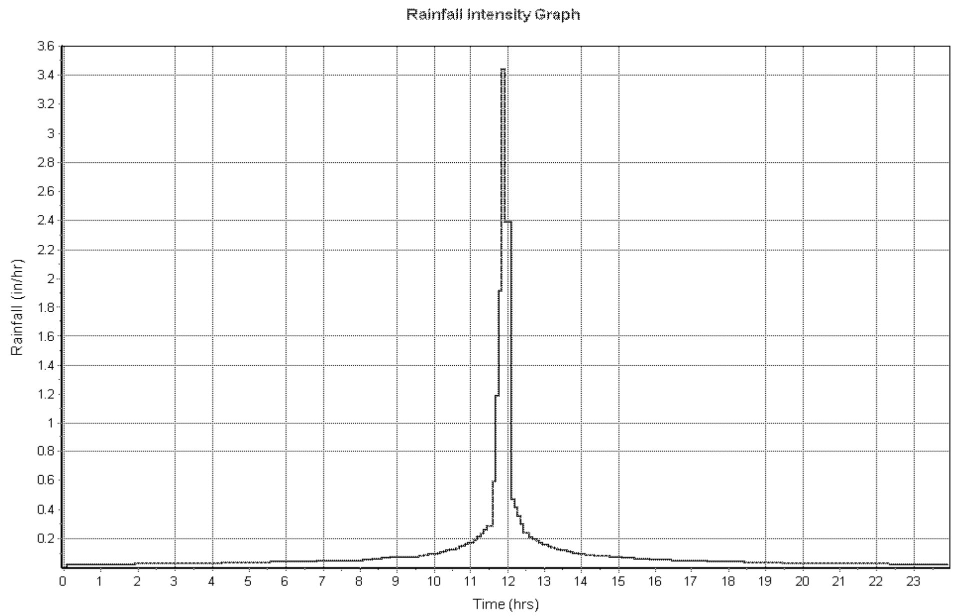
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	1942.86	0.00	0.00
Channel Slope (%) :	6	0.00	0.00
Cross Section Area (ft²) :	.15	0.00	0.00
Wetted Perimeter (ft) :	1.85	0.00	0.00
Velocity (ft/sec) :	4.56	0.00	0.00
Computed Flow Time (min) :	7.10	0.00	0.00

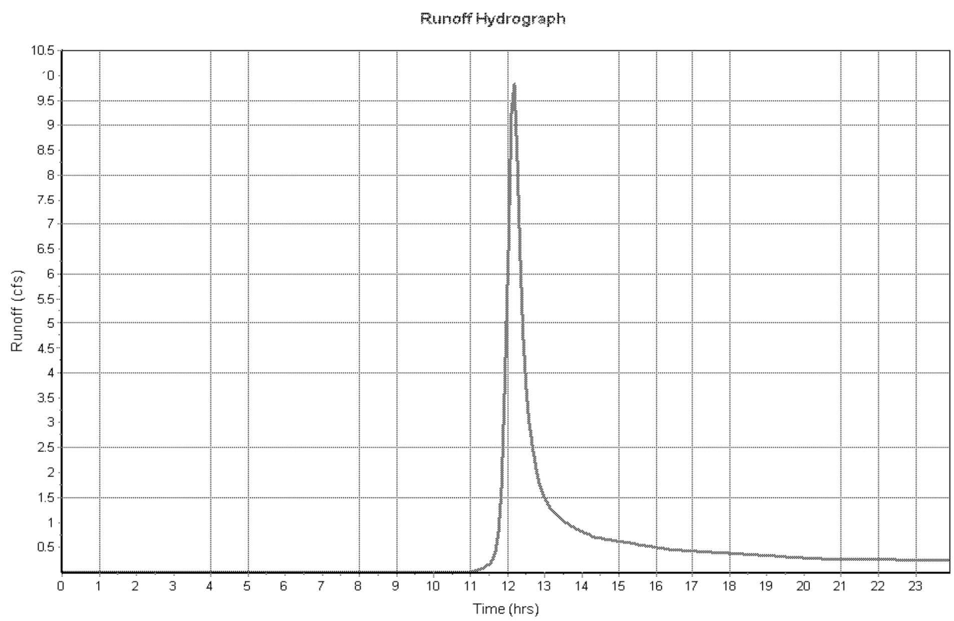
Total TOC (min) 24.21

Subbasin Runoff Results

Total Rainfall (in) 2.51
Total Runoff (in) 0.82
Peak Runoff (cfs) 9.91
Weighted Curve Number 78.45
Time of Concentration (days hh:mm:ss) 0 00:24:13

Subbasin : DevelopedSite





Subbasin : Downstream

Input Data

Area (ac) 1.89
Peak Rate Factor 484.00
Weighted Curve Number 88.00
Rain Gage ID FF10

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Natural western desert	1.89	D	88.00
Composite Area & Weighted CN	1.89		88.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	172.66	0.00	0.00
Slope (%) :	18	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.15	0.00	0.00
Computed Flow Time (min) :	19.14	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	306.09	0.00	0.00
Slope (%) :	8	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	4.56	0.00	0.00
Computed Flow Time (min) :	1.12	0.00	0.00

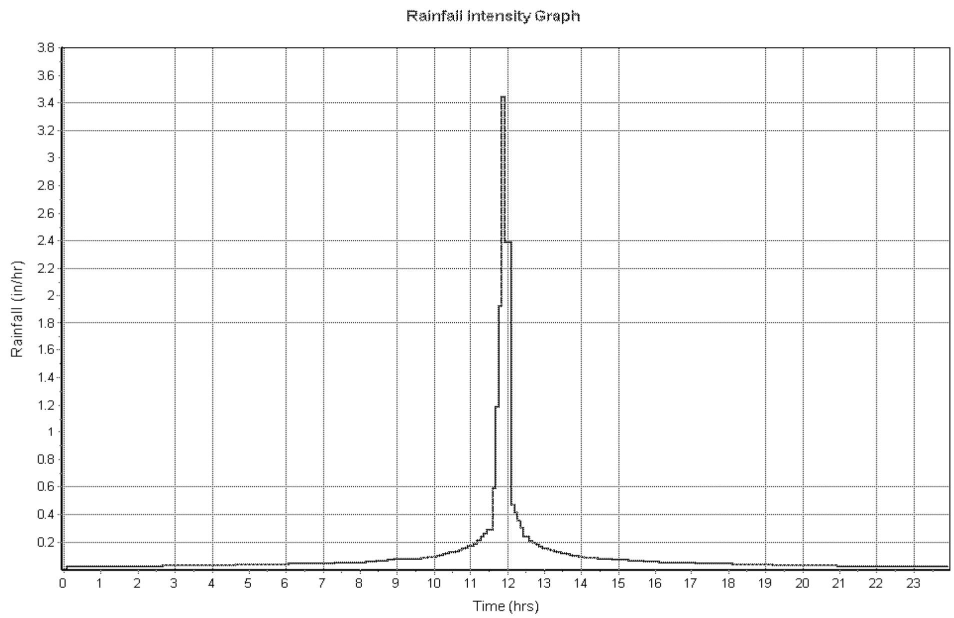
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	259.02	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	.15	0.00	0.00
Wetted Perimeter (ft) :	1.85	0.00	0.00
Velocity (ft/sec) :	2.63	0.00	0.00
Computed Flow Time (min) :	1.64	0.00	0.00

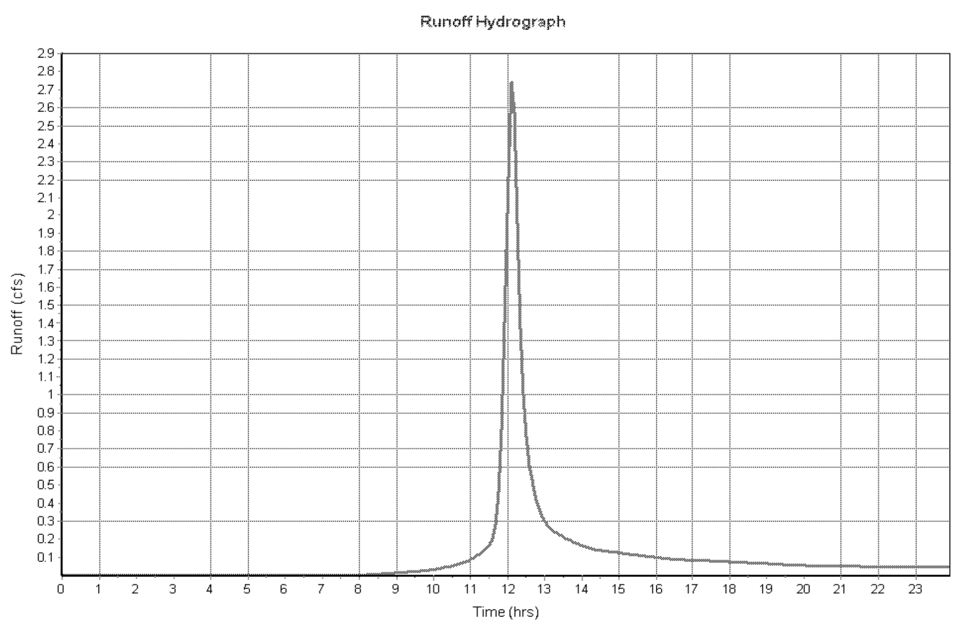
Total TOC (min) 21.90

Subbasin Runoff Results

Total Rainfall (in) 2.51
Total Runoff (in) 1.39
Peak Runoff (cfs) 2.77
Weighted Curve Number 88.00
Time of Concentration (days hh:mm:ss) 0 00:21:54

Subbasin : Downstream





Subbasin : PreDevelopedSite

Input Data

Area (ac) 12.86
Peak Rate Factor 484.00
Weighted Curve Number 63.00
Rain Gage ID ....

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Natural western desert	12.86	A	63.00
Composite Area & Weighted CN	12.86		63.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	185.22	0.00	0.00
Slope (%) :	12	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.13	0.00	0.00
Computed Flow Time (min) :	23.81	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	298.26	0.00	0.00
Slope (%) :	12	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	5.59	0.00	0.00
Computed Flow Time (min) :	0.89	0.00	0.00

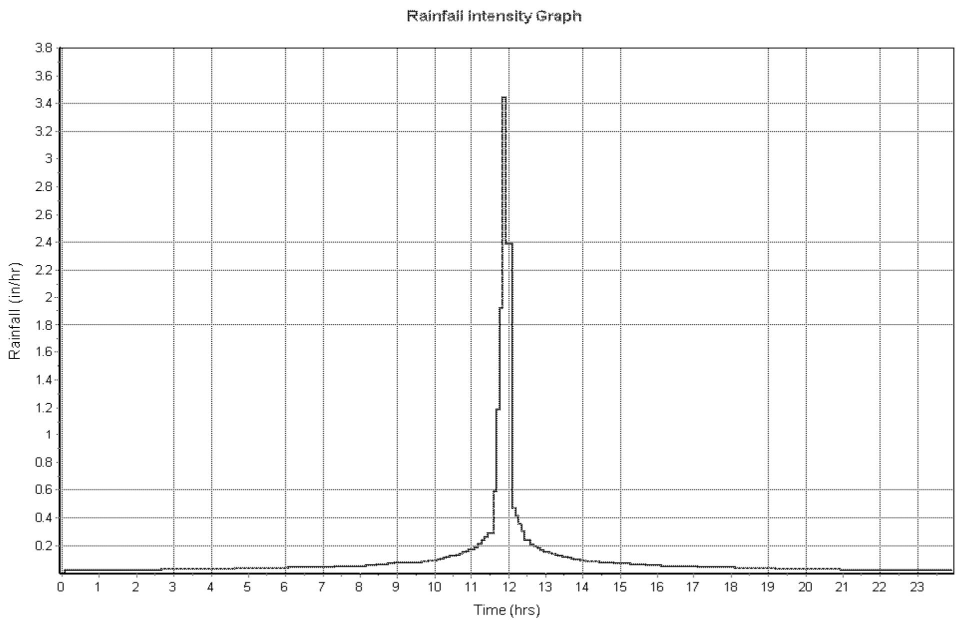
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.023	0.00	0.00
Flow Length (ft) :	654.28	0.00	0.00
Channel Slope (%) :	12	0.00	0.00
Cross Section Area (ft²) :	.5	0.00	0.00
Wetted Perimeter (ft) :	2	0.00	0.00
Velocity (ft/sec) :	8.91	0.00	0.00
Computed Flow Time (min) :	1.22	0.00	0.00

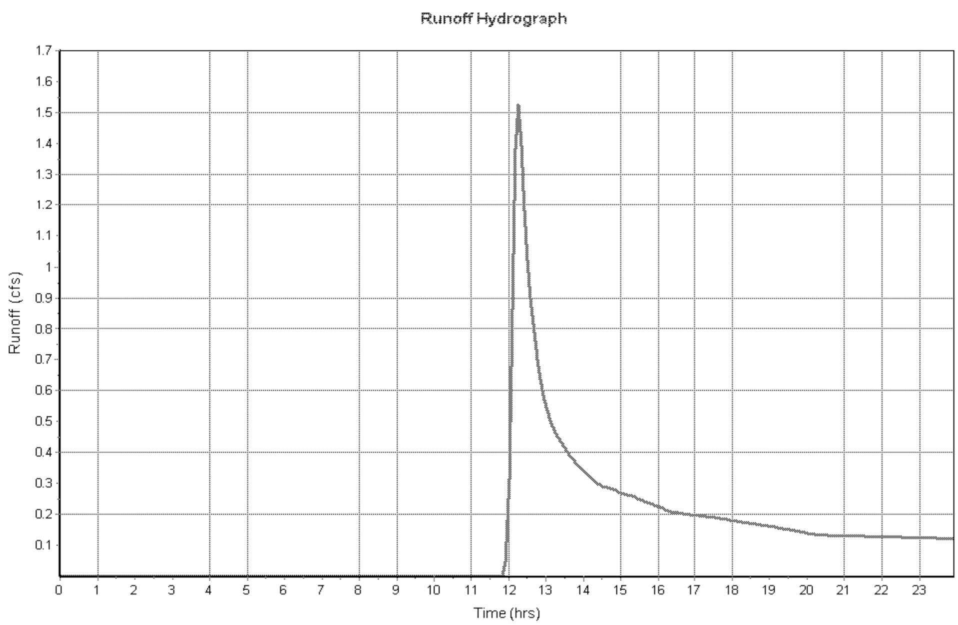
Total TOC (min) 25.93

Subbasin Runoff Results

Total Rainfall (in) 2.51
Total Runoff (in) 0.25
Peak Runoff (cfs) 1.53
Weighted Curve Number 63.00
Time of Concentration (days hh:mm:ss) 0 00:25:56

Subbasin : PreDevelopedSite





Subbasin : Upstream

Input Data

Area (ac) 4.16
Peak Rate Factor 484.00
Weighted Curve Number 88.00
Rain Gage ID ....

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Natural western desert	4.16	D	88.00
Composite Area & Weighted CN	4.16		88.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.3	0.00	0.00
Flow Length (ft) :	241.27	0.00	0.00
Slope (%) :	20	0.00	0.00
2 yr, 24 hr Rainfall (in) :	1.05	0.00	0.00
Velocity (ft/sec) :	0.17	0.00	0.00
Computed Flow Time (min) :	23.99	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	151.97	0.00	0.00
Slope (%) :	10	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	5.10	0.00	0.00
Computed Flow Time (min) :	0.50	0.00	0.00

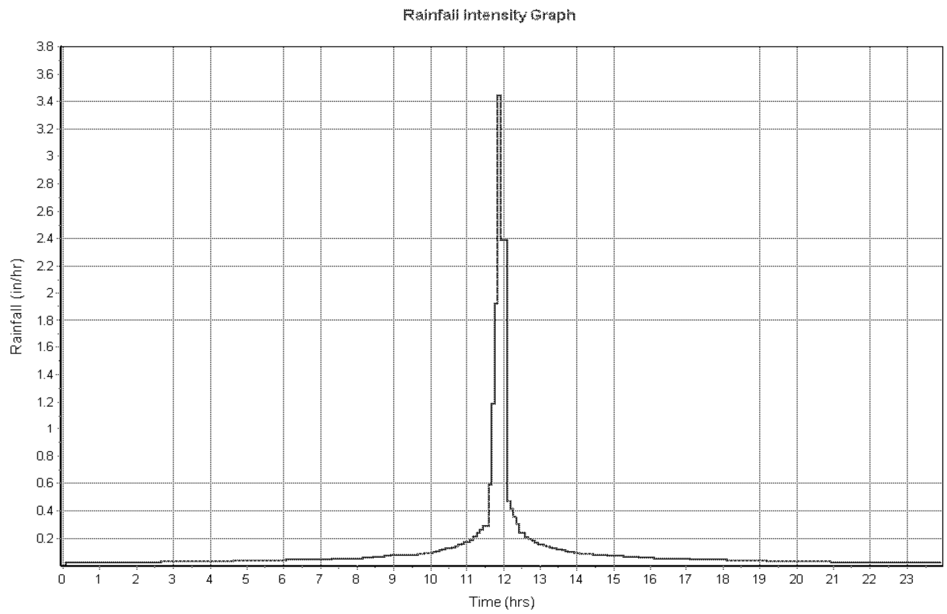
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	747.90	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	.15	0.00	0.00
Wetted Perimeter (ft) :	1.85	0.00	0.00
Velocity (ft/sec) :	2.63	0.00	0.00
Computed Flow Time (min) :	4.74	0.00	0.00

Total TOC (min) 29.22

Subbasin Runoff Results

Total Rainfall (in) 2.51
Total Runoff (in) 1.39
Peak Runoff (cfs) 5.19
Weighted Curve Number 88.00
Time of Concentration (days hh:mm:ss) 0 00:29:13

Subbasin : Upstream



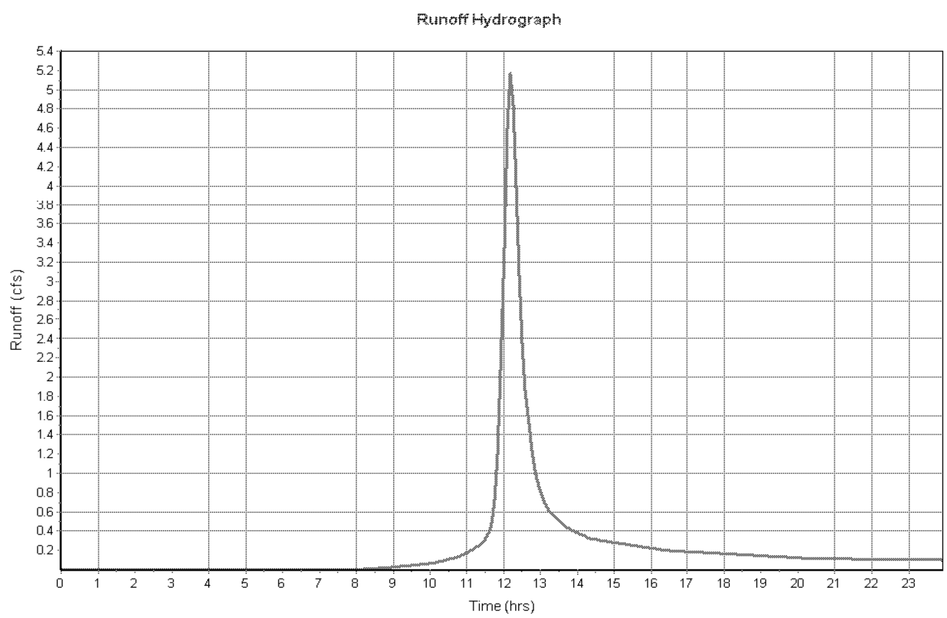


Exhibit F
Geotechnical Report

Important Information About Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

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Applied Geotechnical Engineering Consultants, Inc.

GEOTECHNICAL INVESTIGATION

NETTAS KNOLL

ST. GEORGE, UTAH

PREPARED FOR:

WALTER PLUMB
809 EAST EDGEHILL ROAD
SALT LAKE CITY, UTAH 84103

PROJECT NO. 2062743

MARCH 2, 2007

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SUMMARY

1. The subsurface profile observed in the borings drilled and test pits excavated at the site generally consists of silty to clayey sand underlain by silty gravel with sand. The gravel is underlain by mudstone bedrock to the maximum depth investigated, approximately 39 feet. The mudstone bedrock is commonly known as "blue clay" and is expansive when wetted. Conglomerate (well cemented gravel) was also encountered in the majority of the borings and test pits. The depth to mudstone bedrock varies from the surface to greater than 30 feet below the existing grade.

2. Groundwater was not encountered to the maximum depth investigated, approximately 39 feet. Our experience has shown that surface water may infiltrate and perch on the underlying mudstone as development occurs in the area.

3. The existing slopes are currently stable in their existing geometry and moisture condition. Analysis also indicates the proposed slopes would remain stable following grading and development. To maintain stability of the slopes, the proposed grading plan should be strictly followed and proper drainage should be provided to reduce infiltration of surface water into the subsurface soil/mudstone in the slopes. Drainage and grading recommendations within the recommendations section of this report should be followed.

4. Due to the expansive characteristics of the underlying mudstone, AGEC evaluated the heave potential to determine foundation recommendations for the proposed condominiums. We estimate approximately ½ to ¾ of an inch of potential foundation/slab heave may occur for residences constructed where the expansive clay or mudstone is present within 15 feet of the finished pad grade.

5. Buildings located in areas where the expansive clay/mudstone bedrock is at depths of 15 feet or greater, below the finished pad grade, may be supported on conventional spread footings with slab-on-grade floors.

6. We recommend the proposed residences/structures constructed in areas where mudstone bedrock is at a depth less than 15 feet below the finished pad grade be supported on deep (pier) foundation systems due to the presence of expansive mudstone. The deep foundation systems should be designed by a structural engineer according to the parameters provided in this report. The drilling of piers will likely be very difficult in areas where cemented gravel/conglomerate is present.

SUMMARY

7. As an alternative to the use of deep foundations, the expansive mudstone bedrock may be overexcavated and replaced with non-expansive, low permeable fill to a depth of at least 17 feet below the finished pad grade. The pads may also be raised to provide this separation. Owners and builders should be aware that the use of this alternative entails the risk of approximately ½ to ¾ of an inch of differential foundation/slab movement if expansive mudstone is present below the overexcavation zone. This amount of differential foundation slab movement may result in cosmetic damage to buildings.

8. The depth to expansive bedrock and the recommended foundation systems for each lot are shown on the Site Plan, Figure 2. Areas where additional investigation are recommended are also shown on Figure 2.

9. The use of positive drainage is critical to reduce the potential for the underlying expansive mudstone being wetted which could result in foundation/slab movement and reduced stability of slopes. The drainage recommendations in this report should be referenced and followed throughout the life of the residences.

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

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

SCOPE OF WORK

This report presents the results of a geotechnical investigation for the proposed Nettas Knoll residential (condominium) development to be located south of th intersection of Riverside Drive and Foremaster Drive in St. George, Utah, as shown on Figure 1. This report presents the subsurface conditions encountered and recommendations for the geotechnical aspects of the project.

Field exploration was conducted to obtain information on the subsurface conditions. Results of the field exploration, laboratory testing, engineering analysis, and our experience were used to develop recommendations for the proposed residential development. We have also reviewed a geologic hazard assessment and preliminary geotechnical recommendations prepared for the site by AGEC under project number 2030907, dated July 7, 2004. Information from this report was utilized to assist in developing geotechnical recommendations.

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 vacant, undeveloped hillside property located south of the intersection of Riverside Drive and Foremaster Drive. The site generally slopes down moderately to steeply to the north and east. The south and west edges of the site slope down steeply to the south and west, respectively. Vegetation at the site generally consists of native desert brush. Vacant properties are located to the south, east, and west. The vacant property to the west is currently in the development process for the proposed Villa de Colina townhome project. The Virgin River is located further to the south and southeast.

FIELD STUDY

Engineers from AGEC visited the site on December 20 and 21, 2006 and January 15, 2007 to observe the drilling of 16 borings excavation of five test pits. The approximate locations of the borings and test pits are shown on Figure 2. The borings were drilled utilizing a track mounted blasting rig and a truck mounted rill rig equipped with 7-inch hollow-stem augers and a 3-inch tri-cone bit using air to remove cuttings.

SUBSURFACE CONDITIONS

The subsurface profile observed in the borings drilled and test pits excavated at the site generally consists of silty to clayey sand underlain by silty gravel with sand. The gravel is underlain by mudstone bedrock to the maximum depth investigated, approximately 39 feet. The mudstone bedrock is commonly known as "blue clay" and is expansive when wetted. Conglomerate (well cemented gravel) was also encountered in the majority of the borings and test pits. The depth to mudstone bedrock varies from the surface to greater than 30 feet below the existing grade.

Descriptions of each soil and bedrock type encountered follow.

Clayey sand with gravel - The clayey sand with gravel contains cobbles. It is medium dense to dense, dry to slightly moist, fine-grained, low plastic, and light brown in color.

Silty sand - The silty sand contains varied amounts of gravel and occasional cobbles and boulders. It is loose to dense, dry, fine to medium-grained, and brown in color.

Laboratory tests conducted on samples of the silty sand indicate an in-place moisture content of 5 percent, an in-place dry density of 110 pcf, and a fines content (percent passing the No. 200 sieve) of 47 percent. A water soluble sulfates test indicates a sulfate concentration of 100 ppm.

Silty gravel with sand - The silty gravel with sand contains occasional cobbles and boulders. It is medium dense to very dense, dry, fine to coarse-grained, sub-angular to angular, and brown in color.

Conglomerate - The conglomerate is very hard, dry, and gray to brown in color.

Mudstone bedrock - The mudstone bedrock is weathered to moderately hard, slightly moist, high plastic, and purple to gray to red in color.

Laboratory tests conducted on samples of the mudstone indicate in-place moisture contents ranging from 14 to 15 percent, in-place dry densities ranging from 103 to 107 pcf, and fines contents (percent passing the No. 200 sieve) ranging from 63 to 89 percent. A triaxial shear test conducted on a sample of the mudstone indicates a cohesion of 290 psf and a friction angle of 23 degrees. Atterberg Limits tests indicate liquid limits ranging from 44 to 56 percent and plasticity indexes ranging from 23 to 35 percent. A water soluble sulfates test indicates a sulfate concentration of 4,960 ppm.

One-dimensional consolidation/swell tests conducted on samples of the mudstone indicate it is slightly expansive when wetted under a constant pressure of 1,000 and 2,000 psf. Swell pressures ranging from approximately 1,700 to 3,500 psf were measured.

The Logs, Legend and Notes of Exploratory Borings and Test Pits are shown on Figures 3-8. The laboratory test results are shown on the logs and are summarized in the Summary of Laboratory Test Results, Table 1. The consolidation/swell test results are shown graphically on Figure 9. The triaxial shear test results are shown on Figure 10.

SUBSURFACE WATER

Groundwater was not encountered within the borings or test pits to the maximum depth investigated, approximately 39 feet. Fluctuations and the existence of groundwater may occur over time. An evaluation of such fluctuations over time is beyond the scope of this report. We anticipate groundwater may exist in a perched condition over the mudstone in the future resulting from infiltration of surface water.

PROPOSED CONSTRUCTION

We understand it is proposed to develop site for construction of a residential subdivision which will include 13 multi-family condominium buildings. We understand the 13 buildings will include approximately 174 residential units. Based on the grading plan provided, we understand cut and fill of up to approximately 23 feet will be required to grade the site.

We understand the condominiums will be three to four story, wood-framed structures with tile roofs and stucco veneer. For the purpose of this report, we have assumed wall loads up to 6 kips per lineal foot and column loads up to 150 kips.

We also understand that private roadways and underground utilities will be constructed as part of the development. Pavement section design is based on a traffic index of 5 for the private roads, a traffic index of 6 for the 66-foot right-of-way access road, and a traffic index of 7 for widening of Riverside Drive (80-foot right-of-way).

If the proposed construction, loading conditions, or grading are significantly different from what is described above, we should be notified so we may reevaluate our recommendations.

SLOPE STABILITY ANALYSIS

The stability of the slopes was evaluated by selecting representative cross sections across the property at the approximate locations shown on Figure 2. The cross sections are based on the proposed grading plan provided by L.R. Pope Engineers & Surveyors, dated January, 2007.

The selected cross-sections of the slope were evaluated with the proposed grading to determine factors of safety in a wet condition utilizing bedrock strengths found in the laboratory by AGEC. Generally accepted factors of safety for static and seismic conditions are 1.5 and 1.0, respectively.

The cross-sections were analyzed using a circular type failure assuming the mudstone bedrock is wetted for a depth of 20 feet. The cross-sections were also analyzed using a sliding block type failure assuming the bedrock is wetted for a depth of 20 feet creating a weak interface through the weathered zone of the mudstone bedrock. Factors of safety obtained in a wet condition during the analysis after grading under static and seismic conditions are listed below:

Circular Failure

Cross Section	Earthquake (0.10g)*	Factor of Safety After Grading
A - A′	No	1.7
A - A′	Yes	1.3
B - B′	No	1.9
B - B′	Yes	1.2
C - C′	No	1.5
C - C′	Yes	1.3

Block Failure

Cross Section	Earthquake (0.10g)*	Factors of Safety After Grading
A - A′	No	1.7
A - A′	Yes	1.3
B - B′	No	1.7
B - B′	Yes	1.3
C - C′	No	2.9
C - C′	Yes	2.0

* A maximum horizontal acceleration having a10% probability of being exceeded in 50 year period.

Acceptable factors of safety were generated during the analysis in the wet condition indicating a relatively safe slope for the selected cross-sections after grading for both failure modes. It is our professional opinion that the slopes will remain stable following the currently proposed grading.

RECOMMENDATIONS

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

A. Site Grading

Based on the subsurface conditions observed and the proposed grading, the following recommendations are provided.

1. Subgrade Preparation

1. General Subgrade Preparation

Prior to placing fill in roadway, building pad, or slab areas, the existing vegetation and soil containing roots and organics should be removed. We anticipate this will require the removal of approximately 2 to 4 inches of soil. Undiscovered fill and loose soils should also be removed their entire depth. Loose soils generally extend approximately 1 to 2 feet below the existing ground surface. Subsequent to grubbing and removal of unsuitable soils, the exposed subgrade should be scarified to a depth of at least 8 inches, properly moisture conditioned, and compacted to meet the requirements in the compaction section of this report.

2. Building Pads (expansive mudstone removal and replacement)

As an alternative to use of deep (pier) foundation systems, the expansive mudstone/clay may be removed and replaced with non-expansive soil to provide a minimum of 17 feet of separation between the finished pad grade and the mudstone bedrock. The building pads may also be raised to provide adequate separation. If the pad is raised, the exposed subgrade should be prepared as previously stated prior to placing fill.

Although our experience has shown residences constructed with the 17 feet of separation have performed as desired, there is a risk of differential foundation/slab heave on the order of ½ to ¾ of an inch if the expansive mudstone is significantly wetted below the overexcavated or overburden zone. This also assumes slab-on-grade construction without the use of basements, partial basements or other below-grade structures. This differential movement will likely result in cosmetic distress to the buildings. This distress may include doors/windows becoming out of square, cracks in drywall, tile distress, etc.

The owners/builders should be aware of anticipated floor slab/foundation movement should the expansive mudstone become wetted. Therefore, the drainage recommendations within this report should be strictly followed. The following recommendations are provided for the mudstone removal alternative.

- The over excavation/removal of the expansive mudstone should extend laterally at least 5 feet beyond the perimeters of the proposed buildings. The area of removal should include porches and overhangs. Consideration should be given to extending the over excavation to include flatwork areas.

- The over excavation zone should extend at least 17 feet below the proposed finished pad grade.

- The base of the excavation (17 foot depth) should be moisture conditioned to at least 4 percent over the optimum moisture content and compacted to 100 percent of the maximum dry density as determined by ASTM D-698.

- The backfill placed in the excavation should consist of pre-approved low permeable soil that meets the requirements provided in the materials section of this report. The material should be non-expansive with a maximum particle size of 2 inches. The upper 3 feet of pads should consist of granular structural fill to provide suitable bearing material for footings and to protect the low permeable fill from drying.

- The placement and compaction of materials should follow the recommendations provided in the compaction section of this report.

- AGEC should observe and document the limits of the mudstone removal. The extent of the mudstone removal should be verified by survey.

- AGEC should frequently test the backfill materials to verify compaction. As a minimum, we recommend a minimum testing frequency of every 2 vertical feet of fill placed.

- Provided the recommendations listed above are followed, AGEC can provide a report which summarizes the recommendations listed above were followed and indicating a conventional foundation system may be used.

c. Roadways

If expansive mudstone bedrock is present within 3 feet of the finished subgrade elevation, it should be removed and replaced with properly compacted low permeable fill to a depth of at least 3 feet below the finished subgrade elevation. We estimate approximately 2 to 3 inches of heave may occur in pavement areas where expansive mudstone is near the near the surface. Additional overexcavation and replacement can be conducted to reduce the potential for heave of pavement areas.

2. Excavation/Earthwork

Excavation of the upper loose soils and weathered bedrock at the site may be accomplished with typical excavation equipment. We anticipate heavy duty excavation equipment and blasting, may be required for excavations which extend into the cemented gravel/conglomerate.

3. Slopes

To maintain slope stability, large cut and fill slopes shown on the grading plan should be graded as designed. Smaller, unretained cut an fill slopes should be graded no steeper than 2 to 1 (horizontal to vertical). 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 natural slopes steeper than 3:1 should be benched into the natural slope. Horizontal benches should be cut into natural slopes to provide an adequate surface for compaction and to assure proper stability of the slope. We further recommend over-filling slopes and cutting them to design grades to assure appropriate compaction of the slope faces and to reduce erosion potential.

Horizontal benches should be constructed in fill and cut slopes at not more than 30 foot vertical intervals to control drainage and erosion. The benches should be at least 6 feet in width. If only one bench is required, it should be constructed at the midheight of the slope.

Foundations should be setback from the crests of slopes a horizontal distance equal to or greater than one-third the height of the slopes. Footings may also be embedded to provide the minimum setback as per the 2006 International Building Code (IBC) section 1805.3.2.

The mudstone at the site is very susceptible to erosion. Erosion protection, such as riprap, vegetation mats, or waffle mats filled with aggregate, should be provided.

4. Compaction

Compaction of fill materials placed at the site should equal or exceed the following percentages when compared to the maximum dry density as determined by ASTM D-698 or ASTM D-1557:

Area	Percent Compaction ASTM D-698*	Percent Compaction ASTM D-1557**
Subgrade (building pads)	100	90
Subgrade (city Improvements)	100	95
Footings/foundations	NA	95
Pads (over excavation)	100	95
Slabs	NA	95
Roadway base course	NA	95
Utility trench backfill	100	95

* Fine-grained low permeable fill/processed mudstone.
** Granular site grading fill/granular low permeable fill/structural fill.

Fill should be placed in lifts which do not exceed the capability of the equipment used. Generally 6 to 8 inch lifts are adequate. Lift thicknesses should be reduced to 4 inches for hand compaction equipment. Fill placed at the site should be properly moisture conditioned prior to placement and should be tested to verify proper compaction.

Fill materials should be properly moisture conditioned prior to placement. Fine-grained/low permeable fill and processed mudstone/sand mixture should be moisture conditioned to 2 to 4 percentage points over the optimum moisture content as determined by ASTM D-698 or D-1557 (whichever is appropriate). Granular fill and coarse-grained, low permeable fill should be moisture conditioned to within 2 percentage points of the optimum moisture content as determined by ASTM D-1557.

5. Materials

The on-site sand and gravel, free of organics, debris, and material larger than 6 inches may be used as structural fill, site grading fill, and utility trench backfill. The on-site conglomerate may be used as structural fill, site grading fill, and utility trench backfill provided it is processed such that a minimum of 50 percent of the material passes the No. 4 sieve and the maximum particle size is 6 inches. Processing of the conglomerate will require the use of a crusher. The on-site expansive mudstone is not suitable for use as site grading fill in structural areas. Processed mudstone is suitable for use as site grading fill and utility trench backfill in non-structural areas and as site grading fill on pier lots.

Recommendations for imported fill types follow. If a structural floor is used, the type of fill placed under the building is not critical. If slab-on-grade is used, we recommend that imported fill be non-expansive and relatively impervious below building pads. Imported fill should be non-expansive and meet the following recommendations.

Area	Fill Type	Recommendations
Footings/pads	Structural fill	-200 <35%, LL <30% Maximum size: 4 inches Solubility < 1%
Under slab	Base course	-200 <12% Maximum size: 1 inch

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

The potential impact of the expansive characteristics of the underlying mudstone bedrock can be reduced by protecting the bedrock from becoming wet. Placement of relatively low permeable fill above the bedrock can help reduce the possibility of water coming in contact with the bedrock.

Low permeable fill used to replace removed mudstone should meet one of the following set of criteria.

Liquid Limit (%)	Percent Passing the No. 200 Sieve
50+	15-20
30-50	20-40
0-30	30-100

Our experience has shown that a blend of the native or imported granular soil and mudstone will likely meet the low permeable fill requirements at a ratio of two parts granular soil to one part processed mudstone. AGEC should conduct additional laboratory testing to verify this process.

6. Drainage

Positive site drainage should be maintained through the course of construction and during the life of the residences and slopes. Positive drainage of the surface water away from each residence ands slopes in all directions should be maintained. In no case should water be allowed to pond adjacent to foundations. We recommend a minimum slope of 6 inches in the first 10 feet from the perimeters of the structures. A 3 to 4 foot concrete skirt (sidewalk) or pavement should be placed around the perimeter of each building. Due to the presence of expansive mudstone, desert-type landscaping or landscaping which requires little to no water is recommended. This is extremely critical to reduce the potential for foundation/slab movement and to maintain slope stability.

Roof drains should be utilized and roof downspouts should discharge out away from foundations to eliminate the potential for infiltration of water into the underlying supporting soils. We recommend roof drains outlet into the storm drain system.

On-site retention of surface water should not be used in the vicinity of slopes. We understand that surface runoff retention is proposed for the generally level area on the northeast corner of the site.

B. Foundations

Buildings to be constructed in areas where the expansive mudstone is at depths of 15 feet or greater, below the finished pad grade, may be supported on conventional spread footings with slab-on-grade floors.

We recommend the proposed residences/structures constructed in areas where mudstone bedrock is at a depth less than 15 feet below the finished pad grade be supported on deep (pier) foundation systems due to the presence of expansive mudstone. The deep foundation systems should be designed by a structural engineer according to the parameters provided in this report. The foundation system for proposed swimming pool should be evaluated when the location is determined.

Recommended foundation systems for each lot are shown on Figure 2. Areas where additional investigation is required are also shown on Figure 2.

The design parameters and construction details for various foundation types follow:

1. <u>Conventional Spread Footings/Slab-on-Grade System</u>

   Conventional spread footings with a slab-on-grade floors may be utilized where the expansive mudstone bedrock is present at a depth of 15 feet or greater below the existing grade or is removed to a depth of at least 17 feet below the finished pad elevation. The building pads may also be raised to provide adequate separation.

   a. Spread footings bearing on a minimum of 1 foot of properly compacted structural fill or dense, undisturbed natural gravel may be designed for the following net allowable bearing pressures.

Footing Width "B" (feet)	Allowable Bearing Pressure (psf)
B < 2.5	2,000
2.5 ≤ B < 3	2,500
3 ≤ B < 4	3,000
B ≥ 4	3,500

b. The bearing pressures indicated above may be increased by one-half for temporary loading conditions such as wind and seismic loads.

c. Spread footings should have a minimum width of 18 inches and should be placed at least 12 inches below the lowest adjacent grade.

d. Based on the subsoil conditions encountered and the assumed building loads, we estimate total settlement for the foundations designed as indicated above to be approximately 1 inch. Differential settlement is estimated to be on the order ½ inch. Differential heave of approximately ½ to ¾ of an inch may occur if the mudstone bedrock is wetted below the 15 foot overexcavation zone or overburden soil zone. This may result in cosmetic distress to the residences.

e. The footing bearing level should be cleared of loose or deleterious material and properly compacted prior to placing concrete.

f. Lateral resistance for footings is controlled by the sliding resistance between the footings and subgrade soil. A friction value of 0.45 may be used in the design for lateral resistance.

g. A representative of AGEC should observe footing excavations prior to placing structural fill or concrete.

2. Deep (Drilled) Pier Foundation System

The pier foundation system utilizes straight-shaft drilled concrete piers which are drilled at least 15 feet into the underlying expansive mudstone bedrock with a minimum pier length of 20 feet. Due to the presence of dense overburden soils and conglomerate, the use of steel helical piers may not be practical. Grade beams are utilized to span the distance between piers and support the structural floor system with a crawl space. The following recommendations should be followed if a pier system is used:

a. The piers may be designed using a net allowable end bearing pressure of 30,000 pounds per square foot for piers bearing on the expansive mudstone bedrock. A representative of AGEC should verify that competent bearing material is encountered prior to completing the drilling of concrete piers. Drilled piers should be at least 12 inches in diameter to allow for placement of concrete around reinforcing steel.

b. Due to the presence of expansive mudstone bedrock, the piers should be designed and spaced so that a minimum dead load pressure of 10,000 psf is sustained based on the pier bottom end area of each pier. If the minimum dead load cannot be met and piers are spaced as far apart as practical, the drilled pier length should extend beyond the minimum penetration to make up the dead load deficit. If drilled piers are used, this can be accomplished by assuming 1,200 pounds per square foot of skin friction for the portion of the pier below the minimum penetration depth.

c. Piers should be placed as far apart as practical in order to achieve minimum dead load recommendations and a minimum of three diameters apart center to center.

d. The piers should be structurally reinforced to resist tensile forces on the piers due to negative skin friction. The tensile force may be calculated utilizing at least 6 feet of pier length with a skin friction of 1,200 psf.

e. Laterally loaded piers may be designed using a horizontal modulus of subgrade reaction of 75 pci for the portions of the piers embedded in the sand, a horizontal modulus of subgrade reaction of 90 pci for the portions of the piers embedded in the gravel, and a horizontal modulus of subgrade reaction of 1,500 pci for the portions of the piers embedded in the mudstone and conglomerate.

f. Drilled pier holes should be properly cleaned prior to placing concrete.

g. Care should be taken to assure the drilled piers are not over-sized (mushroomed) at the ground surface, which could reduce the end bearing pressure and/or provide an area where swelling soil/rock could exert uplift forces on the piers. If necessary, a sonotube should be used at the surface.

h. Concrete used in drilled piers should be a fluid mix with sufficient slump to fill in the voids between reinforcement steel and the pier hole. We recommend a slump of approximately 4 inches.

i. Concrete should be placed in the piers the same day they are drilled. If caving occurs or water enters the pier holes, it may be necessary to place concrete immediately after the pier hole is completed. Failure to place concrete the day of drilling may require re-drilling for additional bedrock penetration.

j. Concrete piers should be placed in one pour to the required elevations (bottom of the grade beams) so no construction joints are present in the pier, subsequently compromising the integrity of the pier. We recommend placing a short piece of sonotube at the top of the pier to allow the pier to be poured to the appropriate elevation above the existing ground surface.

C. Floor Systems

1. Structural Floor

Raised structural floors, supported on the grade beams, should be used in conjunction with deep foundation systems. The grade beams should be designed and reinforced to span the distance between the piers. We recommend that a minimum 24 inch crawl space be provided below structural floors. A 6-inch void space should be provided below the grade beams to allow the expansive mudstone to swell without exerting uplift forces on the grade beams. Subsequent to removing concrete forms from grade beams, the void should be inspected by AGEC to ensure the proper void space is provided.

2. Concrete Slab-on-grade

Concrete slabs may be utilized for the interior floor of the proposed structures where the expansive mudstone is greater than 15 feet below the existing grade. The concrete slabs should be supported on 1 foot of properly compacted structural fill.

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

3. Plumbing and Utility Lines

Plumbing lines and utility lines should be hung from the floor when a pier foundation system is utilized. Plumbing lines should have flexible joints where connections are made. A 6 inch void space should also be provided below plumbing where it crosses below grade beams.

4. Exterior and Garage Flatwork

The owners should be aware that exterior flatwork and garage slab will likely move where expansive mudstone or clay is present. To avoid concerns for the movement to cause distress to the residence, the flatwork should be separated from the main structure to allow for unstrained vertical movement. This generally is accomplished by providing a construction joint between the concrete flatwork and the wall/slab with a heavy felt board. This is extremely important during construction of the porch columns and door entries.

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

5. <u>Exterior Porches/Garage Walls</u>

Exterior porches, overhangs, and garage walls that are structurally tied to the remainder of the residences should be supported by the same foundation system as the remainder of the residences.

D. Subgrade Walls

The following equivalent fluid weights are given for design of possible subgrade and earth retaining walls. The active condition is where the wall moves away from the soil and the passive is where the wall moves into the soil. The at-rest condition is where the wall does not move.

Condition	Equivalent Fluid Weight On-site Granular Soil (pcf)	Equivalent Fluid Weight On-site Fine-grained Soil/Processed Mudstone (pcf)
Active	40	50
Passive	350	200
At Rest	60	70

The equivalent fluid weights given in the table above should be increased by 15 pcf for the active and at-rest conditions and reduced by 15 pcf for the passive condition for seismic design. The seismic increases and decrease are based on a horizontal ground acceleration of 0.25g which represents a 2 percent probability of exceedance in a 50 year period.

It should be recognized that the above values account for the lateral earth pressures due to the soil and level backfill conditions and do not account for hydrostatic pressures. Lateral loading should be increased to account for surcharge loading if structures are placed above the wall and are within a horizontal distance equal to the height of the wall.

Care should be taken to prevent percolation of surface water into the backfill material adjacent to the walls. The risk of hydrostatic buildup can be reduced by placing subdrains behind the walls consisting of free-draining gravel wrapped in a filter fabric. In addition, weep holes may be provided every 10 feet at the base of the wall to assist in drainage of water.

E. Soil Corrosion

Based on laboratory test results and our experience in the area, there is a relatively high concentration of water soluble sulfates in the native soil and bedrock which present a "severe" sulfate attack potential for concrete exposed to these materials. Therefore, we recommend that concrete that will be in contact with the on-site soil and bedrock contain Type V sulphate-resistant cement and be designed in accordance with the provisions provided in American Concrete Institute Manual of Concrete Practice (ACI) 318 Section 4.3 and the 2006 International Building Code. Table 4.3.1 of ACI 318 should be referenced utilizing a sulfate exposure category of "severe". Consideration should be given to cathodic protection of buried metal pipes or the use of PVC pipe when permitted by local building codes.

F. Seismicity and Liquefaction

Buildings should be designed and constructed in accordance with "Site Class C" requirements according to the 2003 International Building Code. Liquefiable soils were not observed in the borings or test pits.

G. Pavement

1. Subgrade Support

We anticipate that the subgrade materials at the site will consist of a combination of silty sand to silty gravel with sand to mudstone 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 of 10 percent was assumed for a sand subgrade and for a low permeable fill subgrade (in expansive mudstone areas) for purposes of design. If expansive mudstone bedrock is encountered within 3 feet of the finished subgrade elevation it should be removed to a depth of 3 feet below the finished subgrade and replaced with low permeable fill as recommended in the Subgrade Preparation of section of this report.

2. Pavement Thickness

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

Roadway	Asphalt (in.)	Base Course (in.)
Private Road	2½	6
Access Road	3	8
Riverside Drive	3½	12

Although the recommended pavement sections are based on a 20 year design life, it is likely that the life span of the pavement will be shorter and additional maintenance will be required due to the presence of relatively shallow expansive mudstone bedrock. The relatively shallow mudstone is generally located on the northern and eastern edges of the site.

3. Pavement Materials

The pavement materials should meet St. George 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 Marshal 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.

Due to the moisture sensitivity of the on-site mudstone, it is critical that infiltration of water be minimized to reduce the potential for future movement of pavement utilities. Maintaining natural soil moisture conditions of the moisture sensitive bedrock reduces potential for expansion of underlying bedrock and subsequent heave. To reduce infiltration, we recommend the following:

a. Maintain positive site drainage during and following construction. Ponding of water should be minimized.

b. Surface drainage of streets should be maintained by providing sufficient crown/grade in the road and into the curb in gutter. Positive flow of the gutters should be provided and maintained.

c. Seams and joints in the asphalt and concrete should be properly sealed to reduce infiltration of water to the underlying expansive bedrock.

d. Maintenance should be provided to maintain asphalt cracks which may occur over time.

H. Design Review/Construction Observation

Design review and construction observations are recommended to verify the recommendations in this report are properly implemented and followed. We recommend conducting construction materials testing on city improvements at a frequency which meets or exceeds St. George City specifications.

In order to provide a foundation compliance reports as required by St. George City, we recommend the following be done as a minimum:

1. Pier Foundation Option

   a. Review the foundation plan along with calculated loads per pier by the structural engineer.

   b. Observe on a part time basis the drilling of the piers.

   c. Observe the reinforcing steel in the grade beams and drilled piers.

   d. Verify the proper void space is provided below the grade beams.

2. Building Pad Overexcavation/Conventional Spread Footings

   a. Observe the removal of expansive mudstone from building pads which are overexcavated.

   b. Verify that the mudstone is removed to the proper depth. We recommend that the extent and depth of the removal be surveyed.

   c. Conduct compaction testing on fill placed within the building pads. We recommend a minimum testing frequency of every two vertical feet of fill placed.

   d. Conduct compaction testing on the footing subgrade prior to placement of concrete.

The above observations will be conducted by qualified individuals and according to standard test methods (ASTM).

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/test pits drilled/excavated, laboratory test results, information from the referenced geotechnical investigation, and our experience in the area. Variations in the subsurface conditions may not become evident until additional exploration or excavation is conducted. If the subsurface soil or groundwater conditions are found to be different from what is described in this report, we should be notified to reevaluate the recommendations given.

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

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

Shawn Turpin, P.E.

Reviewed by: Arnold DeCastro, P.E.

LICENSED PROFESSIONAL ENGINEER
3-2-07
NO. 301324
SHAWN L.
TURPIN
STATE OF UTAH

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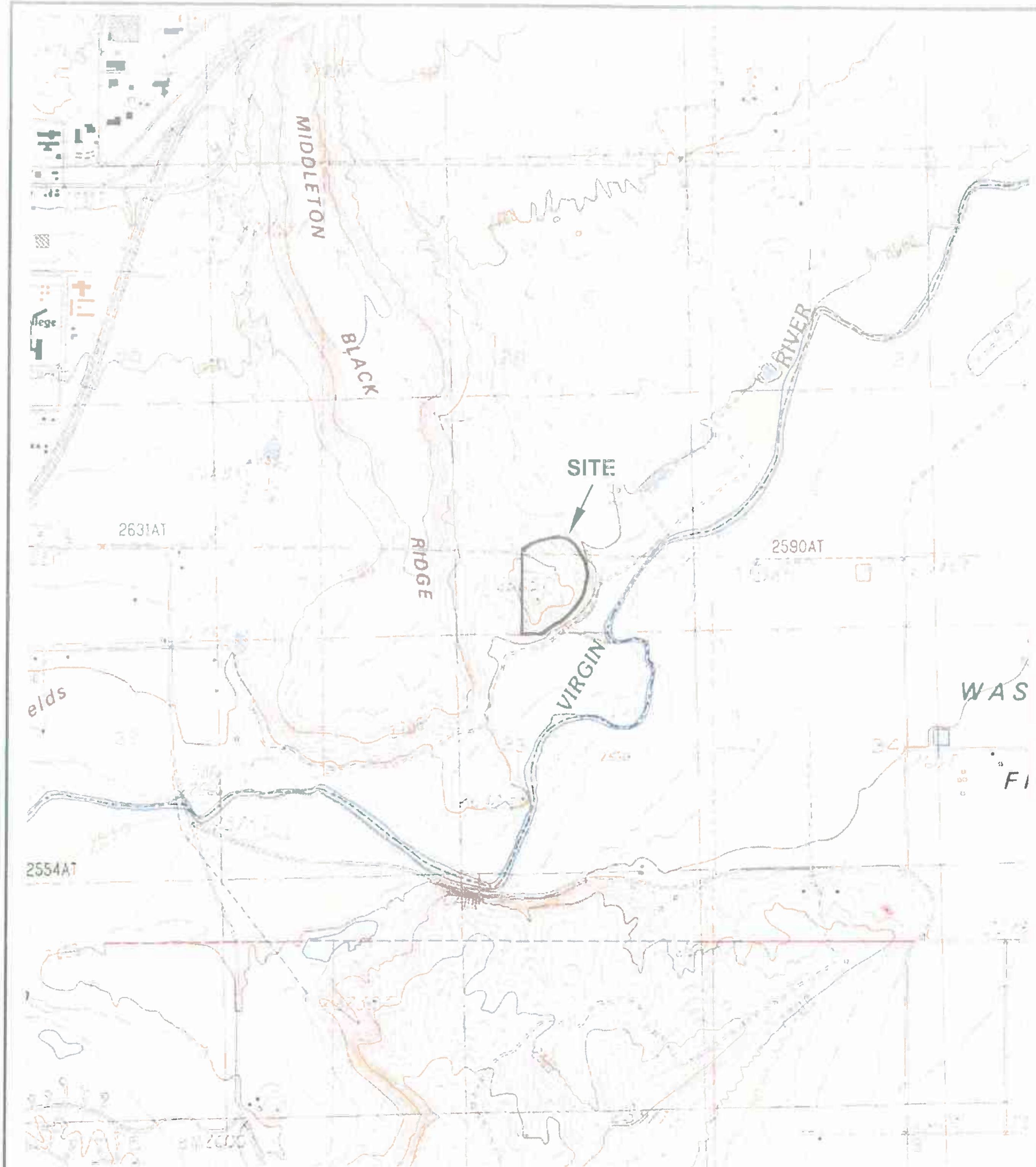


St. George Quadrangle, 1986

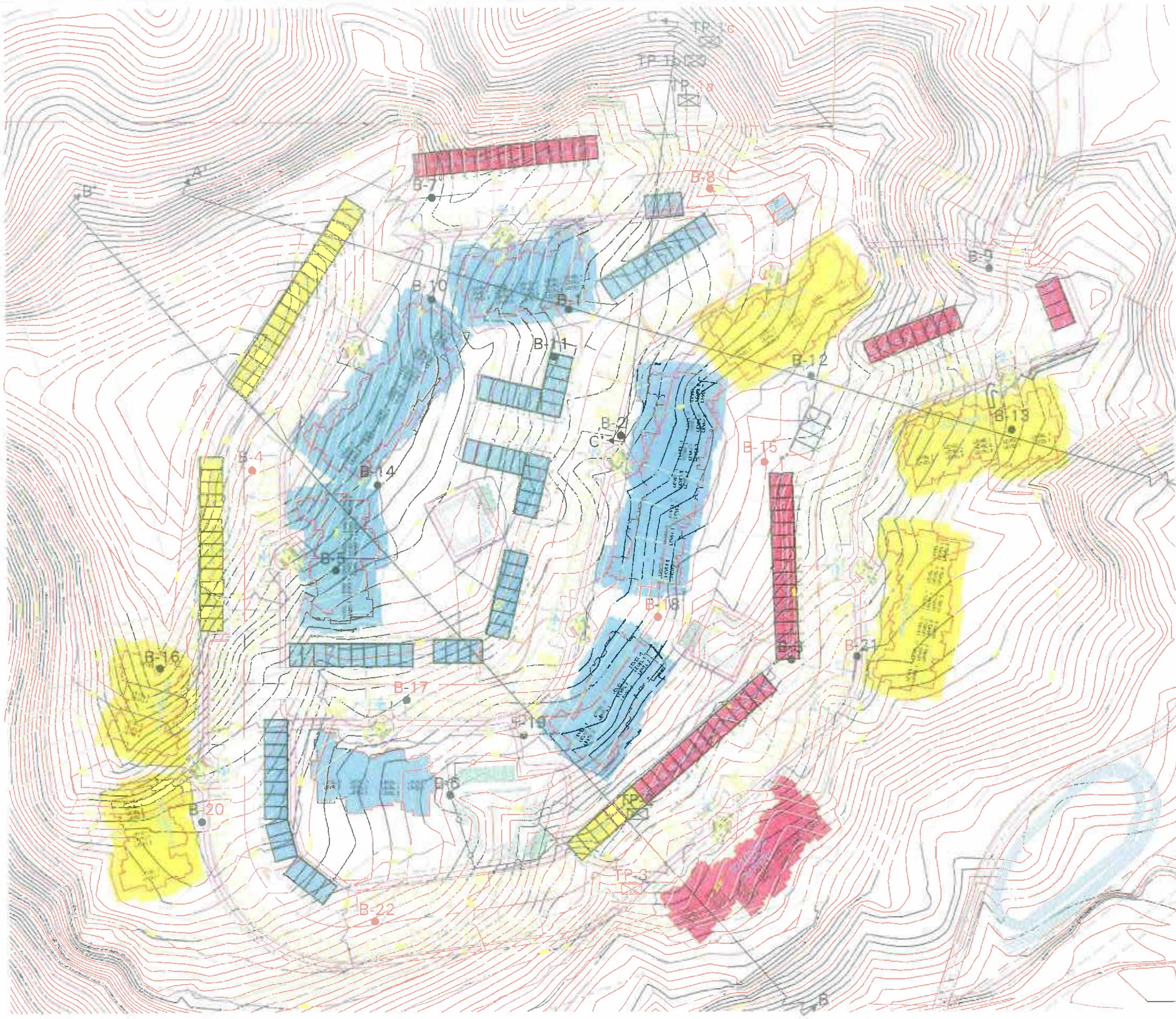
NETTAS KNOLL
ST. GEORGE, UTAH

N

Scale 1:24,000

2072743	AGEC	Vicinity Map	Figure 1

NETTAS KNOLLS
ST. GEORGE, UTAH



- Approximate test pit location
- Approximate boring location
- Conventional spread footings/slab-on-grade floors
- Additional investigation required
- Deep (pier) foundation or conventional spread footings with slab-on-grade floors with overexcavation and replacement
- Cross section location

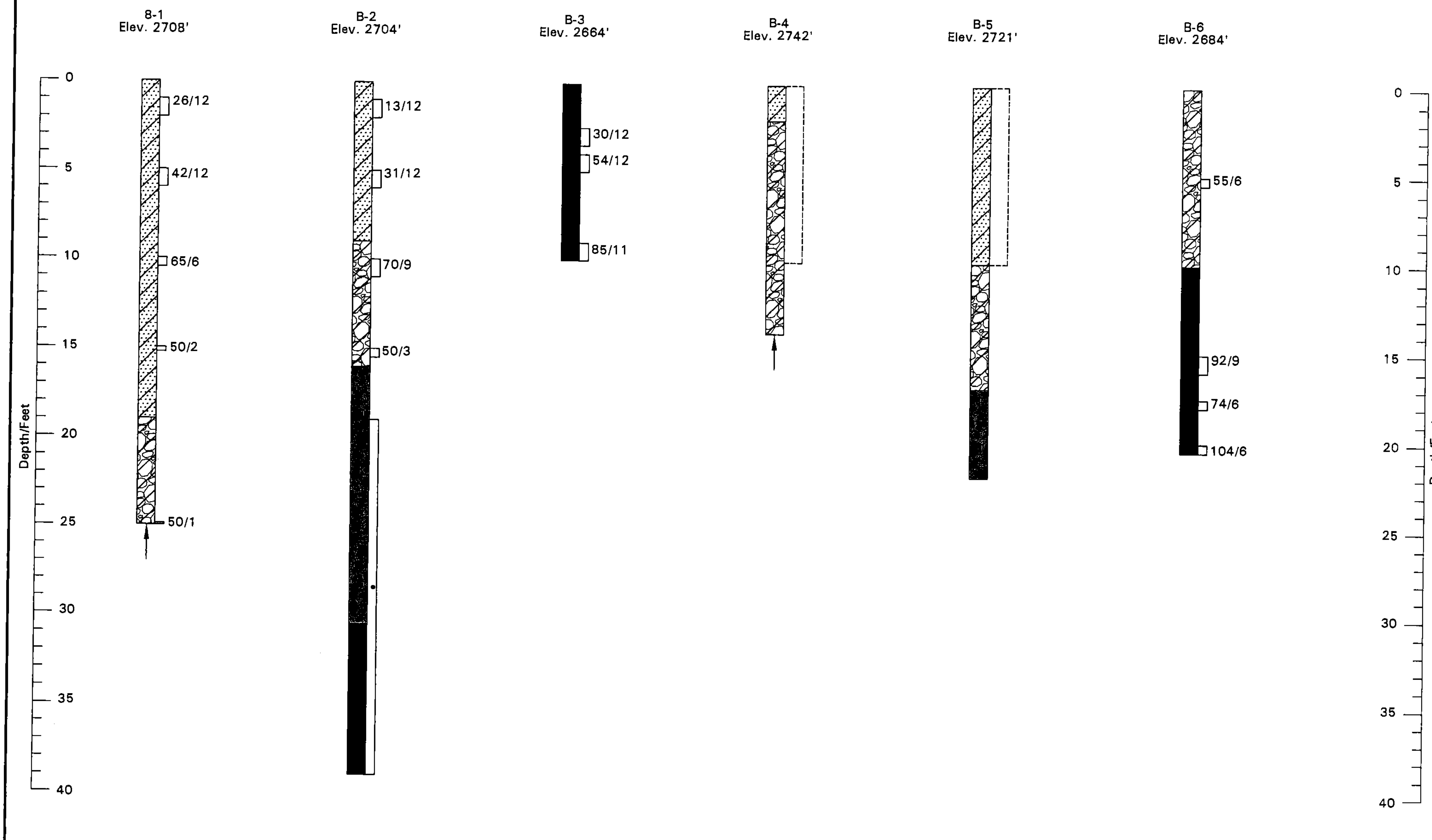
Note: Foundation recommendations are based on grading plan provided by LR Pope, dated January, 2007.

N

0 100 200 feet

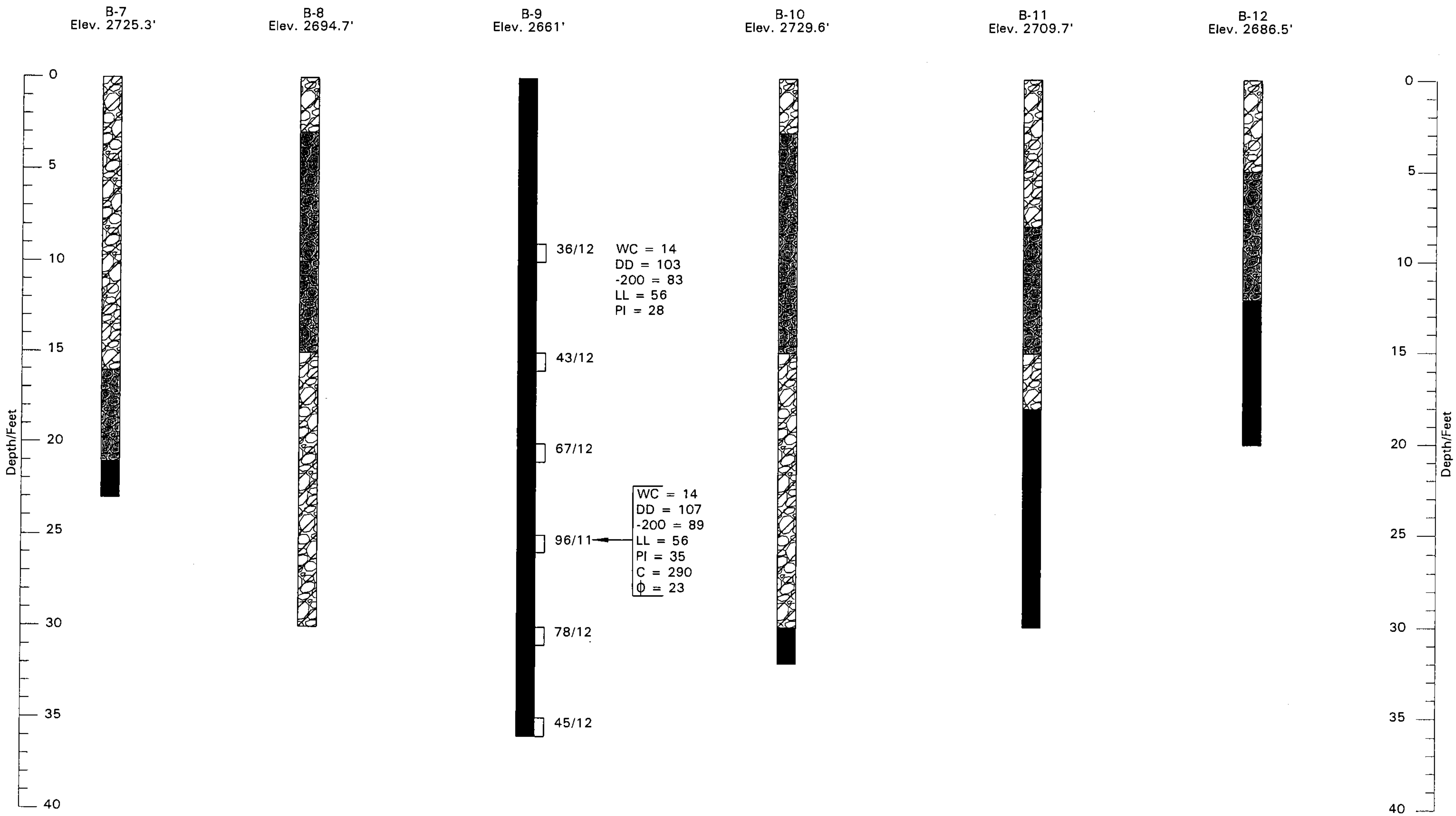
Approximate Scale

2062743	AGEC	Site Plan	Figure 2



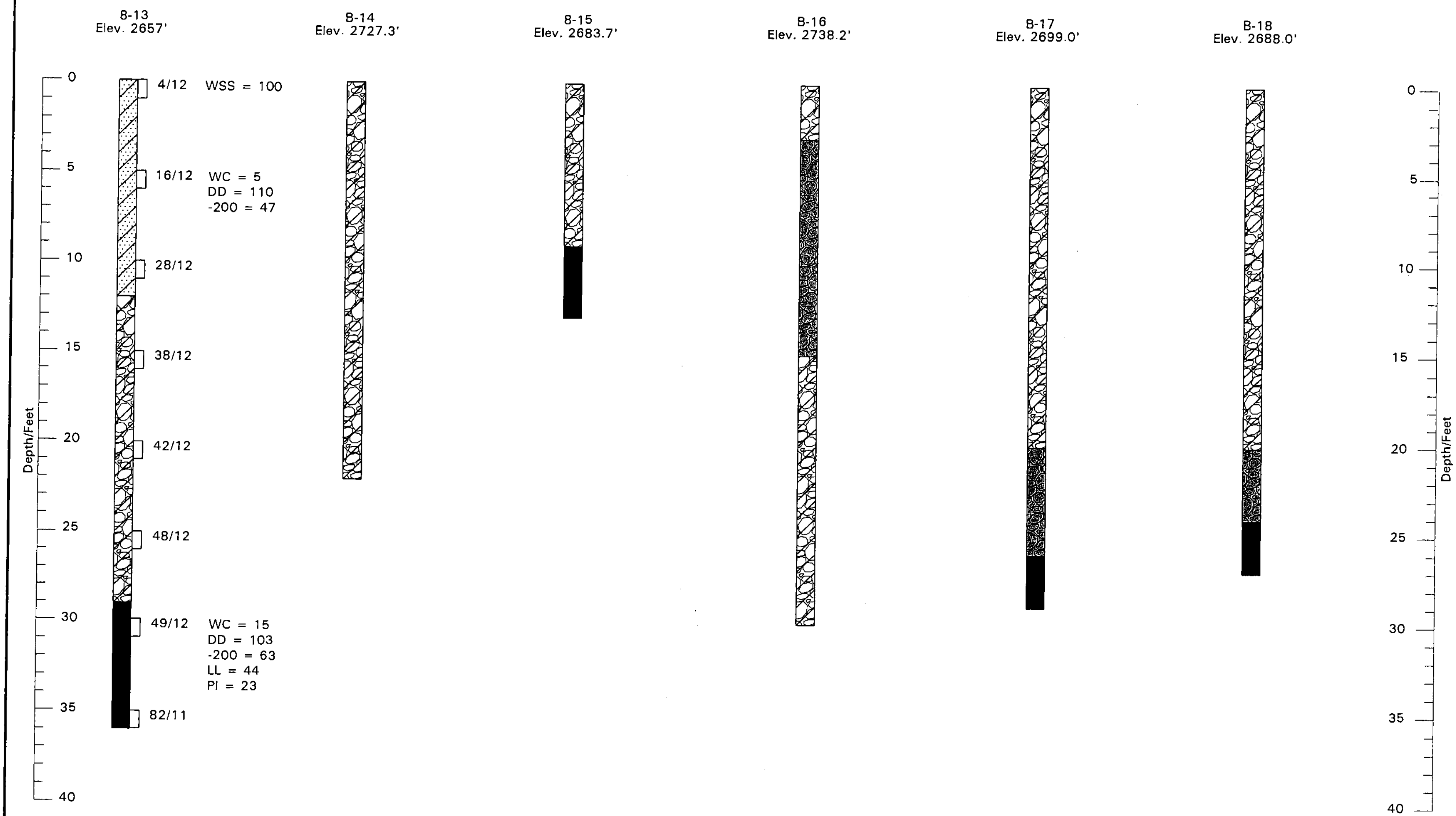
See Figure 8 for Legend and Notes

2062743	AGEC	Logs of Exploratory Borings	Figure 3



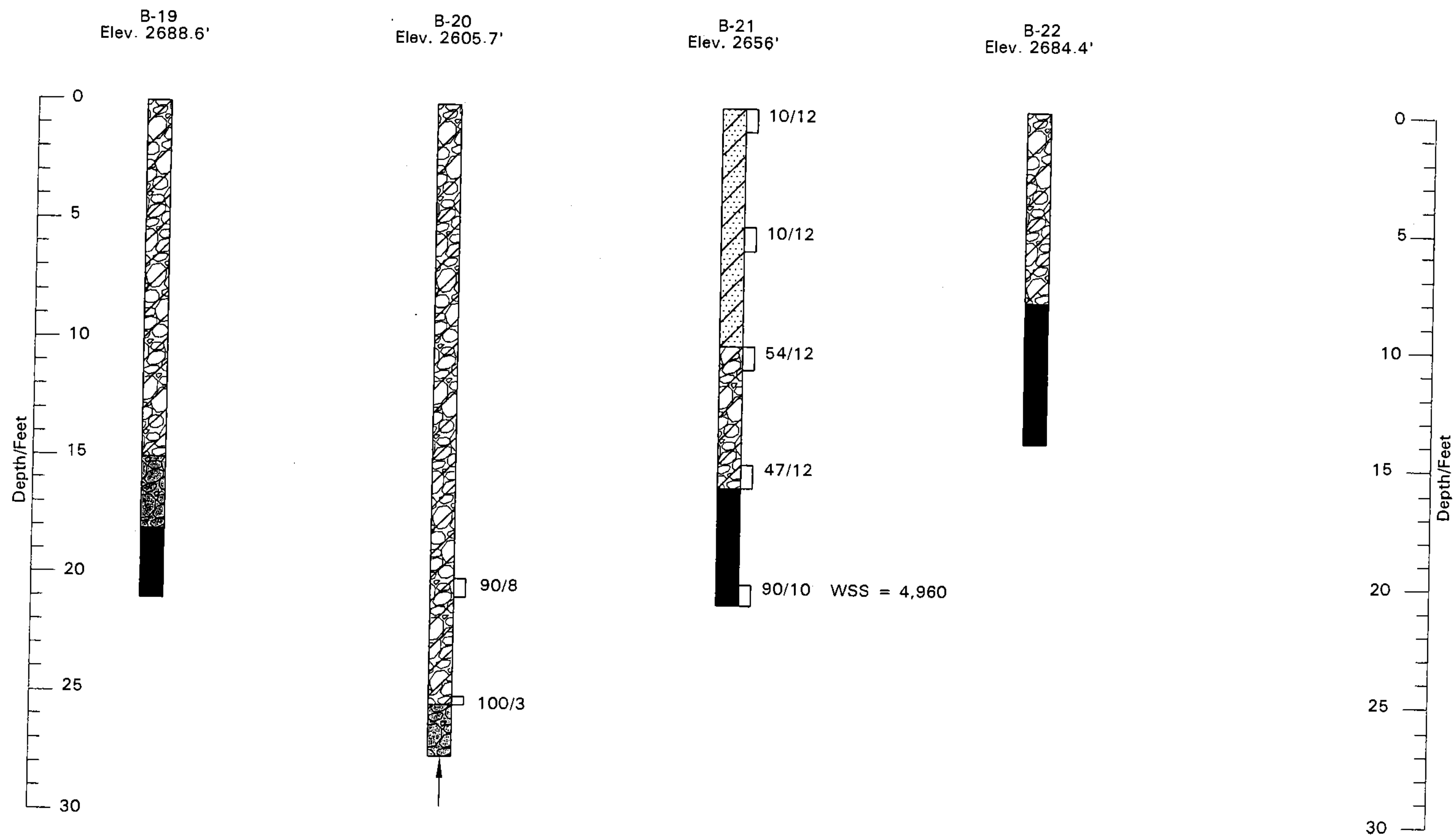
See Figure 8 for Legend and Notes

2062743	Logs of Exploratory Borings	Figure 4



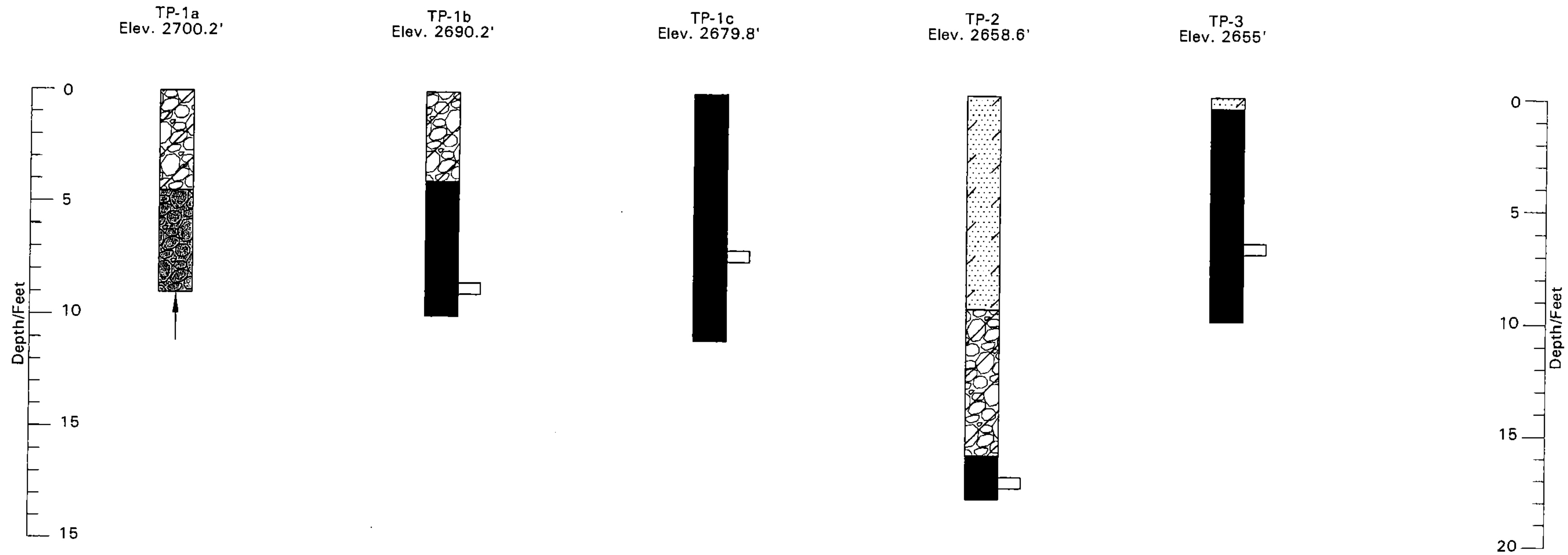
See Figure 8 for Legend and Notes

2062743 | AGEC | Logs of Exploratory Borings | Figure 5



See Figure 8 for Legend and Notes

2062743	AGEC	Logs of Exploratory Borings	Figure 6



2062743 | Logs of Test Pits | Figure 7

LEGEND:

Clayey sand with gravel (SC); cobbles, medium dense to dense, dry to slightly moist, fine-grained, low plastic, light brown.

Silty sand (SM); varied amounts of gravel, occasional cobbles and boulders, loose to dense, dry, fine to medium-grained, brown.

Silty gravel with sand (GM); occasional cobbles and boulders, medium dense to very dense, dry, fine to coarse-grained, sub-angular to angular, brown.

Conglomerate; very hard, dry, gray to brown.

Mudstone bedrock; weathered to moderately hard, slightly moist, high plastic, slightly gypsiferous, purple to gray to red.

Indicates relatively undisturbed block sample taken.

10/12 California Drive sample taken. The symbol 10/12 indicates that 10 blows from a 140 pound hammer falling 30 inches were required to drive the sampler 12 inches.

Indicates core sample taken.

Indicates practical tri-cone or trackhoe refusal on conglomerate or cemented gravel.

NOTES:

1. Borings B-1 through B-6 were drilled on September 8 and 24 and October 14, 2003 (AGEC project number 2030907) with a truck mounted drill rig equipped with 5-inch solid flight augers, 7-inch hollow stem augers and a 2-inch NX core barrel. The other borings were drilled on December 20 and 21, 2006 and January 15, 2007 with a track-mounted blasting rig and a truck mounted drill rig equipped with 7-inch hollow stem augers and a 3-inch tri-cone. The test pits were excavated on January 23, 2007 with a trackhoe.
2. The locations of the borings were surveyed by the civil engineer. The locations of the test pits were determined with a global positioning system (GPS).
3. The elevations of the borings and test pits were determined with a global positioning system (GPS) based on U.S. State Plane 1983 Utah South 4303 .
4. The boring and 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 boring and test pits logs represent the approximate boundaries between material types and the transitions may be gradual.
6. No free water was encountered in the borings or test pits at the time of drilling/excavation.
7. WC = Water Content (%);
DD = Dry Density (pcf);
-200 = Percent Passing No. 200 Sieve;
LL = Liquid Limit (%);
PI = Plasticity Index (%);
C = Cohesion (psf);
ϕ = Friction Angle (deg.);
WSS = Water Soluble Sulfates (ppm).

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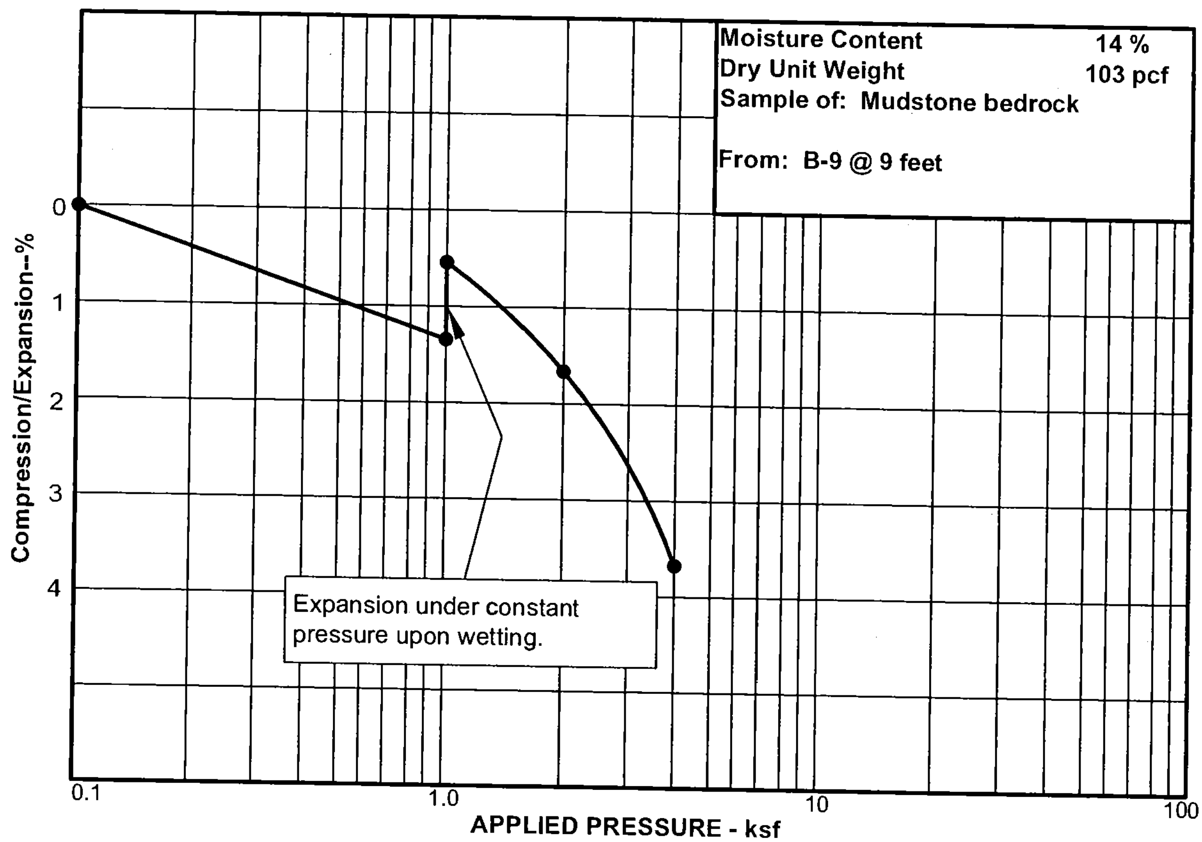

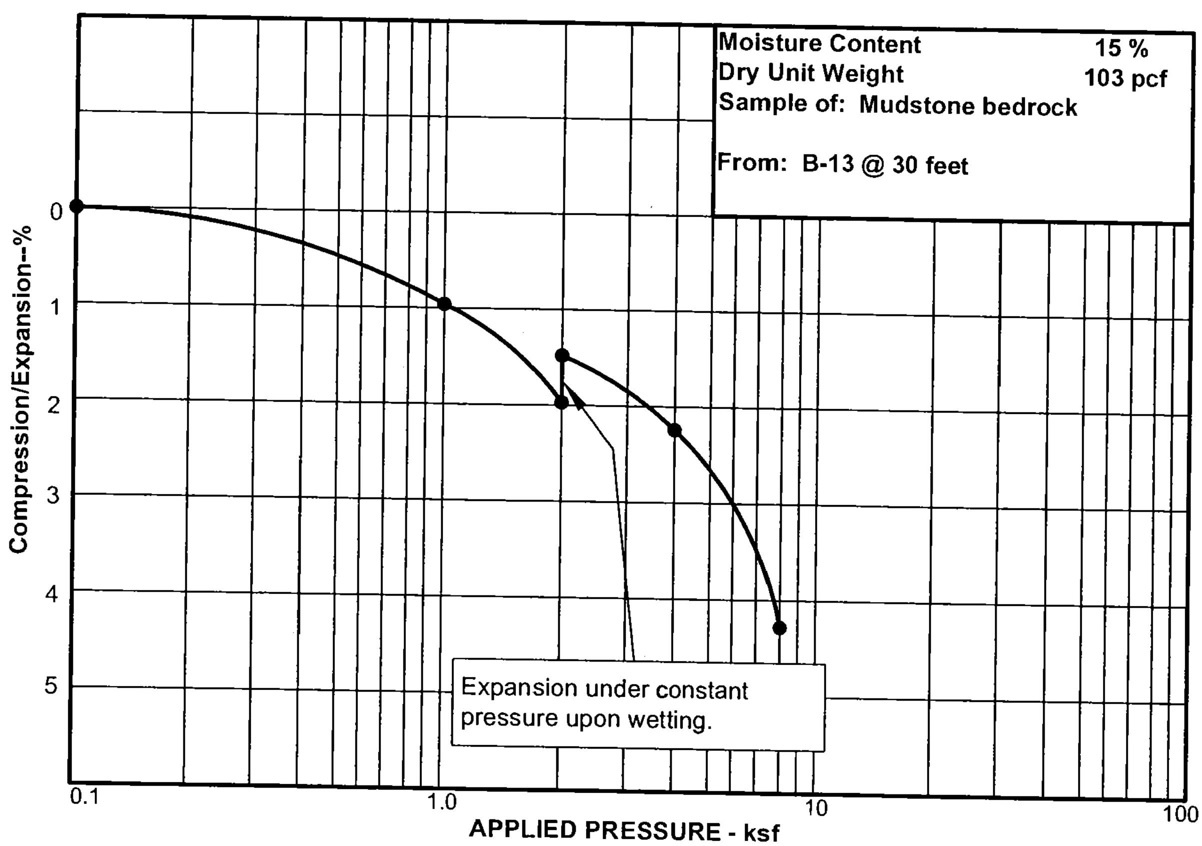

Project No. 2062743 CONSOLIDATION TEST RESULTS Figure 9

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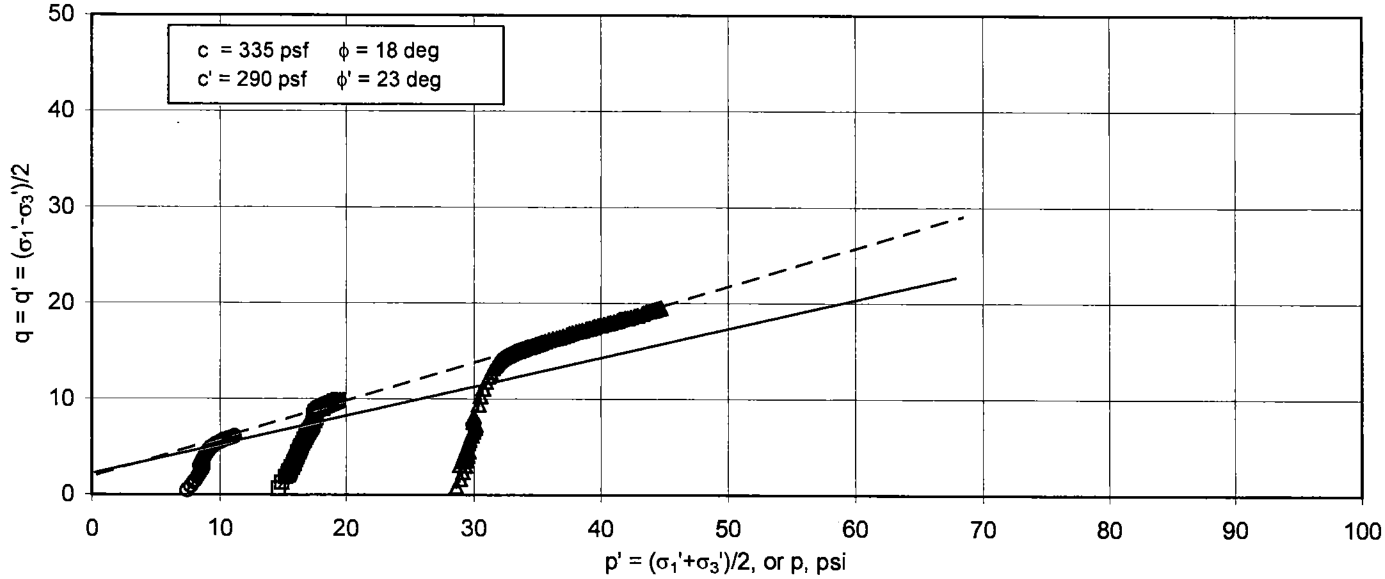
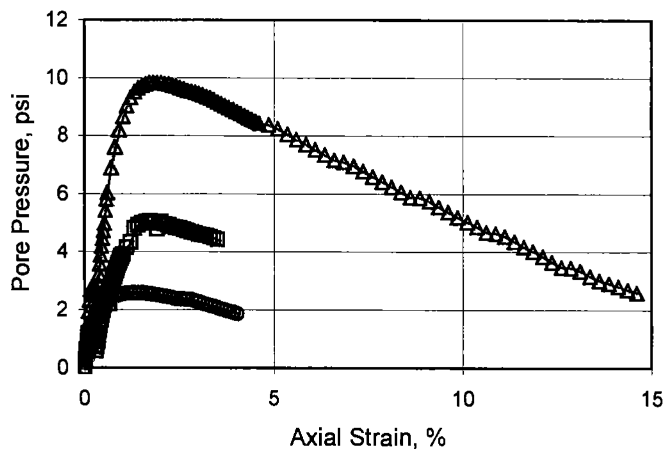
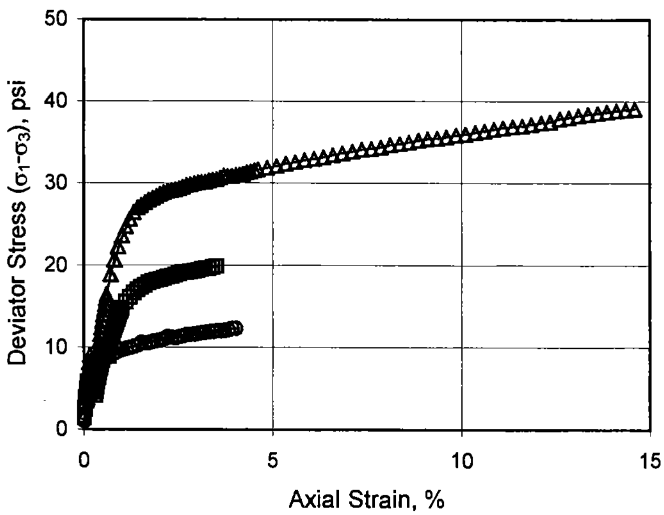






Test No. (Symbol)	O	□	Δ
Sample Type	undisturbed		
Length, in.	3.39	3.26	3.13
Diameter, in.	1.92	1.79	1.66
Dry Density, pcf	107	N/A	N/A
Moisture Content, %	14	N/A	N/A
Consolidation Pressure, psi	6.9	13.9	27.8
"B" Parameter	0.95	0.95	0.95
Total Confining Stress (σ_3), psi	6.9	13.9	27.8
Total Axial Stress (σ_1), psi	18.6	33.3	57.9
Deviator Stress (σ_1-σ_3), psi	11.7	19.4	30.1
Effective Lateral Stress (σ_3'), psi	4.6	9.3	18.3
Effective Axial Stress (σ_1'), psi	16.3	28.7	48.4
Pore Pressure (μ), psi	2.3	4.6	9.5
Strain, %	3.0	3.0	3.0
Remarks	Multistage Test (CU) Consolidated		
Undrained with pore pressure measurements.			
Sample saturated with back pressure saturation.			

Sample Index Properties	
Natural Dry Density, pcf	107
Natural Moisture Content, %	14
Liquid Limit, %	56
Plasticity Index, %	35
Percent Gravel	0
Percent Sand	11
Percent Passing No. 200 Sieve	89

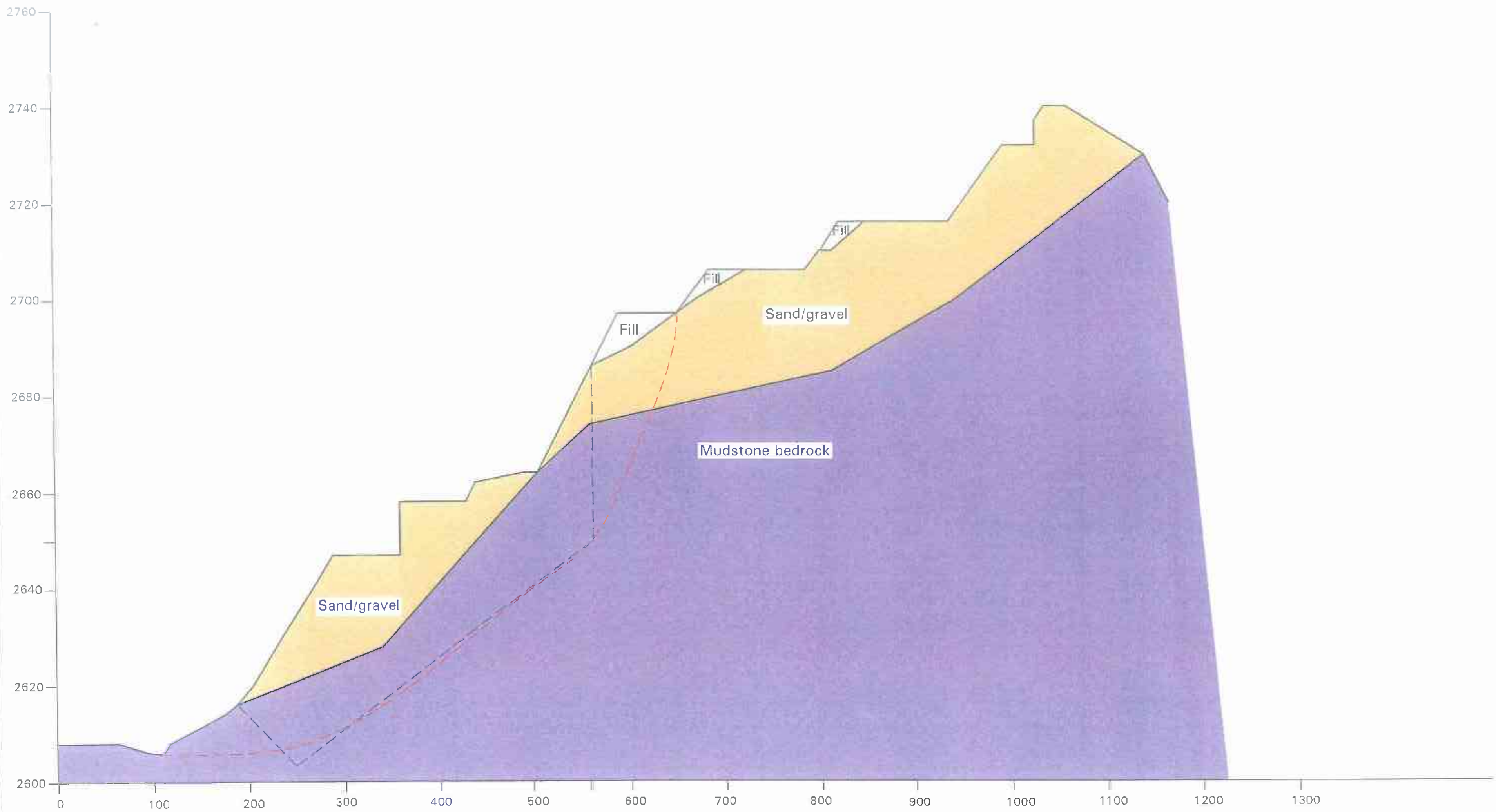
Sample Description Mudstone bedrock

Sample Location B-9 @ 25'

Project No. 2062743

Triaxial Compresion Test

Figure 10



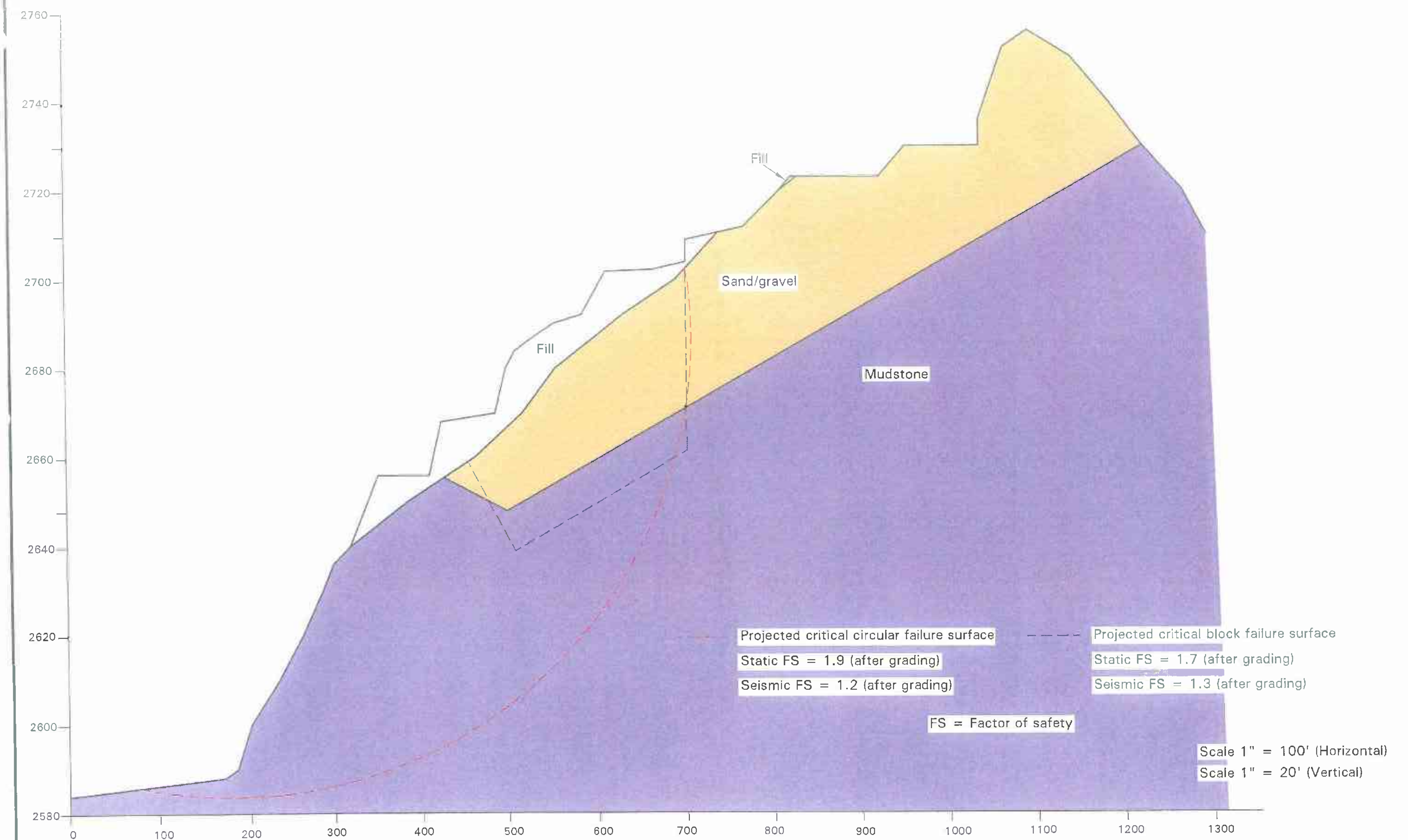
Projected critical circular failure surface
Static FS = 1.7 (after grading)
Seismic FS = 1.3 (after grading)

Projected critical block failure surface
Static FS = 1.7 (after grading)
Seismic FS = 1.3 (after grading)

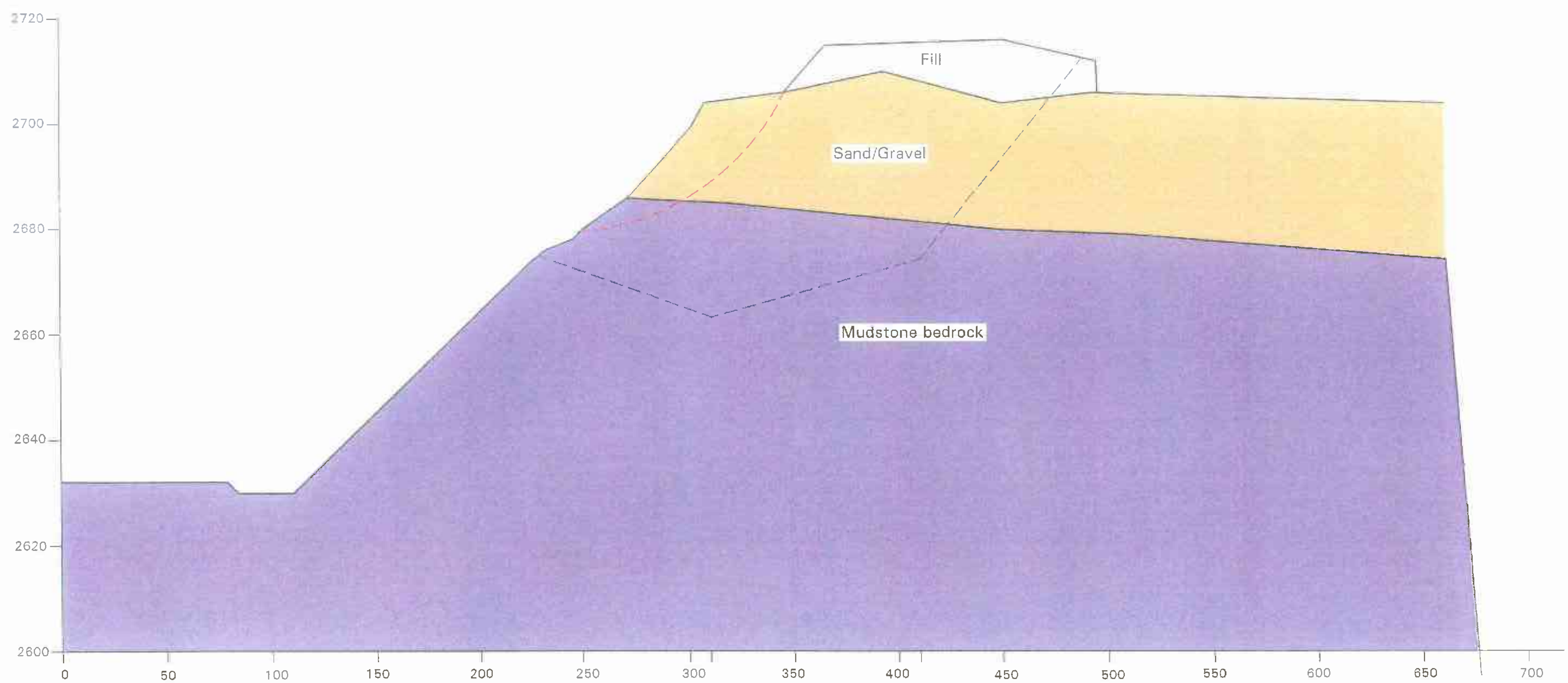
FS = Factor of safety

Scale 1" = 100' (Horizontal)
Scale 1" = 20' (Vertical)

2062743	AGEC	Cross-Section A-A'	Figure 11



2062743 | AGEC | Cross-Section B-B' | Figure 12



Projected critical circular failure surface
Static FS = 1.5 (after grading)
Seismic FS = 1.3 (after grading)

Projected critical block failure surface
Static FS = 2.9 (after grading)
Seismic FS = 2.0 (after grading)

FS = Factor of safety

Scale 1" = 50' (Horizontal)
Scale 1" = 20' (Vertical)

2062743	AGEC	Cross-Section C-C'	Figure 13

Applied Geotechnical Engineering Consultants, Inc.

Table 1 - Summary of Laboratory Test Results

NETTAS KNOLL

Project No. 2062743

Sample Location				Gradation			Atterberg Limits		Triaxial Shear			
Boring No.	Depth (ft)	Natural Moisture Content (%)	Natural Dry Density (pcf)	Gravel (%)	Sand (%)	Silt/Clay (%)	Liquid Limit (%)	Plastic Index (%)	Cohesion (psf)	Friction Angle (deg.)	Water Soluble Sulfates (ppm)	Soil Type
B-9	9	14	103			83	56	28				Mudstone bedrock
B-9	25	14	107			89	56	35	290	23		Mudstone bedrock
B-13	0										100	Silty sand (SM)
B-13	5	5	110			47						Silty sand (SM)
B-13	30	15	103			63	44	23				Mudstone bedrock
B-21	20										4,960	Mudstone bedrock

HILLSIDE REVIEW BOARD
CITY OF ST GEORGE
WASHINGTON COUNTY, UTAH
APRIL 21, 2021

PRESENT:
James Sullivan
James Dotson
Dave Black
Shawn Patten

CITY STAFF:
Assistant Public Works Director Wes Jenkins
Planner III Mike Hadley
Development Services Office Supervisor Brenda Hatch

APPLICANT:
Brandee Walker
Raine Christensen

The agenda for the meetings are as follows:

1. Consider a request for a Hillside Development Permit to allow development of the subject property into townhomes. The applicant is asking for approval of a hillside permit in order to cut into 20-40% slopes. The property is located on the east side of Valley View Drive and just south of Sunset Dr. The property is currently zoned R-1-10 (Residential minimum lots size 10,000 sq ft) & A-P (Administrative Professional). The owner is Raine Christensen. Case No. 2021-HS-003. (*See 'Meeting Place' exhibit below*).

Brandee Walker – They will be coming in for a PD Zone change. We want to put a public street with a cul-de-sac right up the center of it and then 10 townhomes around it. The units he wants to build are 2 stories. We are trying to match ground as possible.

Raine Christensen – We would like to donate the undevelopable hillside to the City. For now, we are just looking at using this piece and then there is a high chance we will donate the rest.

Brandee Walker – We are not disturbing past the old road that led to the water tower. We have a red line there. We have been talking with Landmark about mitigating the 2:1 to try and steepen it up a little bit, I think that is doable.

Wes Jenkins – So is the red line your disturbance area right there?

Brandee Walker – Yes.
James Sullivan – It looks like you are disturbing some 40%.

Brandee Walker – It's a little choppy, you can see in the slope map that we've got the little speckles the deep dark green are the 40 or greater. The little speckles are actually in the 30-39 category.

Wes Jenkins – So I noticed you exceeded the 30% and the 5%, can you explain that?

Brandee Walker – The 20%

Wes Jenkins – Yes, the 20 – 29 you are only allowed to disturb 30% of it and you guys are above that.

Brandee Walker – Some of this stuff down in here are the benching areas for the grading.

Raine Christensen – We tried to do something other than a cul-de-sac to stay in it, but the City did not want to see that.

Brandee Walker – We tried a hammer head and we tried doing private roads, but fire wanted it to be a standard street with turn around. You can see we are not pushing any units into the hillside; it's really just getting that road in there to turn around.

Wes – The 30 – 39 is 5% and you show 9.9, the hillside would have to make a recommendation that they were man made, or it's not contiguous to the hillside.

Brandee Walker – I'm counting the garden in my numbers, does that count if it's open space/gardening?

Dave Black – If it is cut, then it is.

Brandee Walker – It's really not cut, it's the natural soil as it is today.

Raine Christensen – There is a road right there from a previous owner.

James Sullivan – Are these green spots caused by the old road? Is that included in the numbers?

Brandee Walker – I'm not sure.

Dave Black – Brandee mentioned that they have been talking to Landmark and they want to steepen up that 2:1 slope, which I would definitely support, I think it could go steeper. That would reduce the extent of the cut up the hill dramatically. I wish they would have done it before so we could see. My thought was as if their disturbance could come down more like this (drew his own line on the paper) look at all the steeper stuff we could avoid and by steepening up that back cut, if that was the limit of the disturbance then I think that is a great improvement.

Brandee Walker – I agree with you, in fact I got looking at this and his contours are just a smidge tighter than what is on the ground so if we could steepen up just a little bit we would catch probably about where you have drawn it.

James Dotson – Is that cut pretty much solid rock?

Brandee Walker – Yes

James Dotson – What do you finish that off with?

Raine Christensen – Seeding for this area.

Brandee Walker – That's how we handled the one over there.

Dave Black – If it's bedrock, and if you go steeper than 2:1, you won't get anything back. So, you basically will need rock faced slopes or big block faced slopes, something to help minimize the back. I think on this site the amount of the disturbance is the issue for the hillside board and I think it can be minimized and reduced by steepening up that. I think that would be a lot easier for us to recommend approval if you went further down the hill. And the other issue they addressed in the Landmark report was a moderate rock fall concern here and they had some guidelines, I'm not sure if that is implemented in your design, but Landmark's recommendations for rock fall need to be implemented as well.

Brandee Walker – We can update the grading to show the steepen of the cut.

Dave Black – A 1:1 may bring right in where you need it. If you leave the 1:1 exposed then you have the raveling issues and stuff like that. They have put up either rock or block in the other areas along this street to help mitigate the cuts.

Discussion continued on unraveling and how to mitigate that.

Dave Black – So without seeing the final plans, can we recommend it for approval, or does it need to come back? Do you review it? We don't really know how it will end up.

Wes Jenkins – Would you like us to send it out to you once it comes in?

Dave Black – Yes, we would like to see what the extent of it is, I don't think we need to come out here again.

James Sullivan – If these lines are drawn at 2:1 and it decreases to 1:1 then it decreases that distance by half, won't it?

Brandee Walker – It will be better than that.

Shawn Patten – I think that we have talked about it but how will it be finished off?

Dave Black – Have you seen a drainage report?

Brandee Walker – Yes, it's in the packet.

Wes Jenkins – Are you comfortable with the rock facing? This is a prominent hillside; we would want it to match.

Dave Black – It blends in better than red. The red comes up because we create the scar, but the natural hillside itself is not red.

Brandee Walker – Raine is proposing 2-story buildings as well, because of the height, you shouldn't see much of that.

James Sullivan – If it's reduced to a 1:1 I don't see us putting a rock face on it, can you put a rock face on a 1:1?

MOTION: Dave Black made a motion to recommend for approval a Hillside Development Permit for Desert Garden Cove with the following conditions: 1. The back-cut slope be steepened as much as feasible to minimize disturbance 2. The rockfall guidelines issued in the Landmark Geotech report be implemented into the design component 3. The City Council review the finished product as far as the facing of the cut slope and the wall to their satisfaction.
SECOMD: Shawn Patten
AYES (4)
James Sullivan
James Dotson
David Black
Shawn Patten
NAYS (0)
Motion carries.

2. Consider approval of the meeting minutes from January 27, 2021 and February 17, 2021.

MOTION: James Dotson made a motion to approve the minutes from the January 27, 2021 and the February 17, 2021 meetings.
SECOND: Dave Black
AYES (4)
James Sullivan
James Dotson
David Black
Shawn Patten
NAYS (0)
Motion carries.

James Dotson made a motion to adjourn.