AGEC

Applied GeoTech

GEOTECHNICAL INVESTIGATION

PROPOSED EVANS AND MATHIAS CANYON

DEBRIS BASIN SITES

PERRY, UTAH

PREPARED FOR:

JONES AND ASSOCIATES
1716 EAST 5600 SOUTH
SOUTH OGDEN, UTAH 84403

ATTENTION: MATTHEW ROBERTSON

PROJECT NO. 1150963

MARCH 18, 2016

600 West Sandy Parkway • Sandy, Utah 84070 • (801) 566-6399 • FAX (801) 566-6493

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EXECUTIVE SUMMARY

1. The subsurface materials encountered at the Mathias Canyon site consist of approximately 1 to 1½ feet of topsoil overlying gravel in Test Pits TP-1, TP-2 and TP-3 underlain by bedrock at a depth of approximately 13 feet. Approximately 1½ feet of topsoil overlying silty sand was encountered in Test Pit TP-5 and is underlain by gravel at a depth of approximately 6 feet. The gravel extends the full depth of Test Pit TP-5, approximately 17 feet.

   The subsurface soil encountered at the Evans Canyon west site consists of approximately 2 and 1 foot of fill in Test Pits TP-6 and TP-7, respectively, and approximately 1 foot of topsoil in Test Pit TP-8 overlying sand and gravel, which extends the full depth investigated, approximately 22 feet.

   The subsurface soil encountered at the Evans Canyon east site consists of approximately 1 and 1½ feet of topsoil overlying gravel in Test Pits TP-9 and TP-10, respectively. The gravel extends the full depth investigated, approximately 23 feet.

2. Subsurface water was perched on the bedrock in Test Pits TP-1 and TP-2 at a depth of approximately 13 feet. Water was encountered in Test Pit TP-5 at a depth of approximately 11 feet. Subsurface water was encountered at the Evans Canyon west site in Test Pit TP-6 at a depth of approximately 7 feet. No subsurface water was encountered in the other test pits excavated at the three sites.

   Fluctuations in the water level are expected over time. An evaluation of such water level fluctuations is beyond the scope of this report.

3. The debris basin embankments may be constructed of the natural sand and gravel excavated from the basin sites. Embankments may be constructed with side slopes of 2 horizontal to 1 vertical or flatter. The embankment should have a crest width of at least 15 feet. A toe drain should be installed if there is a potential for the outlet to become plugged.

4. The Wasatch fault is mapped to extend through the area. Review of aerial photographs, Lidar data and geologic literature finds no evidence that fault surface traces extend through the proposed dam sites but the fault traces extend close to the proposed dam sites and fault surface traces would project near or through the Mathias and Evans Canyon west sites. Consideration should be given to performing a fault study if fault rupture is considered a potential concern for the proposed construction. Due to the long return period of surface fault rupture at the sites and assuming that the embankments are not planned to impound water, this hazard may not be of significance for the proposed construction.

Executive Summary (continued)

5. A seismic stability analysis indicates that the long-term seismic stability for the operating basis earthquake is greater than 1 for the proposed dams. We estimate deformation will be on the order of 30 inches or less for the maximum credible earthquake condition. We have assumed that the basins will not impound water except during debris flow events.

6. Geotechnical information related to embankment construction, subgrade preparation, compaction and materials is included in the report.

SCOPE

This report presents the results of a geotechnical investigation for the proposed debris basin sites at Mathias and Evans Canyons to be constructed on the east side of Perry, Utah at the approximate locations indicated on Figure 1. The report presents the subsurface conditions encountered, laboratory test results, engineering analysis and recommendations for construction of the proposed debris basins. The study was conducted in general accordance with our proposal dated November 6, 2015 with some modifications to the number of test pits excavated at each site due to access constraints.

Field exploration was conducted to obtain information of the subsurface conditions. Samples obtained during the field investigation were tested in the laboratory to determine physical and engineering characteristics of the subsurface soil. Results of the field exploration and laboratory tests were used to define conditions at the three sites for our engineering analysis and to develop recommendations for the proposed embankments for the debris basins.

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

At the time of our field study, the Mathias Canyon and Evans Canyon east sites consisted of drainage areas just east of the Questar Gas line. These sites consist of channels cut into the Lake Bonneville shoreline deposits. The Evans Canyon west site is currently a basin with an embankment planned to be enlarged. The basin site is also located in a drainage.

The Mathias Canyon and Evans Canyon east sites are heavily vegetated with grass, shrubs and trees. There is some grass, shrubs and trees at the Evans Canyon west site.

The topography of each site generally consists of a channel sloping down to the west with moderate to steep side slopes on the north and south. The general topography of the sites is presented on Figures 4 and 5.

The surrounding area consists of undeveloped hillside. There is a water tank north of the Evans Canyon west site.

FIELD STUDY

The field study was conducted on February 8 and 9, 2016. Nine test pits were excavated at the approximate locations indicated on Figures 4 and 5 using a CAT 336E tracked excavator. The test pits were logged and soil samples obtained by an engineer from AGEC. Logs of the subsurface conditions encountered in the test pits are graphically shown on Figures 6, 7 and 8 with legend and notes on Figure 9.

The test pits were backfilled without significant compaction. The backfill in the test pits should be properly compacted where it will support the proposed construction.

SUBSURFACE CONDITIONS

The subsurface materials encountered at the Mathias Canyon site consist of approximately 1 to 1½ feet of topsoil overlying gravel in Test Pits TP-1, TP-2 and TP-3 underlain by bedrock at a depth of approximately 13 feet. Approximately 1½ feet of topsoil overlying silty sand was encountered in Test Pit TP-5 and is underlain by gravel at a depth of approximately 6 feet. The gravel extends the full depth of Test Pit TP-5, approximately 17 feet.

The subsurface soil encountered at the Evans Canyon west site consists of approximately 2 and 1 foot of fill in Test Pits TP-6 and TP-7, respectively, and approximately 1 foot of topsoil in Test Pit TP-8 overlying sand and gravel, which extends the full depth investigated, approximately 22 feet.

The subsurface soil encountered at the Evans Canyon east site consists of approximately 1 and 1½ feet of topsoil overlying gravel in Test Pits TP-9 and TP-10, respectively. The gravel extends the full depth investigated, approximately 23 feet.

A description of the various soils and bedrock encountered in the test pits follows:

Fill - The fill consists of clayey sand and gravel. It is moist to wet and brown to gray.

Topsoil - The topsoil consists of silty to clayey sand and gravel. It is moist to very moist, dark brown and contains roots and organics.

Silty Sand - The sand contains a small to large amount of gravel and some clayey zones. The sand is medium dense, moist to wet and brown.

Laboratory tests conducted on samples of the sand indicate that it has natural moisture contents ranging from 2 to 25 percent and natural dry densities of 92 to 98 pounds per cubic foot (pcf). Results of gradation tests performed on samples of the sand are presented on Figures 12, 13 and 14. The permeability of the sand from TP-7 at 4 feet was measured as 5.5×10^{-4} cm/sec. The test was performed on the sand with gravel removed and the sand compacted at the natural moisture content in a relatively dense condition.

Poorly-graded Gravel with Silt and Sand - The gravel contains clayey zones, sand lenses, cobbles and boulders up to approximately 2 feet in size. The gravel is medium dense, moist to wet and brown.

Laboratory tests conducted on samples of the gravel indicate that it has natural moisture contents ranging from 3 to 21 percent. Results of gradation tests performed on samples of the gravel are presented on Figures 10, 11, 13, 14, 15 and 16. The permeability of the gravel from TP-3 at 2 feet was measured as 3.6 X 10^{-6} cm/sec. The test was performed on the sand from the sample with gravel removed and the sand compacted at the natural moisture content in a relatively dense condition.

Bedrock - The bedrock consists of argillite to phyllite, likely of the Kelly Canyon Formation (Crittenden and Sorensen, 1985). The bedrock is fissile, hard, very moist to wet and brown to gray to black.

Laboratory tests performed on a sample of the bedrock indicate it has a natural moisture content of 16 percent.

Results of the laboratory tests are summarized on Table I and are included on the logs of the test pits.

SUBSURFACE WATER

Subsurface water was perched on the bedrock in Test Pits TP-1 and TP-2 at a depth of approximately 13 feet. Water was encountered in Test Pit TP-5 at a depth of approximately 11 feet. Subsurface water was encountered at the Evans Canyon west site in Test Pit TP-6 at a depth of approximately 7 feet. No subsurface water was encountered in the other test pits excavated at the three sites.

Fluctuations in the water level are expected over time. An evaluation of such water level fluctuations is beyond the scope of this report.

GEOLOGIC SETTING

A. Regional Geology

Perry is located in the Basin and Range province. The province is made up of north/south elongated mountain blocks and valleys. Perry is located on the east side of a valley once occupied by a large lake know as Lake Bonneville during the Wisconsin glacial period of the Pleistocene age. The present day Great Salt Lake is a remnant of ancient Lake Bonneville. Stillstands of Lake Bonneville formed benches along the Wasatch mountain front. The highest level of Lake Bonneville is marked by a bench, the Bonneville shoreline, at approximate elevation 5160 to 5200 feet. The lake remained at this high level from approximately 17,000 to 15,000 years before present, until it dropped approximately 350 feet during a catastrophic flood known as the Bonneville flood (Jarrett and Malde, 1987). Two lower stillstands of Lake Bonneville are the Provo and Gilbert, which formed at approximate elevations 4850 and 4250 feet, respectively (Nelson and Personius, 1993). There is no evidence that the lake has risen above the Gilbert stillstand during Holocene time (last 10,000 years).

Based on topography provided, the two east basins are near the Provo shoreline elevation and the west basin is about 150 feet below the Provo shoreline elevation.

B. Tectonic Setting

The site is located along the Wasatch mountain front, which is a prominent mountain-front escarpment extending approximately 240 miles from near Malad, Idaho to the vicinity of Fayette, Utah. The prominent west-facing steep escarpment of the Wasatch mountain front is the result of repeated normal fault displacements which have taken place over the last several million years. The system of normal faults that makes up this escarpment is known collectively as the Wasatch fault zone. Relatively recent fault movements are evidenced by offsets in Lake Bonneville sediments and more recent alluvial and colluvial deposits.

The Wasatch fault is mapped to extend through the area. Based on a review of aerial photographs, lidar data and geologic maps, the approximate locations of fault surface traces are presented on Figures 1, 2 and 3. Based on this information, the main surface trace of the Wasatch fault is located just east of the proposed Evans Canyon east debris basin and continues north to where it is west of the Mathias Canyon debris basin site. There are poorly defined fault traces that trend toward the Evans Canyon west and the Mathias Canyon sites as indicated on the two figures. There is no evidence from review of the aerial photographs, lidar data or geologic maps that surface traces of faults extend through these sites. However, with the close proximity of the fault surface traces to the proposed debris basins, consideration should be given to performing fault studies if surface rupture is considered a concern for the proposed construction. Due to the long return period of surface fault rupture at the sites and assuming that the embankments are not planned to impound water, this hazard may not be of significance for the proposed construction.

C. Site Geology

The geology of the sites is presented on Figure 1. All three sites are located within the young alluvial-fan deposits of upper-Holocene age. The sides of these drainages consist predominantly of Lake Bonneville sediments of Pleistocene age.

PROPOSED CONSTRUCTION

We understand that the debris basins will be constructed with a height of approximately 30 feet on the downstream side and 15 feet on the upstream side. Embankment slopes will be 2 horizontal to 1 vertical or flatter. The approximate configurations of the proposed debris basins and embankments are presented on Figures 4 and 5.

LIQUEFACTION AND SEISMICITY

A. Liquefaction

Research indicates that the soil type most susceptible to liquefaction during a severe seismic event is loose, clean sand. In order for liquefaction to occur, potentially liquefiable soils must be saturated. The liquefaction potential for soil below the groundwater level tends to decrease with an increase in fines content and density.

The Mathias Canyon site is underlain by bedrock and the Evans Canyon sites are underlain by medium dense to dense sand and gravel. Liquefaction is not considered a potential hazard at these sites.

B. Seismicity

The stability of embankments was evaluated considering two seismic events (operating basis earthquake (OBE) and maximum credible earthquake(MCE)) in accordance with the Utah Administrative Code R655-11-5A.

Based on the site locations, USGS data and engineering analysis, the following information is provided:

Seismic Event	Earthquake Magnitude	Peak Ground Acceleration
MCE - Deterministic Value (Mean plus 1 Std. Dev.)	6.95	0.72g
MCE - Probabilistic Value (5,000 yr return period)	6.95	0.88g
OBE - Probabilistic Value (200 yr return period)	6.62	0.11g

STABILITY ANALYSIS

The friction angle used in the stability analyses is 37 degrees. This is considered conservative for the subsurface conditions encountered based on a review of the literature for similar soil types. An infinite slope analysis was performed and a safety factor of greater than 1.5 is obtained for the static condition and greater than 1 for the operating basis earthquake. Deformation of the embankment is expected under the maximum credible earthquake condition with an estimate of 30 inches or less deformation (Bray and Travasarou, 2007). However, with the proposed use of the debris basins, which are not planned to store water, such a condition is extremely unlikely during the maximum credible earthquake. Such a condition should not need to be considered in design.

RECOMMENDATIONS

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

A. Site Grading

1. Subgrade Preparation

   Prior to placement of embankments, the topsoil, organics and other deleterious materials should be removed from below proposed embankments.

   Subsequent to overexcavation and prior to placing fill, the exposed subgrade should be scarified to a depth of approximately 8 inches, properly moisture condition and compacted to at least 90 percent of the maximum dry density as determined by ASTM D1557.

2. Excavation/Earthwork

We anticipate the soil and bedrock at the site may be excavated with heavy-duty excavation equipment. If scrapers will be used to excavate, they may experience difficulty in picking up large cobble and boulder sized particles or penetrating the bedrock very deeply.

Excavations that extend below the water level should be dewatered with the water maintained at least 2 feet below the excavation base.

3. Material Suitability

The on-site sand and gravel meeting the imported materials recommendations given below and free of organics, debris and particles larger than 8 inches is suitable for use as site grading and embankment fill. The maximum particle size should not exceed the compacted lift thickness. Some clay or silt may need to be added to the natural soil to meet the percent passing the No. 200 sieve. The bedrock is not recommended for use as embankment fill. The bedrock may be placed outside the embankment areas.

4. Imported Materials

Import materials should have low solubility and meet the criteria below for materials used in the listed condition.

Area	Fill Type	Recommendations
Embankment	Mass grading	10% <-200 <40%, LL <30% Maximum size: 8 inches

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

5. Compaction

Embankment fill should be compacted to at least 90 percent of the maximum dry density as determined by ASTM D1557. The fill should be placed and compacted at a moisture content within 2 percent of optimum.

Fill placed at the site should be frequently tested to verify proper compaction. Fill should be placed in thin enough lifts to allow for proper compaction. Loose lift thicknesses of 10 to 12 inches are generally adequate for large compaction equipment. Loose lift thickness of 4 inches are typically appropriate for hand compaction equipment. Compaction of fill should be completed on a level/horizontal subgrade.

6. Shrinkage

We estimate shrinkage on the order of 15 to 20 percent will occur when placing the on-site soil as compacted fill. This estimate does not consider oversized material removal.

B. Embankment Construction

The following recommendations are provided for construction of the embankments.

1. Slopes

Embankment slopes should be constructed no steeper than 2 horizontal to 1 vertical. Flatter slopes and a toe drain may be needed if the embankment will retain water long enough to result in water buildup in the embankment. Embankment slopes should be protected from erosion by revegetation or other methods.

2. Embankments

Fill for embankments should be placed on a properly prepared subgrade as previously stated in the Subgrade Preparation section of this report. We recommend constructing the slopes by over filling and cutting them to grade to ensure a properly compacted slope face.

Fill placed along slopes of 5 horizontal to 1 vertical or steeper should be placed using a benching procedure to "key" the fill into the slope. Benches should be of sufficient width for compaction equipment.

3. Embankment Crest Width

A crest width of at least 15 feet is recommended.

4. Toe Drain

A toe drain and additional stability analysis are recommended if the embankments are planned to impound water for more than a short-term basis. This may apply if there is a potential for the outlet to plug.

LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practices in the area for the use of the client for design purposes. The conclusions and recommendations included in the report are based on the information obtained from the referenced documents, the test pits excavated, the data obtained from laboratory testing, geologic literature review and engineering analysis. Variations in the subsurface conditions may not become evident until additional exploration or excavation is conducted. If the subsurface conditions or the groundwater level is found to be significantly different from what is described above, we should be notified to reevaluate our recommendations.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

LICENSED PROFESSIONAL ENGINEER
3/18/16
No. 260053
DOUGLAS R. HAWKES
STATE OF UTAH

LICENSED PROFESSIONAL GEOLOGIST
No. 260053
DOUGLAS R. HAWKES
STATE OF UTAH

Douglas R. Hawkes, P.E., P.G.

Reviewed by Jay R. McQuivey, P.E.

DRH/bw

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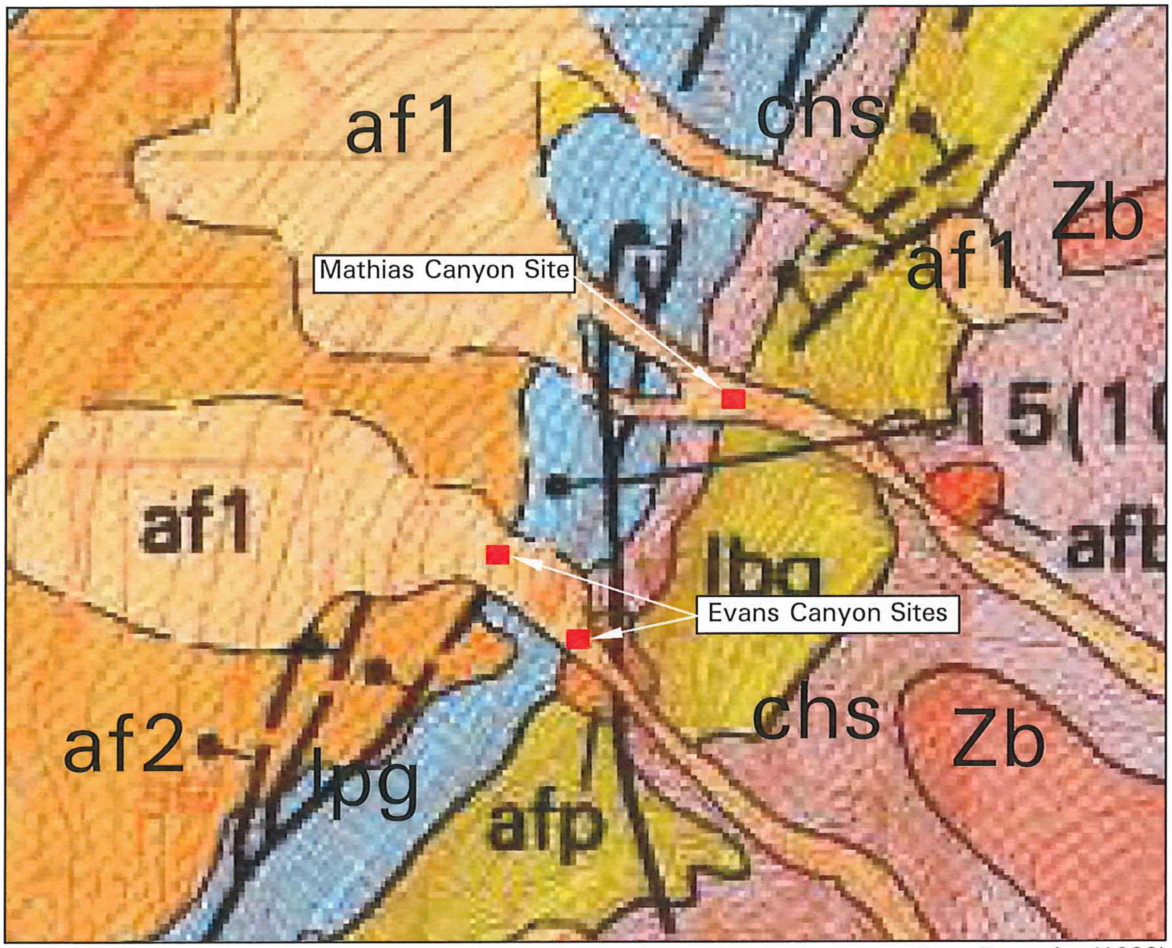


From Personius (1990)

EXPLANATION OF SYMBOLS AND GEOLOGIC UNITS IN AREA OF PROPOSED DEVELOPMENT

chs - Hillside Colluvium (Holocene to upper Pleistocene).

af1 - Fan alluvium 1 (upper Holocene).

af2 - Fan alluvium 2 (middle Holocene to upper Pleistocene).

afp - Fan alluvium related to Provo Shoreline (uppermost Pleistocene).

afb - Fan alluvium related to Bonneville Shoreline (upper Pleistocene).

lpg - Lacustrine sand and gravel related to Provo Shoreline (uppermost Pleistocene).

lbg - Lacustrine sand and gravel related to Bonneville Shoreline (upper Pleistocene).

Zb - Lower part of Brigham Group (Late Proterozoic).

Contact between geologic units, dashed where approximate.

Normal Fault - bar and ball on down thrown side, dashed where approximately located.

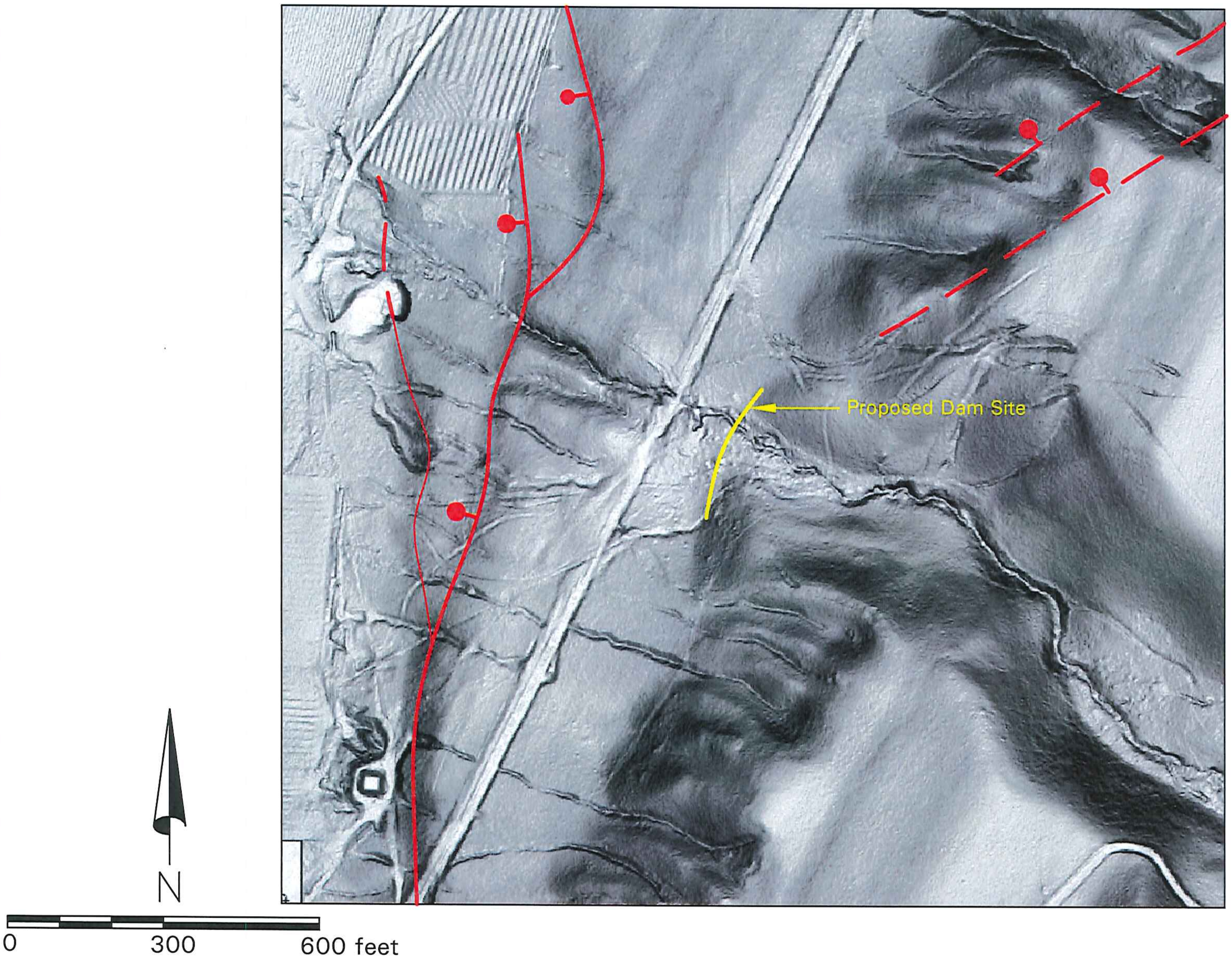
N

0 1000 2000 feet

Approximate Scale

EVANS AND MATHIAS
CANYON SITES
PERRY, UTAH

1150963	AGEC	Geologic Map	Figure 1



From Utah State Lidar

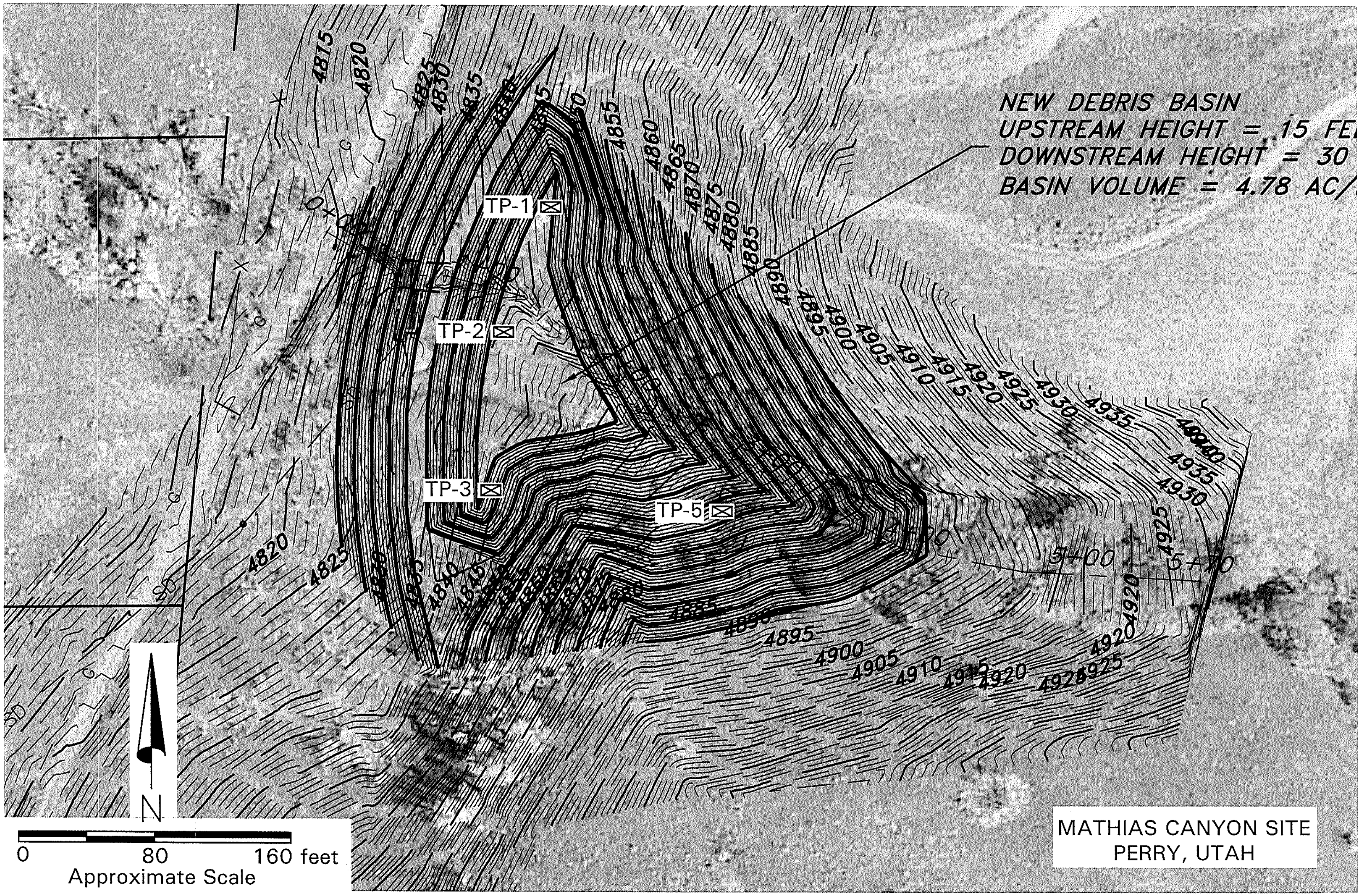
MATHIAS
CANYON SITE
PERRY, UTAH

1150963	AGEC	Fault Locations	Figure 2

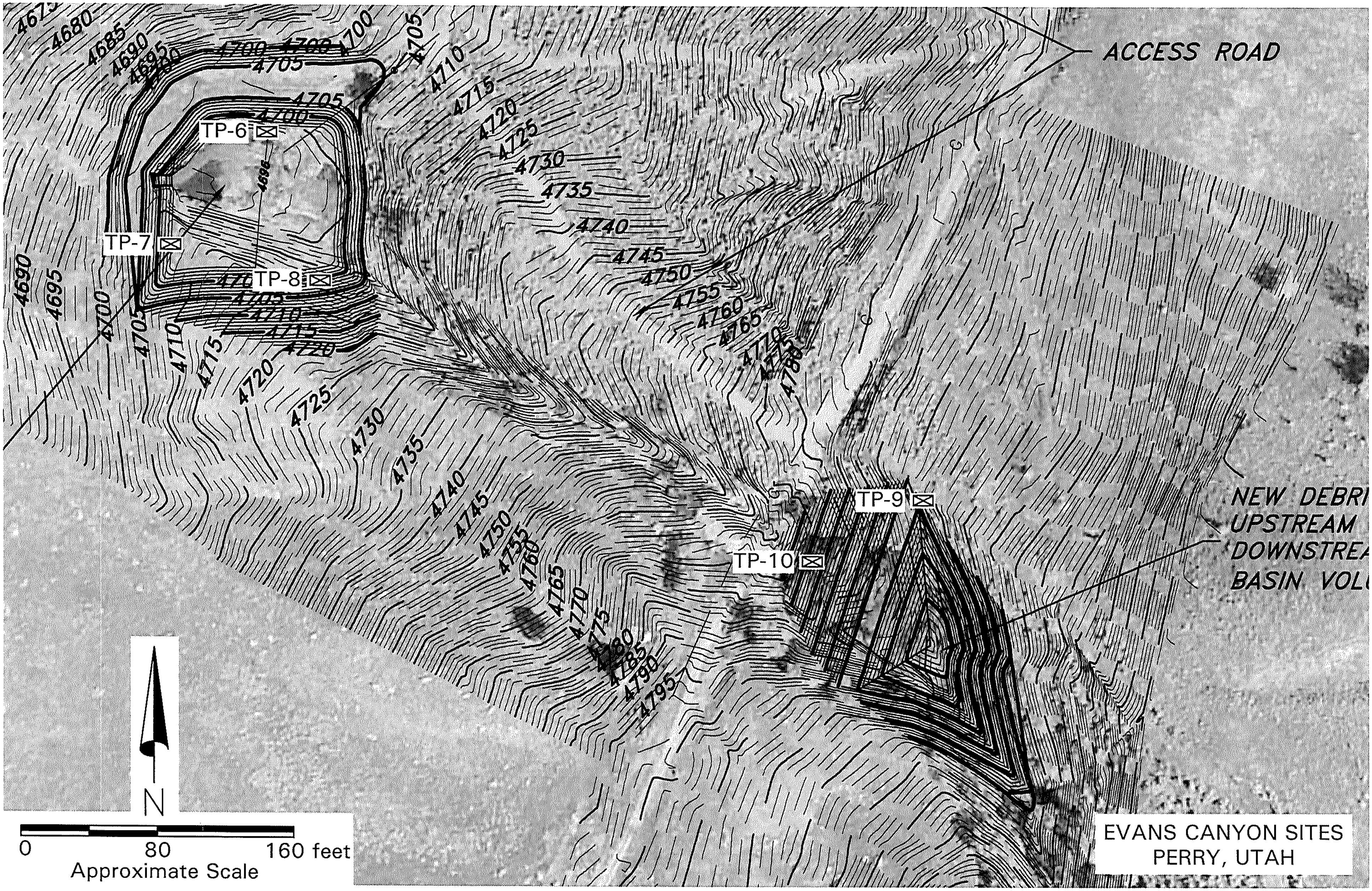
From Utah State Lidar

EVANS
CANYON SITES
PERRY, UTAH

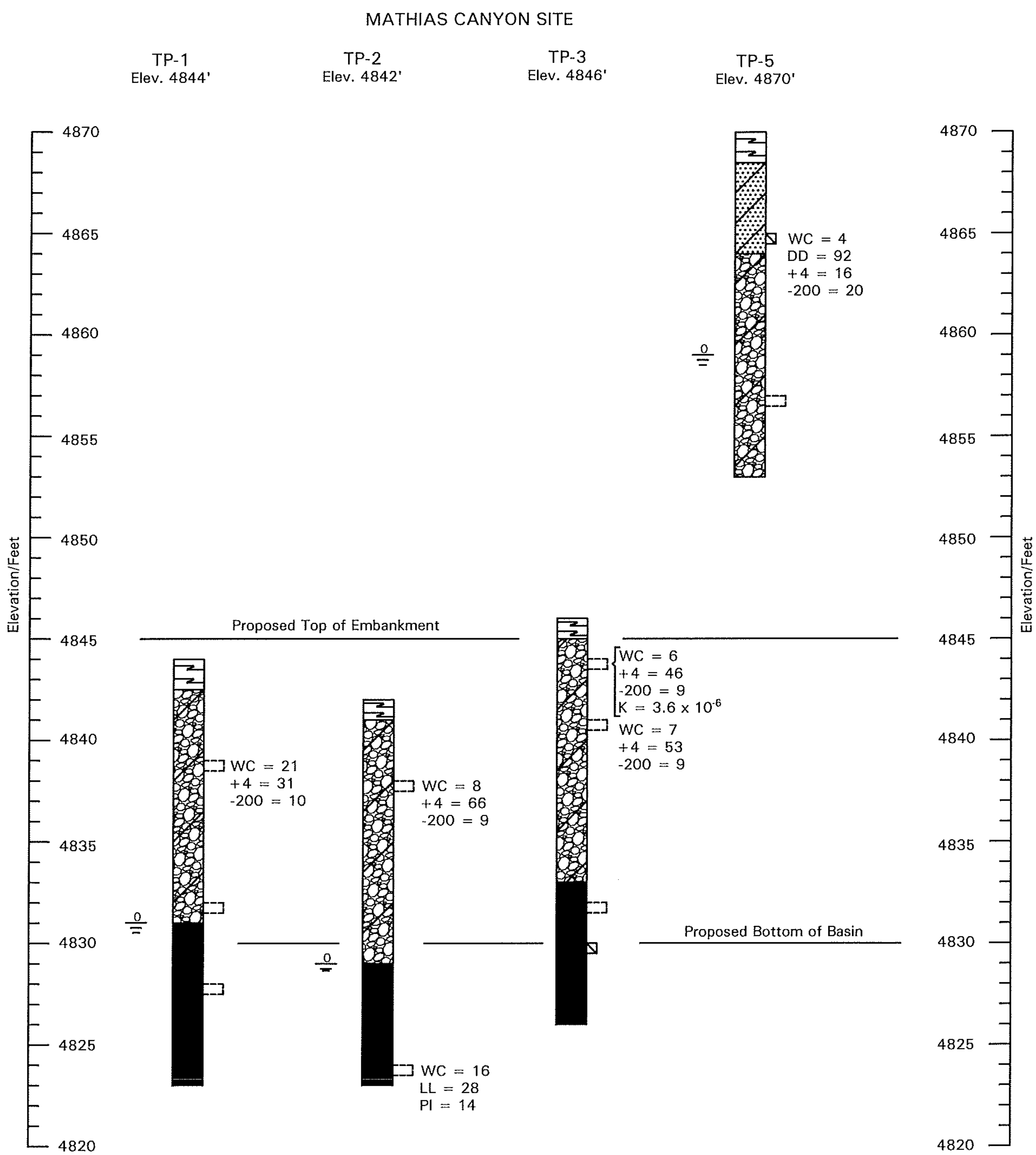
1150963	AGEC	Fault Locations	Figure 3



1150963	AGEC	Test Pit Locations	Figure 4



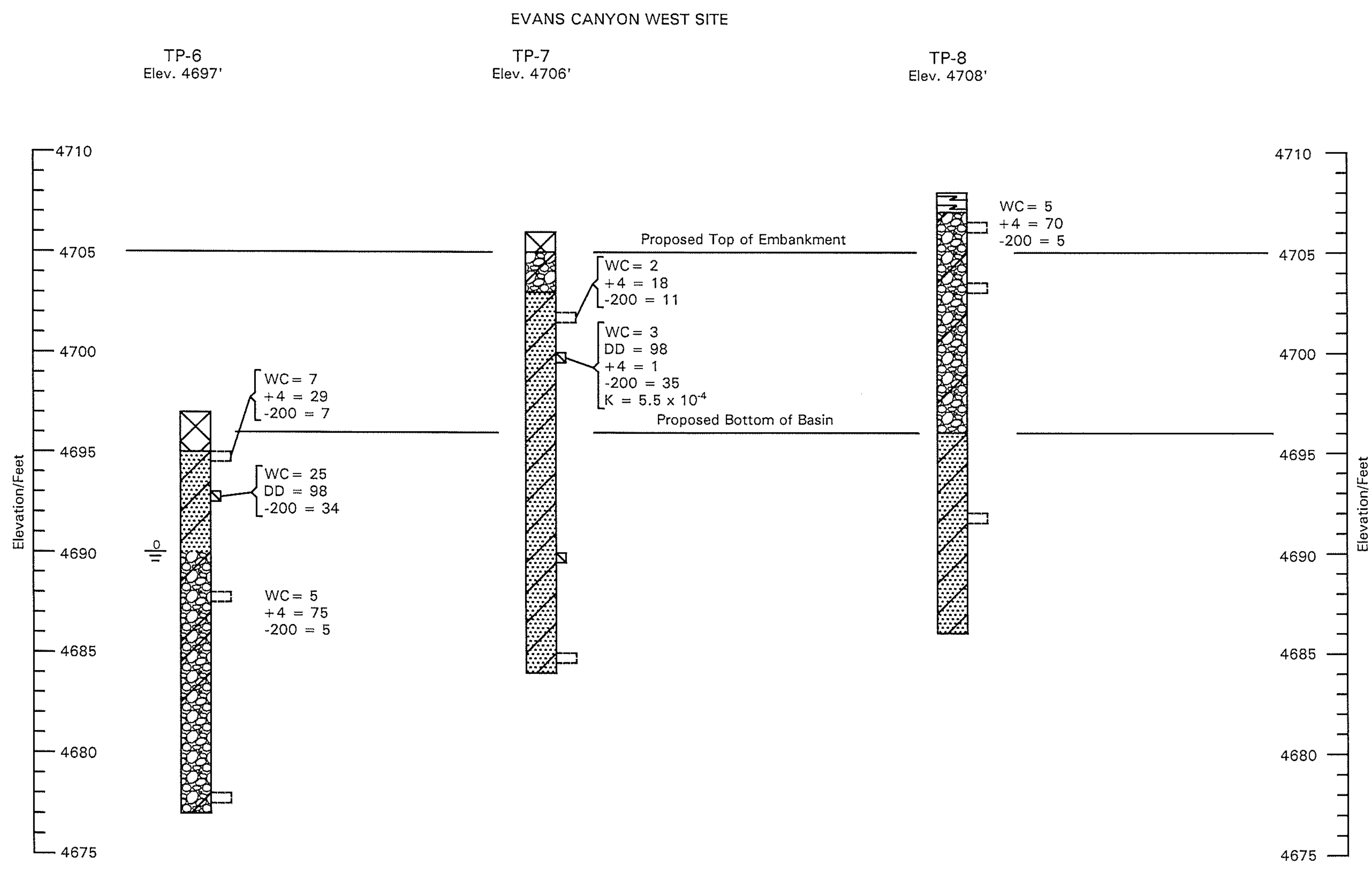
1150963	AGEC	Test Pit Locations	Figure 5



Approximate Vertical Scale 1" = 8'

See Figure 9 for legend and notes.

1150963	AGEC	Test Pit Logs	Figure 6

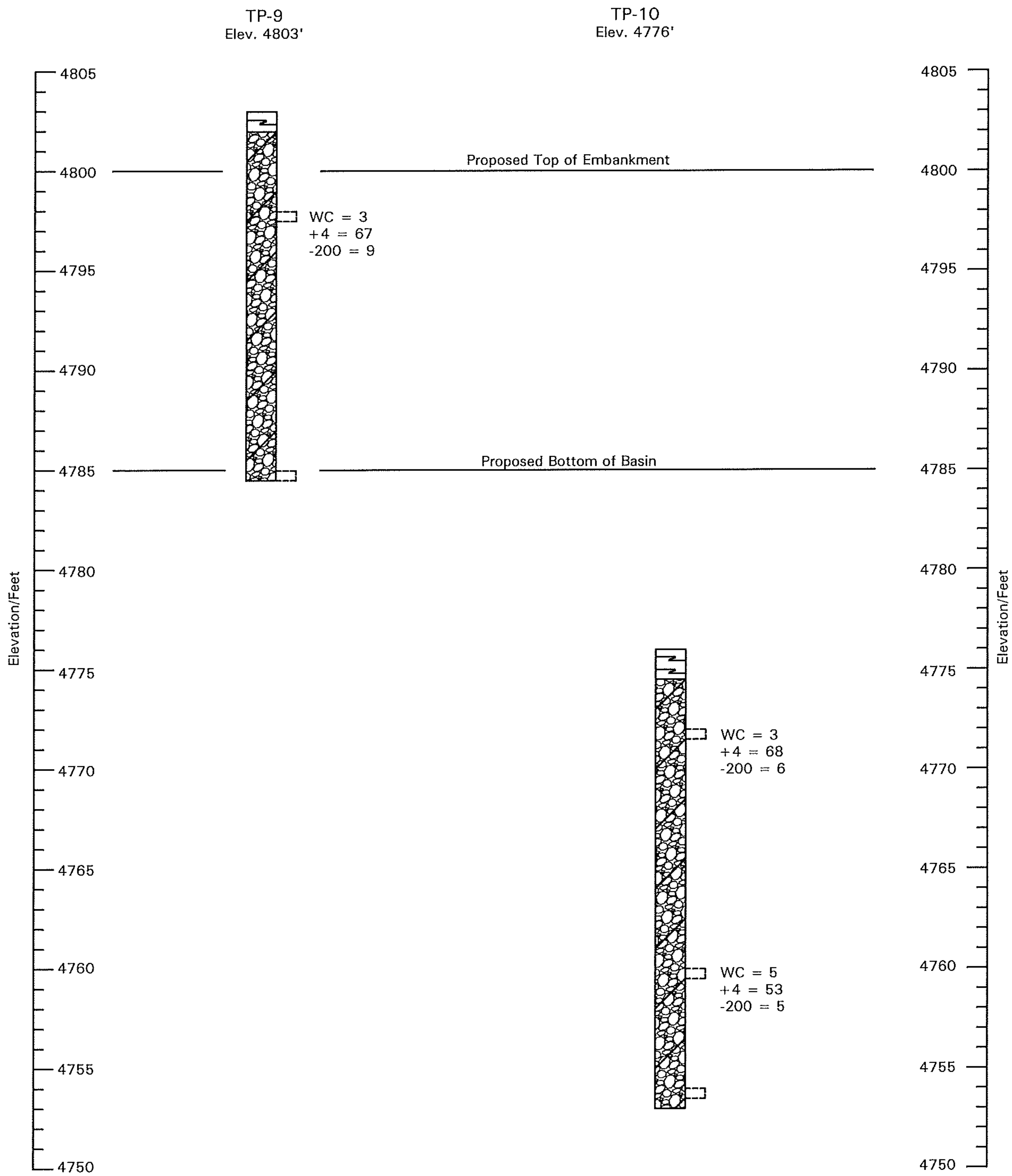


Approximate Vertical Scale 1" = 8'

See Figure 9 for Legend and Notes

1150963	AGEC	Test Pit Logs	Figure 7

EVANS CANYON EAST SITE



Approximate Vertical Scale 1" = 8'

See Figure 9 for legend and notes.

1150963	AGEC	Test Pit Logs	Figure 8

LEGEND:

Fill; clayey sand and gravel, moist to wet, brown to gray.

Topsoil; silty to clayey sand and gravel, moist to very moist, dark brown, roots, organics.

Silty Sand (SM); small to large amount of gravel, some clayey zones, medium dense, moist to wet, brown.

Poorly-graded Gravel with Silt and Sand (GP-GM); clayey zones, sand lenses, cobbles, boulders up to approximately 2 feet in size, medium dense, moist to wet, brown.

Bedrock; argillite to phyllite likely of the Kelley Canyon Formation, fissile, hard, very moist to wet, brown to gray to black.

Indicates relatively undisturbed hand drive sample taken.

Indicates disturbed sample taken.

0 Indicates the depth to free water at the time of excavation.

NOTES:

1. The test pits were excavated on February 8 and 9, 2016 with a CAT 336E tracked excavator.
2. Locations of the test pits were measured approximately by pacing from features shown on the site plan provided.
3. Elevations of the test pits were determined by interpolating between contours shown on the site plan provided.
4. The test pit locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between materials shown on the logs represent the approximate boundaries between material types and the transitions may be gradual.
6. Water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water level will occur with time.
7. WC = Water Content (%);
   DD = Dry Density (pcf);
   +4 = Percent Retained on No. 4 Sieve;
   -200 = Percent passing on No. 200 Sieve;
   LL = Liquid Limit (%);
   PI = Plasticity Index (%);
   K = Permeability of the portion passing No. 4 sieve (cm/sec).

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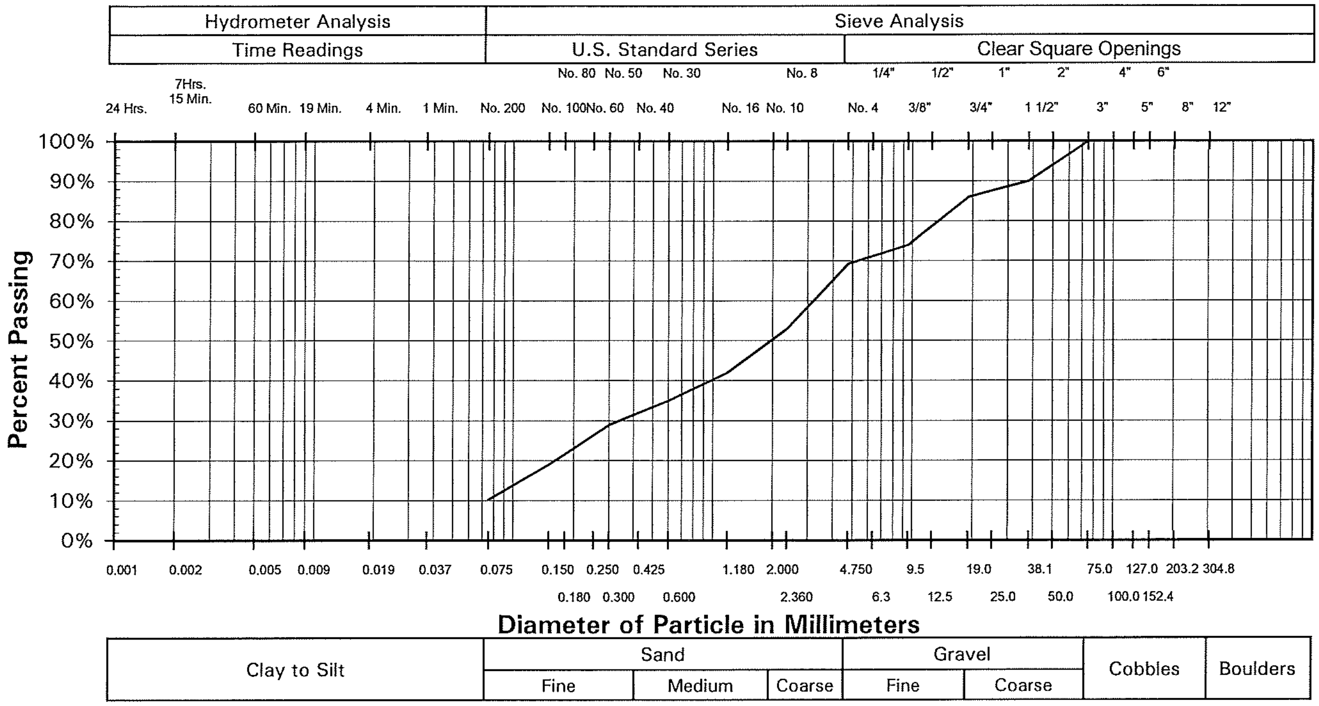
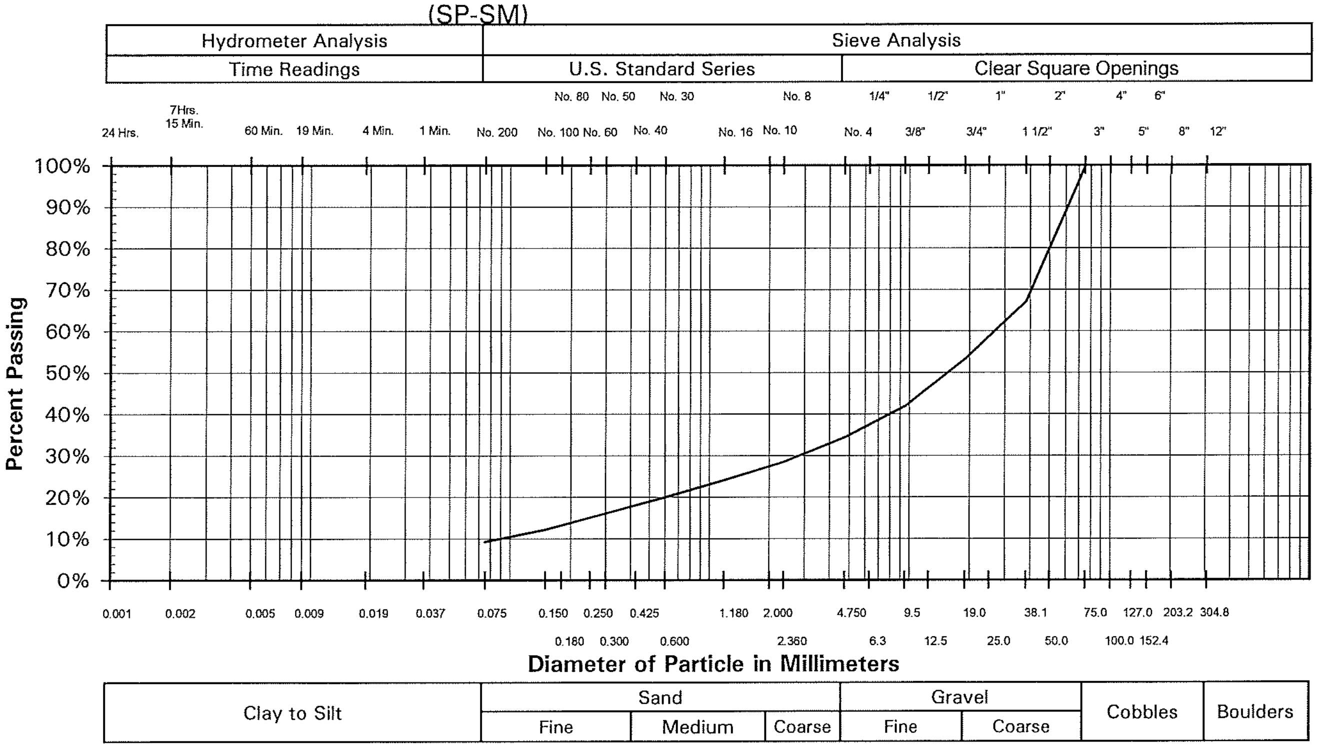


Gravel	31%	Liquid Limit	-
Sand	59%	Plasticity Index	-
Silt and Clay	10%	Sample Location	TP-1 at 5 feet

Sample Description Poorly-graded Sand with Silt and Gravel (SP-SM)



Gravel	66%	Liquid Limit	-
Sand	25%	Plasticity Index	-
Silt and Clay	9%	Sample Location	TP-2 at 4 feet

Sample Description Poorly-graded Gravel with Silt and Sand (GP-GM)

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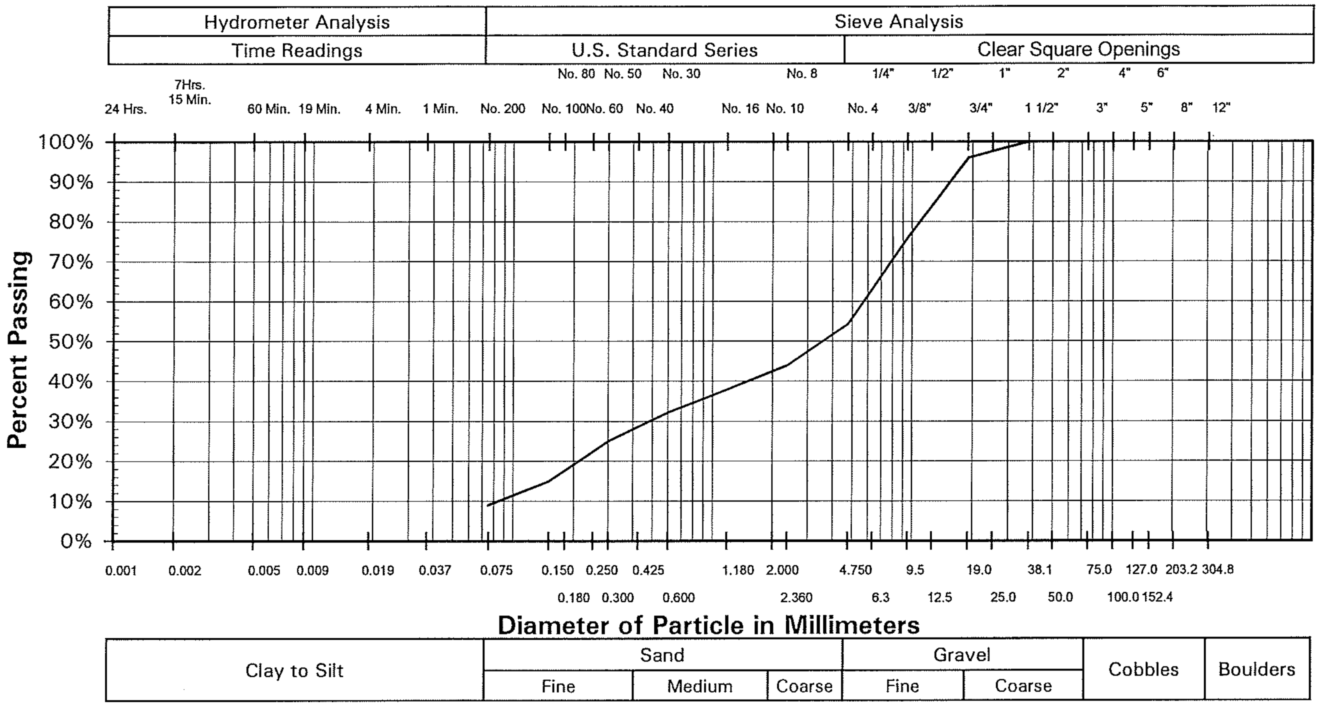
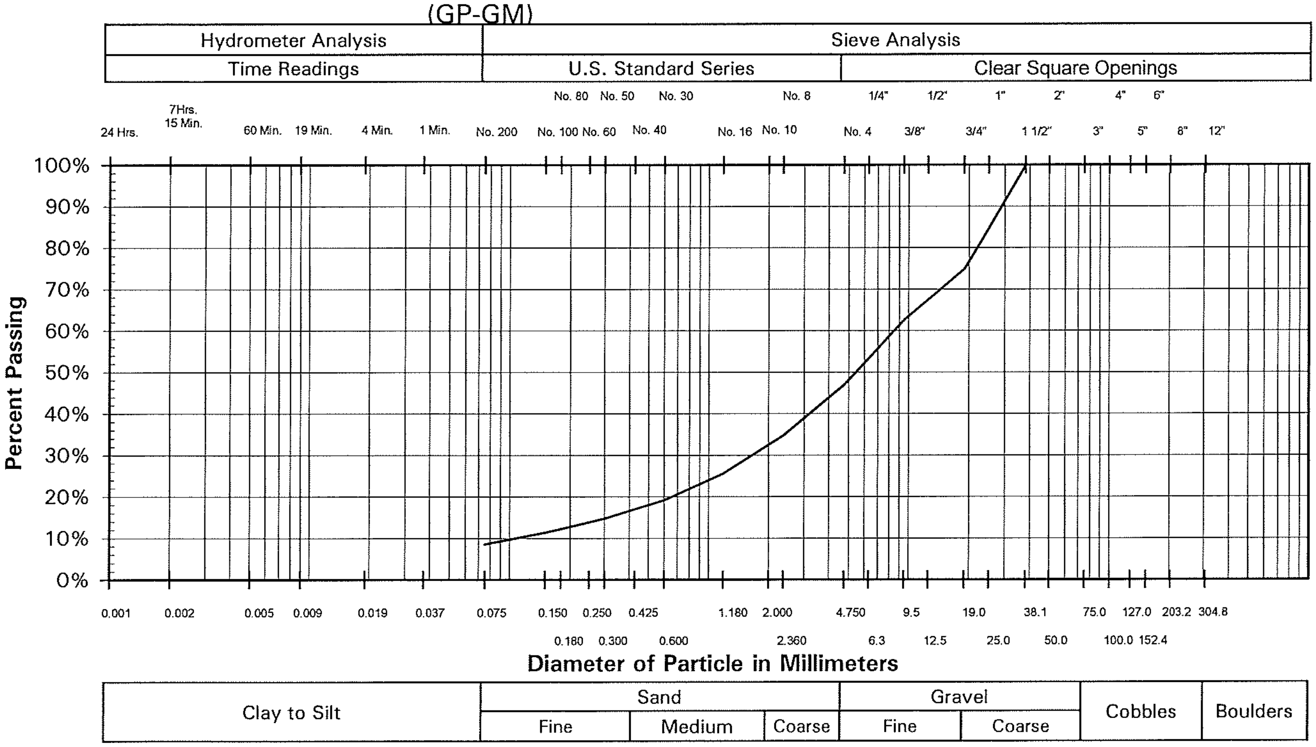


Gravel	46%	Liquid Limit	-
Sand	45%	Plasticity Index	-
Silt and Clay	9%	Sample Location	TP-3 at 2 feet

Sample Description Poorly-graded Gravel with Silt and Sand (GP-GM)



Gravel	53%	Liquid Limit	-
Sand	38%	Plasticity Index	-
Silt and Clay	9%	Sample Location	TP-3 at 5 feet

Sample Description Poorly-graded Gravel with Silt and Sand (GP-GM)

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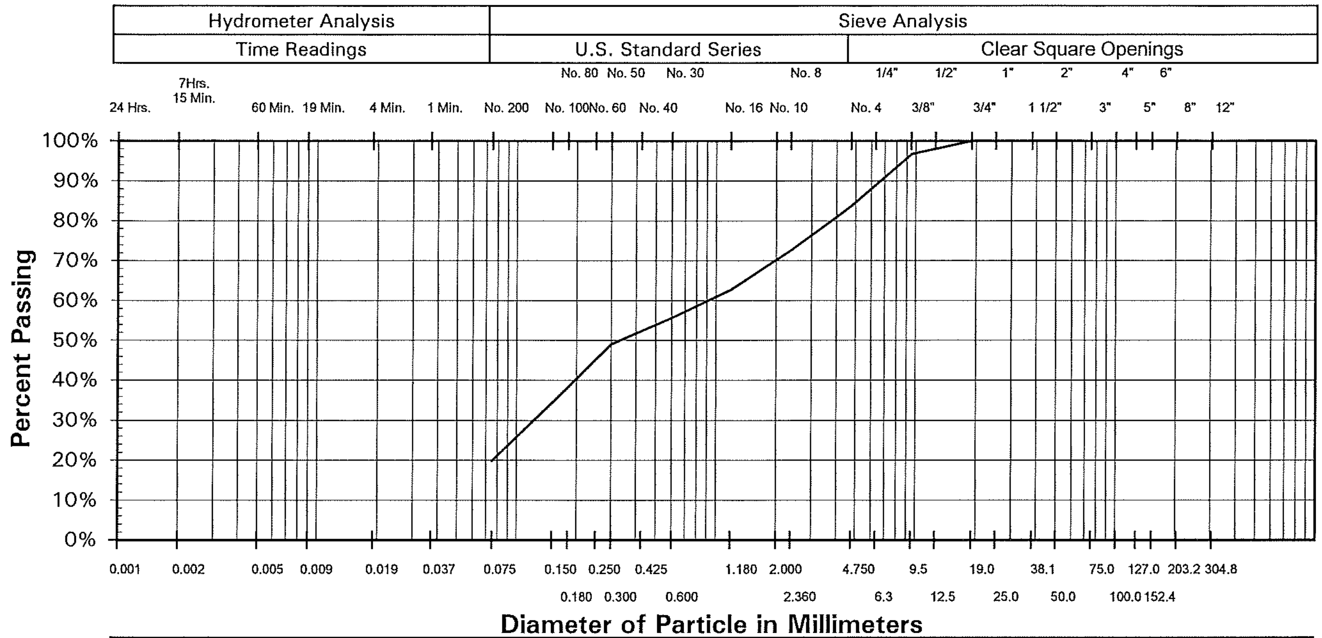
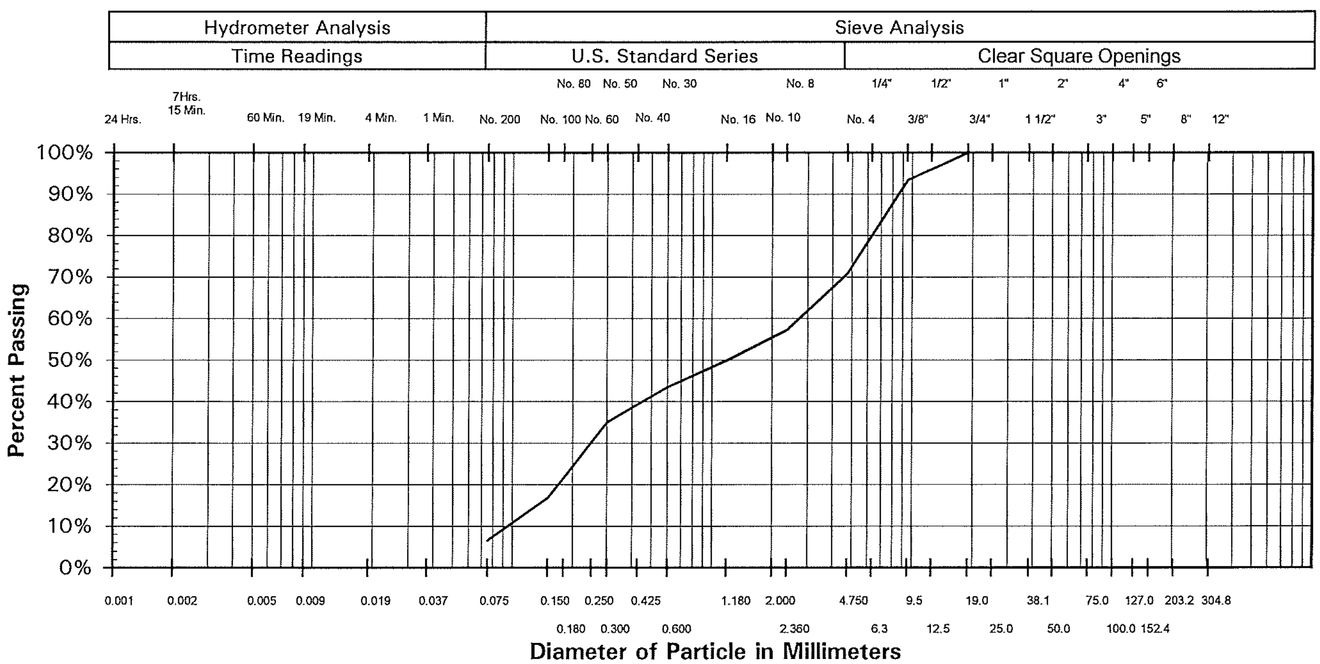


Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel	16%	Liquid Limit	-
Sand	64%	Plasticity Index	-
Silt and Clay	20%	Sample Location	TP-5 at 5 feet
Sample Description	Silty Sand with Gravel (SM)		



Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel	29%	Liquid Limit	-
Sand	64%	Plasticity Index	-
Silt and Clay	7%	Sample Location	TP-6 at 2 feet
Sample Description	Poorly-graded Sand with Silt and Gravel (SP-SM)		

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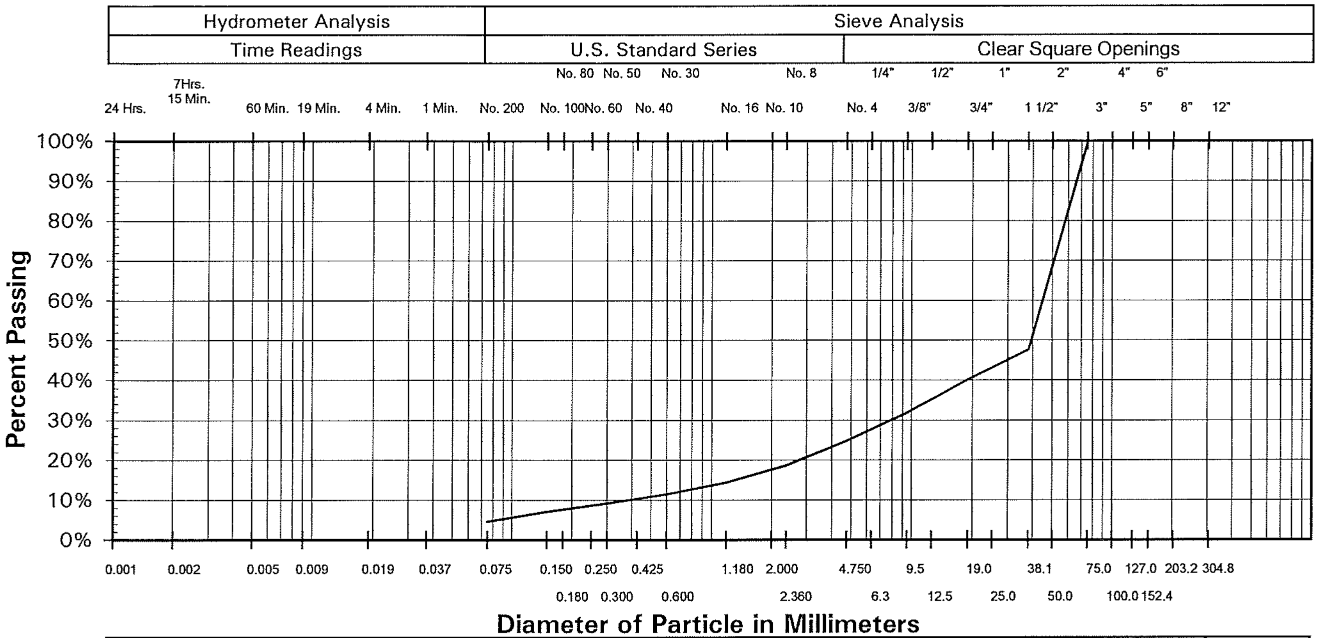
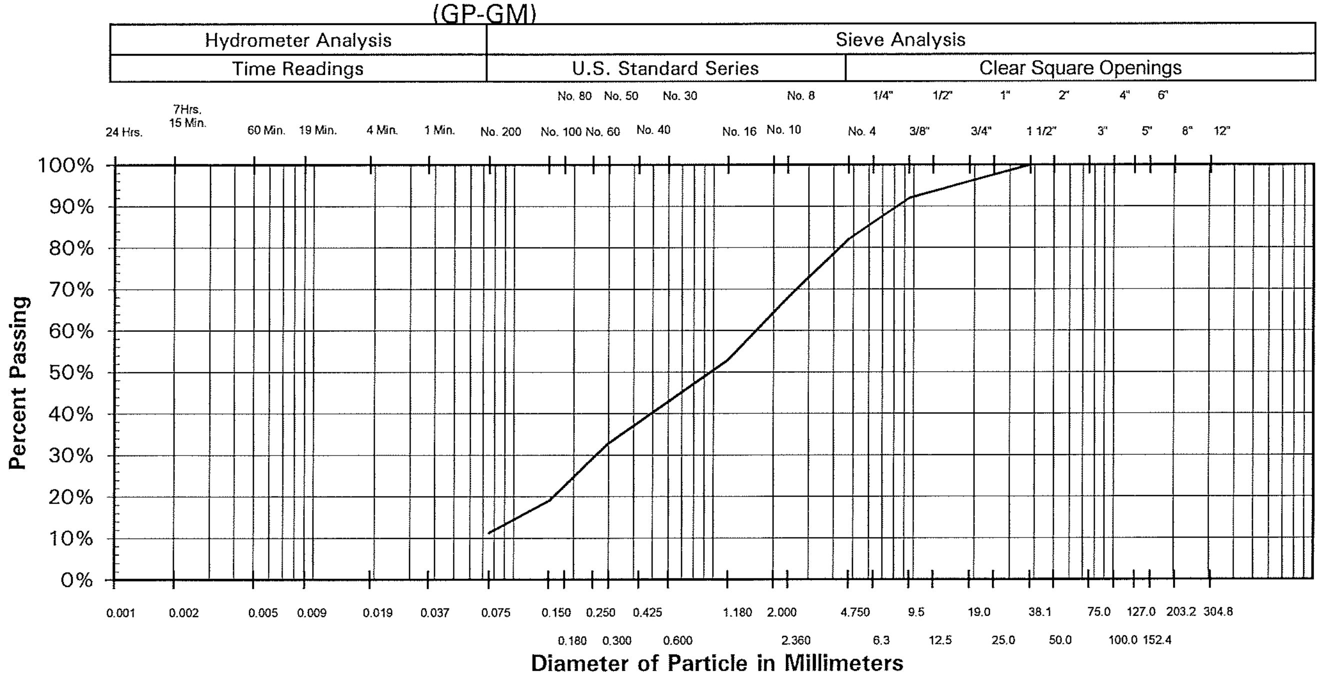


Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel	75%	Liquid Limit	-
Sand	20%	Plasticity Index	-
Silt and Clay	5%	Sample Location	TP-6 at 9 feet
Sample Description	Poorly-graded Gravel with Silt and Sand (GP-GM)		



Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel	18%	Liquid Limit	-
Sand	71%	Plasticity Index	-
Silt and Clay	11%	Sample Location	TP-7 at 4 feet
Sample Description	Poorly-graded Sand with Silt and Gravel (SP-SM)		

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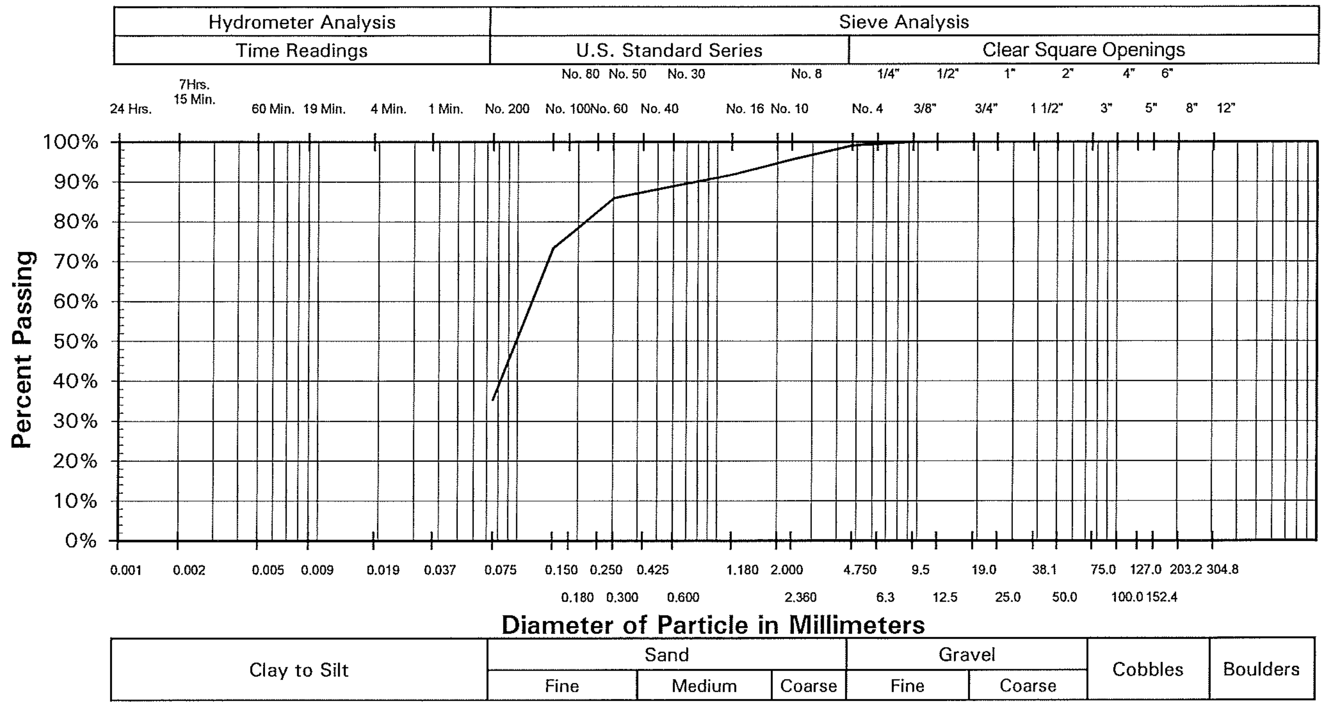
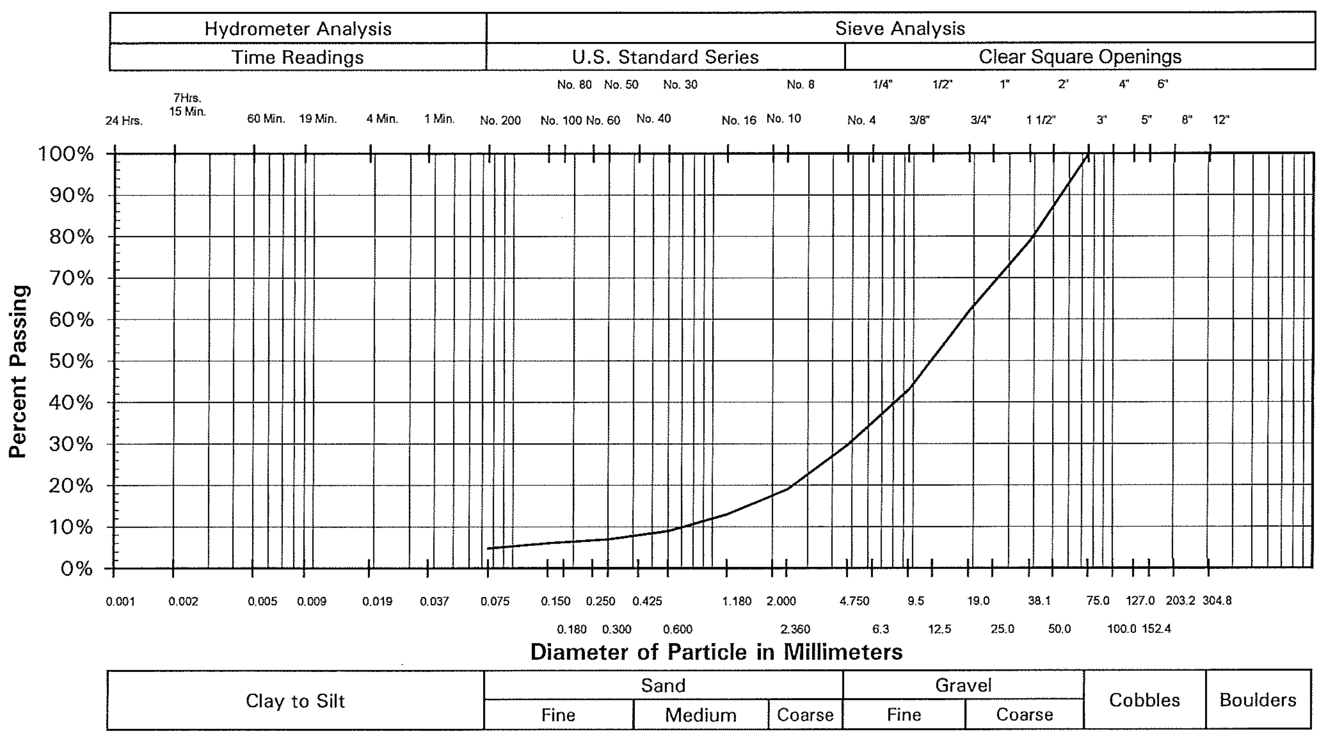


Gravel	1%		Liquid Limit	-
Sand	64%		Plasticity Index	-
Silt and Clay	35%		Sample Location	TP-7 at 6 feet
Sample Description	Silty Sand (SM)			



Gravel	70%		Liquid Limit	-
Sand	25%		Plasticity Index	-
Silt and Clay	5%		Sample Location	TP-8 at 1-1/2 feet
Sample Description	Well-graded Gravel with Silt and Sand (GW-GM)			

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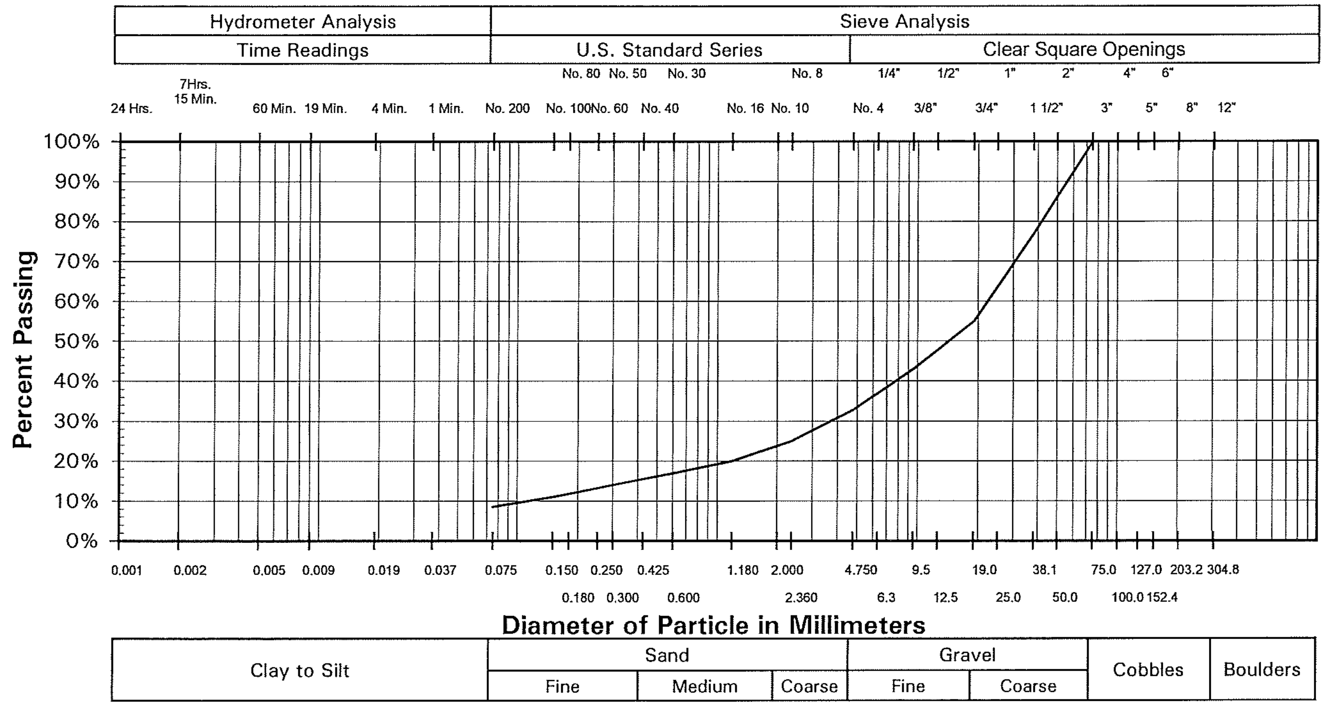
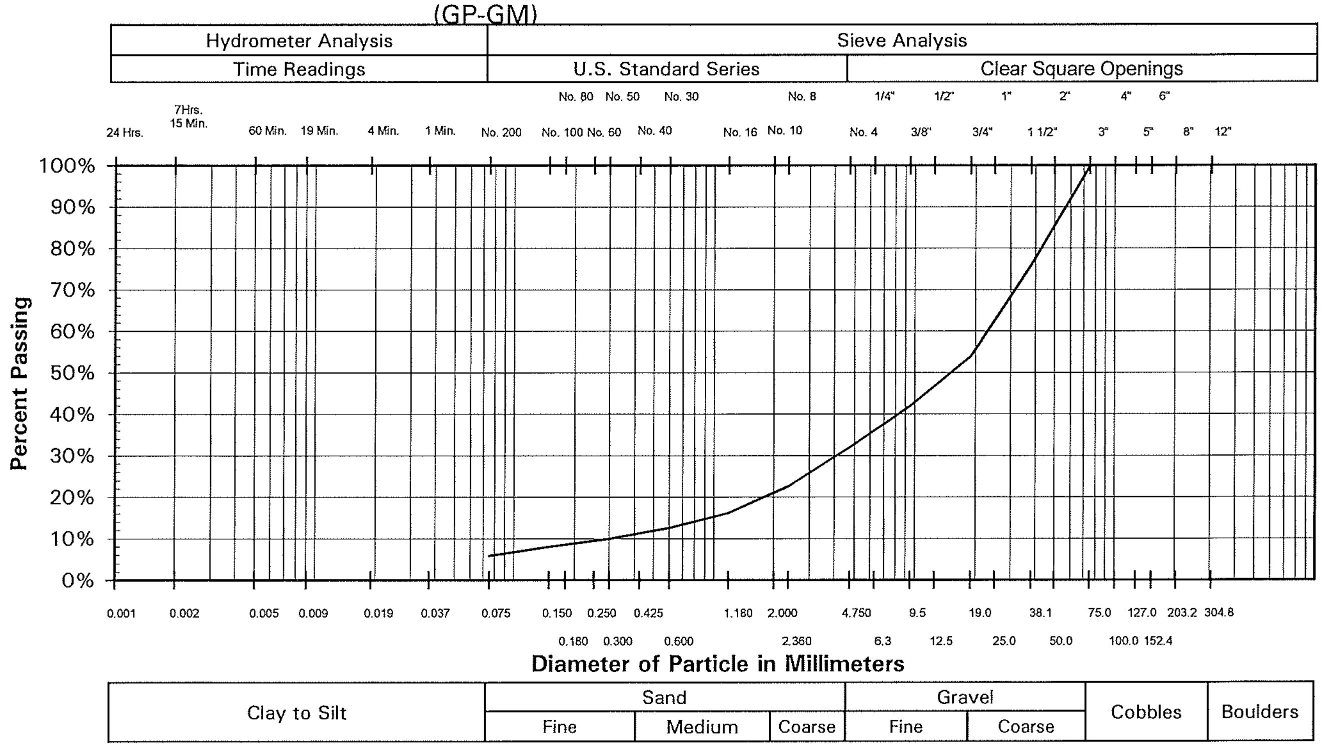


Gravel	67%		Liquid Limit	-
Sand	24%		Plasticity Index	-
Silt and Clay	9%		Sample Location	TP-9 at 5 feet
Sample Description	Poorly-graded Gravel with Silt and Sand (GP-GM)			



Gravel	68%		Liquid Limit	-
Sand	26%		Plasticity Index	-
Silt and Clay	6%		Sample Location	TP-10 at 4 feet
Sample Description	Well-graded Gravel with Silt and Sand (GW-GM)			

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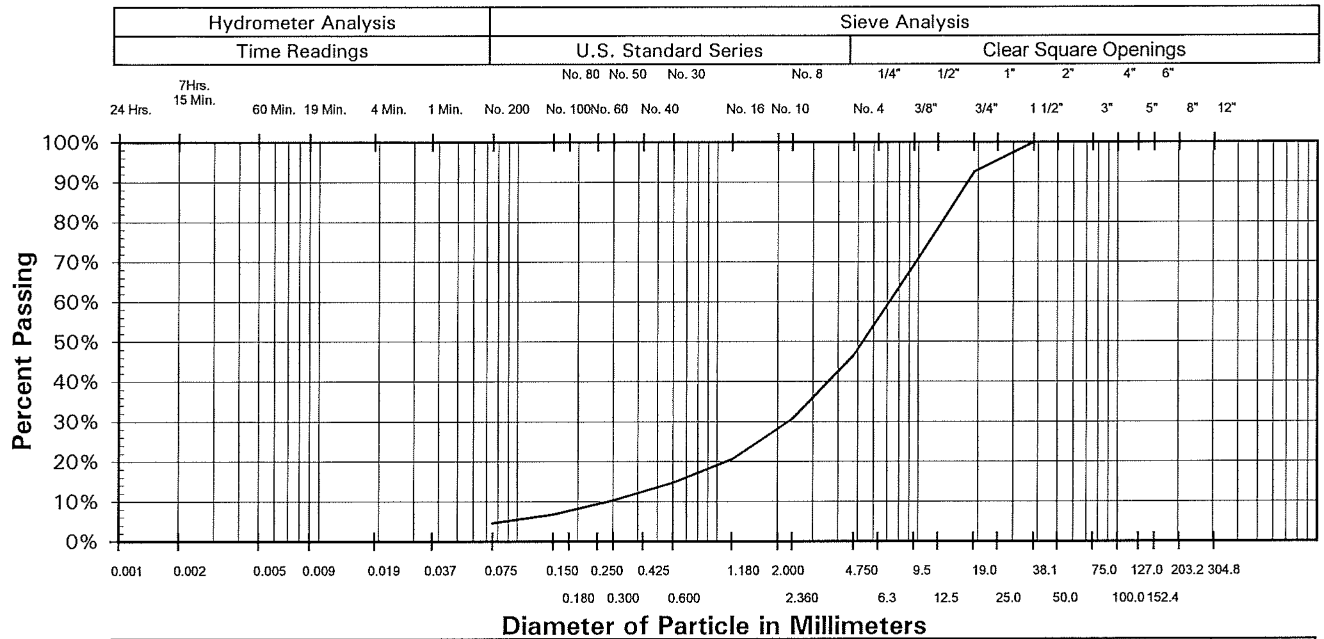
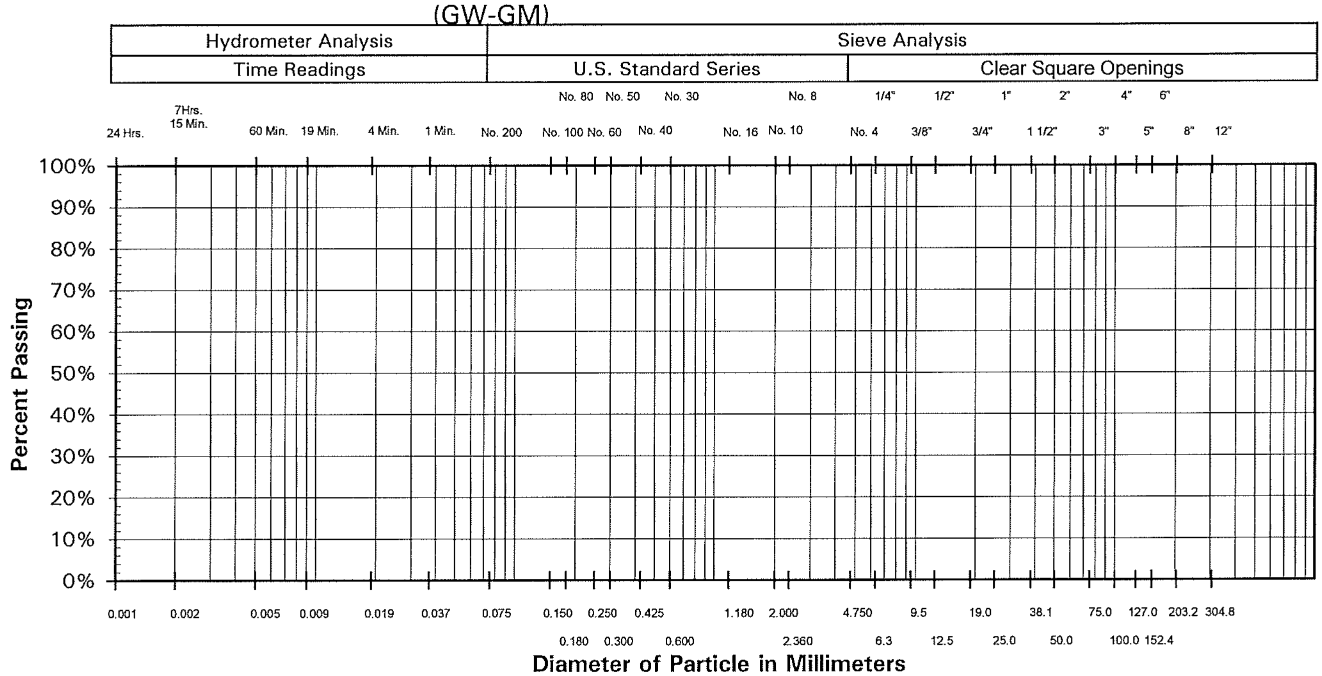


Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel	53%	Liquid Limit	-
Sand	42%	Plasticity Index	-
Silt and Clay	5%	Sample Location	TP-10 at 16 feet

Sample Description Well-graded Gravel with Silt and Sand (GW-GM)



Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel		Liquid Limit	-
Sand		Plasticity Index	-
Silt and Clay		Sample Location	

Sample Description

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NUMBER 1150963

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION			ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	WATER SOLUBLE SULFATE (%)	SAMPLE CLASSIFICATION
TEST PIT	DEPTH (FEET)			GRAVEL (%)	SAND (%)	SILT/ CLAY (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
TP-1	5	21		31	59	10					Poorly-graded Sand with Silt and Gravel
TP-2	4	8		66	25	9					Poorly-graded Gravel with Silt and Sand
	18	16					28	14			Argillite Bedrock
TP-3	2	6		46	45	9					Poorly-graded Gravel with Silt and Sand
	5	7		53	38	9					Poorly-graded Gravel with Silt and Sand
TP-5	5	4	92	16	64	20					Silty Sand with Gravel
TP-6	2	7		29	64	7					Poorly-graded Sand with Silt and Gravel
	4	25	98			34					Silty Sand
	9	5		75	20	5					Poorly-graded Gravel with Silt and Sand
TP-7	4	2		18	71	11					Poorly-graded Sand with Silt and Gravel
	6	3	98	1	64	35					Silty Sand

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I

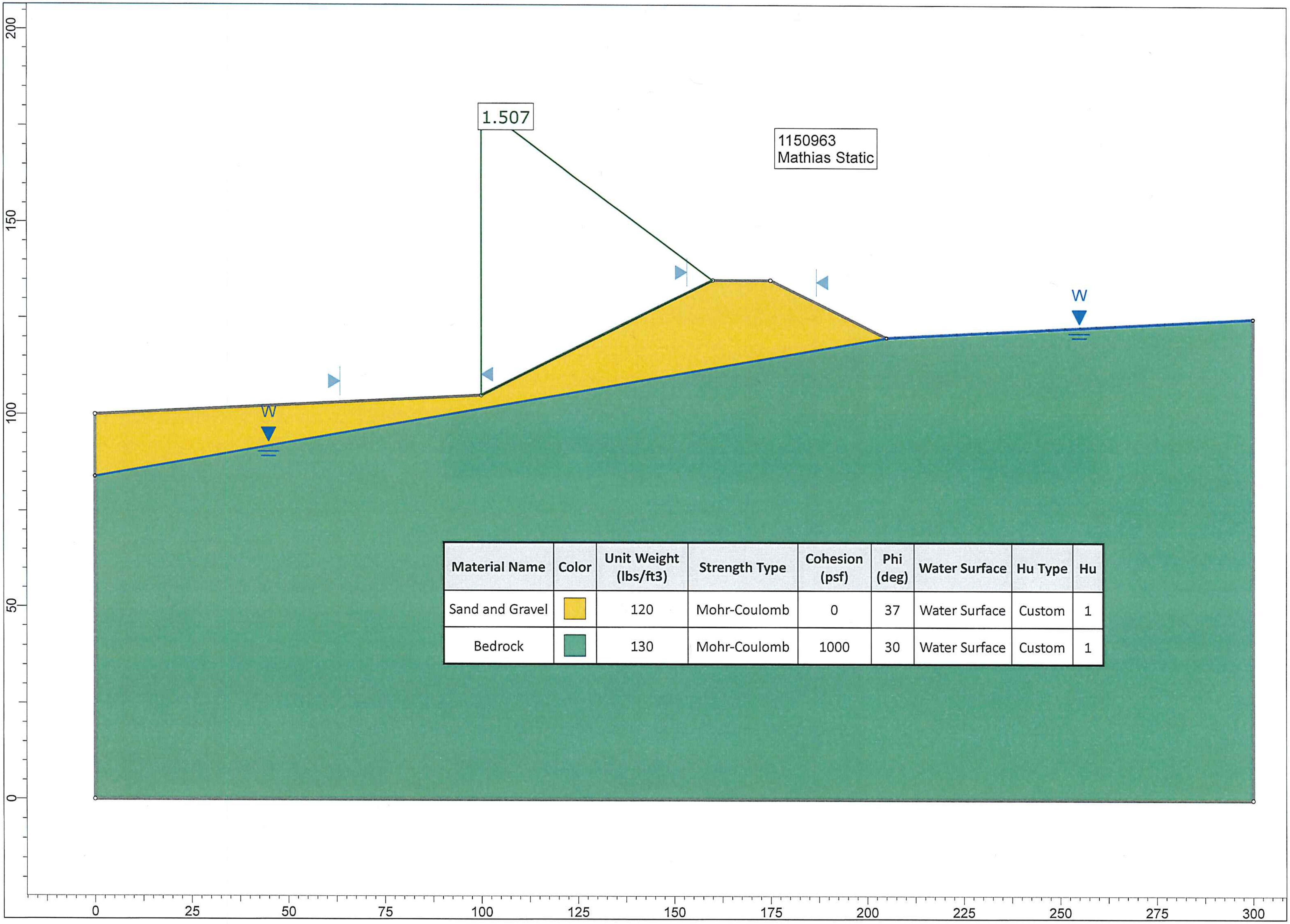
SUMMARY OF LABORATORY TEST RESULTS

PROJECT NUMBER 1150963

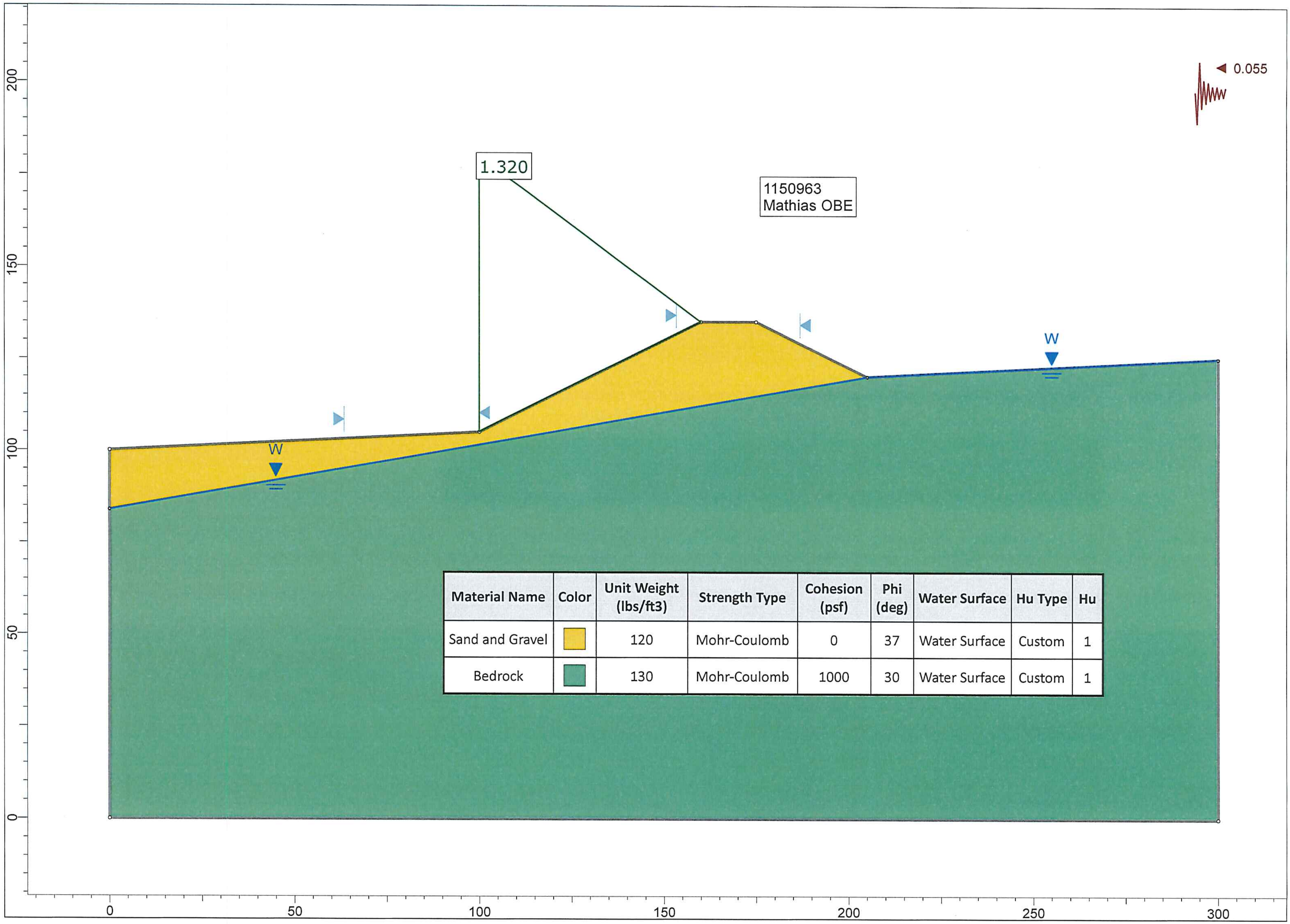
SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION			ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	WATER SOLUBLE SULFATE (%)	SAMPLE CLASSIFICATION
TEST PIT	DEPTH (FEET)			GRAVEL (%)	SAND (%)	SILT/ CLAY (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
TP-8	1 ½	5		70	25	5					Well-graded Gravel with Silt and Sand
TP-9	5	3		67	24	9					Poorly-graded Gravel with Silt and Sand
TP-10	4	3		68	26	6					Well-graded Gravel with Silt and Sand
	16	5		53	42	5					Well-graded Gravel with Silt and Sand

APPENDIX

SLOPE STABILITY PRINTOUTS



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Sand and Gravel		120	Mohr-Coulomb	0	37	Water Surface	Custom	1
Bedrock		130	Mohr-Coulomb	1000	30	Water Surface	Custom	1



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Sand and Gravel		120	Mohr-Coulomb	0	37	Water Surface	Custom	1
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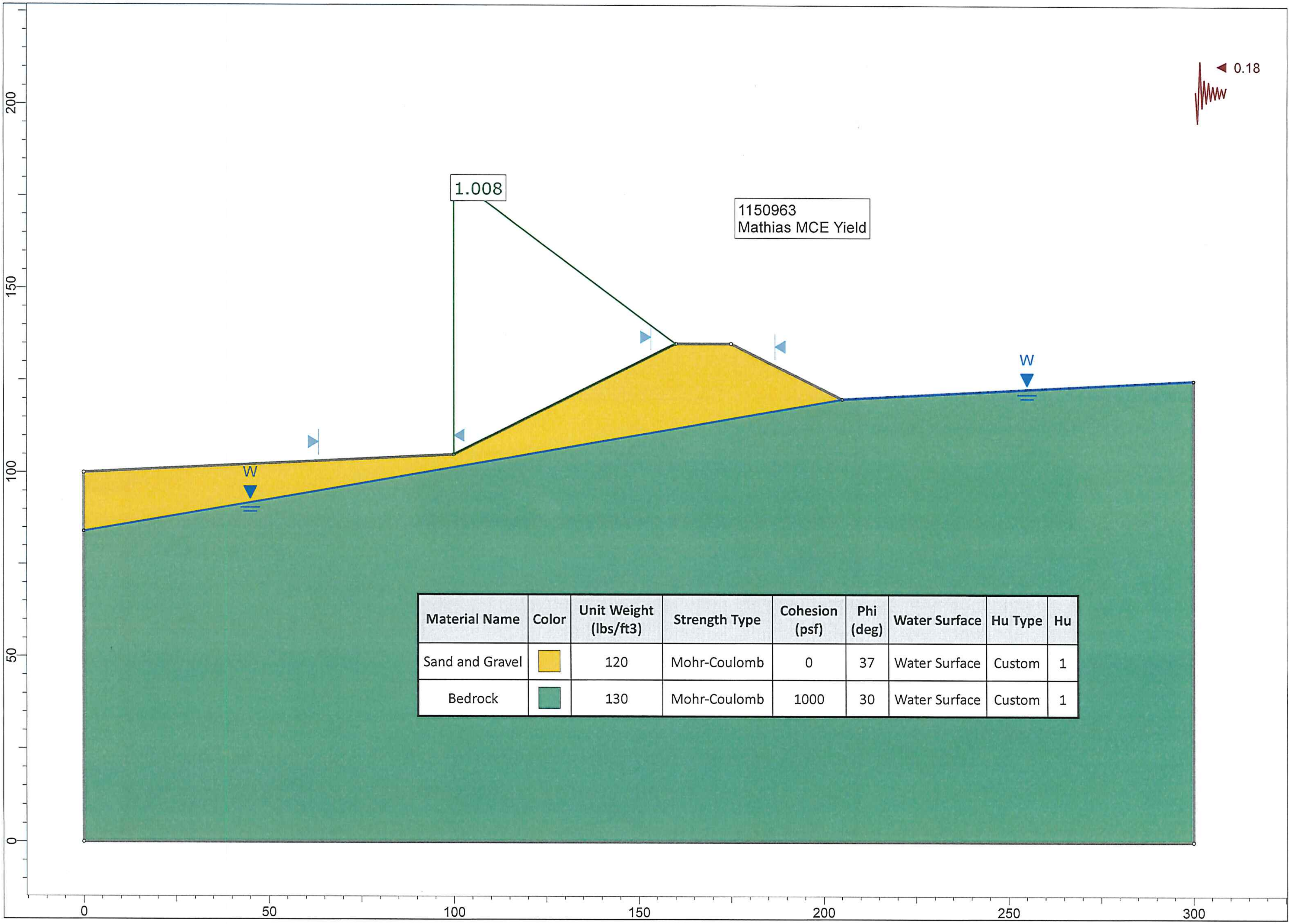

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Sand and Gravel		120	Mohr-Coulomb	0	37	Water Surface	Custom	1
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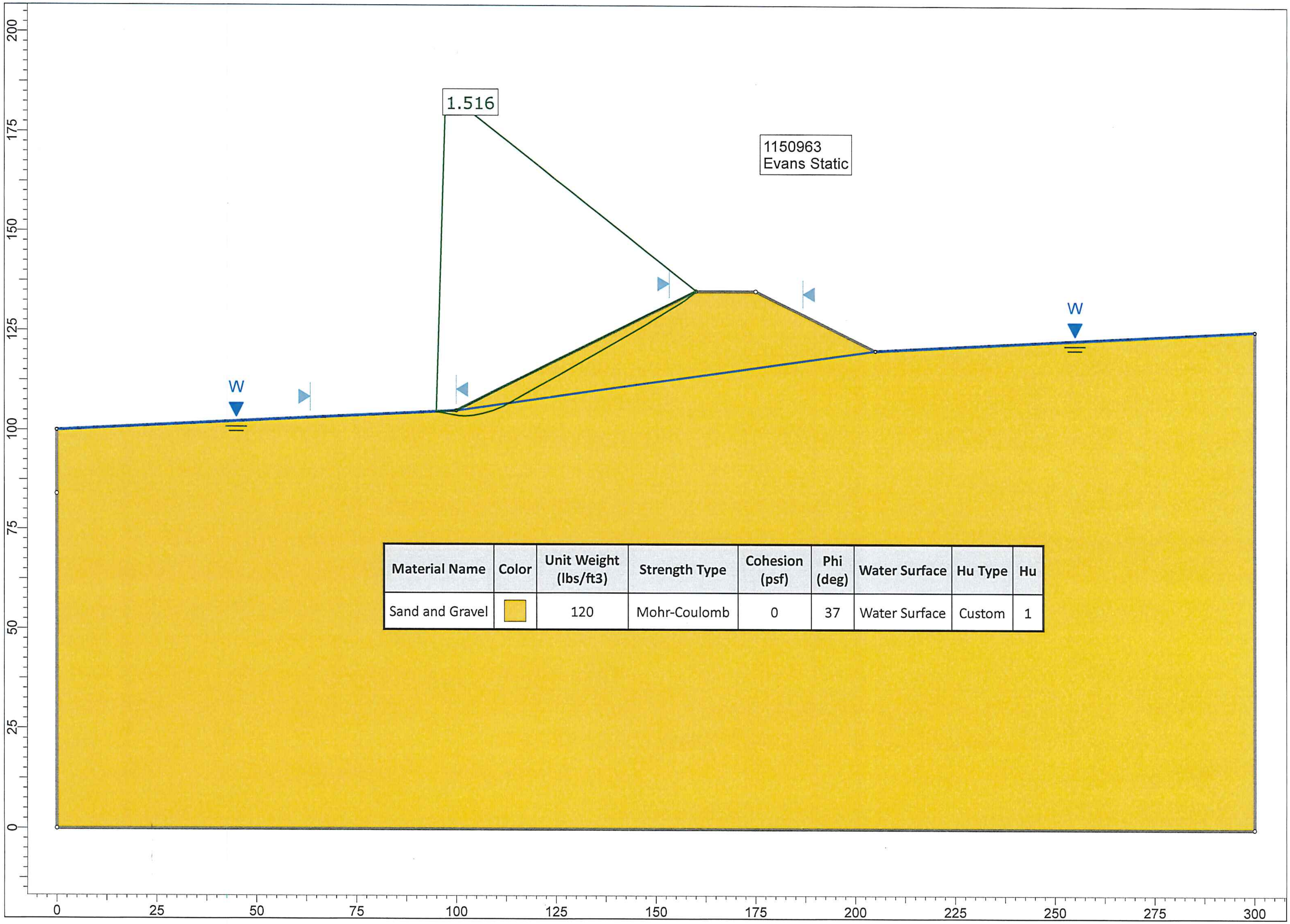
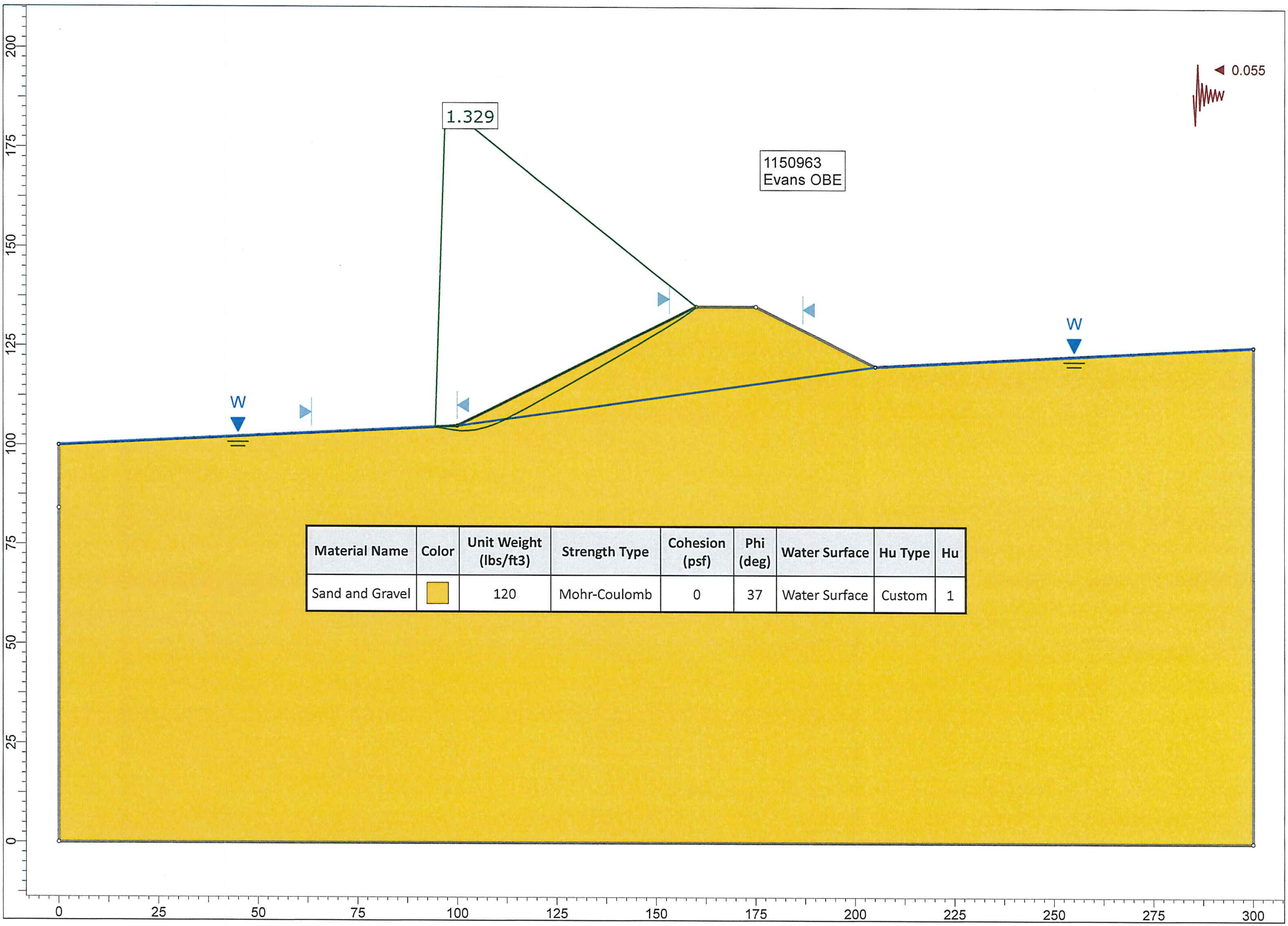
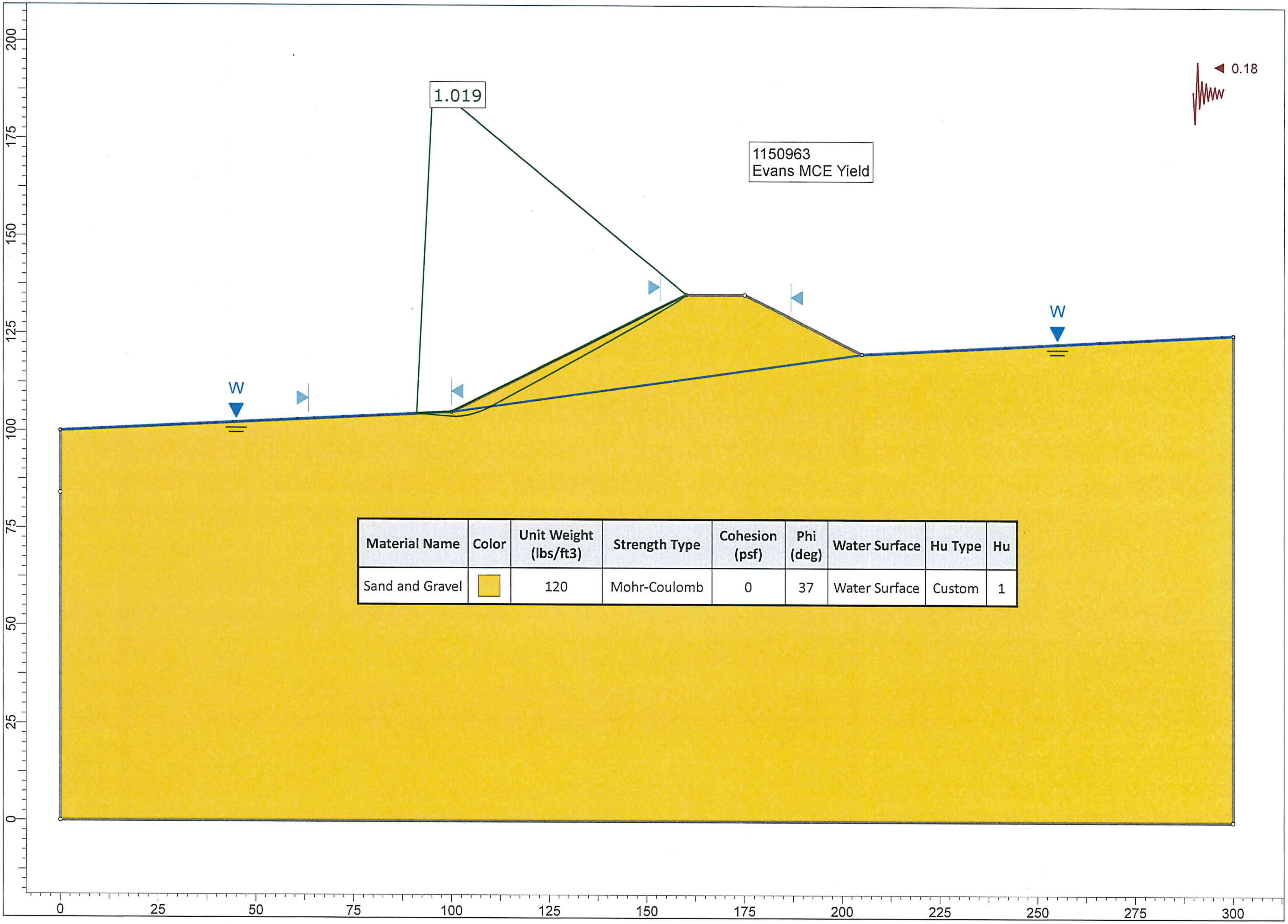

1.516
1150963
Evans Static
W
W
Material Name | Color | Unit Weight (lbs/ft3) | Strength Type | Cohesion (psf) | Phi (deg) | Water Surface | Hu Type | Hu
Sand and Gravel | | 120 | Mohr-Coulomb | 0 | 37 | Water Surface | Custom | 1
0
25
50
75
100
125
150
175
200
225
250
275
300



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Sand and Gravel		120	Mohr-Coulomb	0	37	Water Surface	Custom	1



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Sand and Gravel		120	Mohr-Coulomb	0	37	Water Surface	Custom	1

Newmark Displacement Equations

K_y	0.18	g
PGA	0.88	g
M_w	6.95	
V_s	330	m/s
H	9.14	m
S_A	2.13	g
T_s	0.110788	s
$1.5T_s$	0.166182	g

N_{60} vs V_s

		V_s	
N_{60}		Sand only	All Soil Types
	34	1079	968 ft/s
		329	295 m/s

Bray and Travasarou

lnD	4.323347	
D	75.4 cm	29.7 inches

$$\ln D = -1.10 - 2.83\ln(k_y) - 0.333[\ln(k_y)]^2 + 0.566\ln(k_y)\ln(SA_{T=1.5T_s}) + 3.04\ln(SA_{T=1.5T_s}) - 0.244[\ln(SA_{T=1.5T_s})]^2 + 1.5T_s + 0.278(M_w - 7)$$

$\sigma_{\ln D} = 0.66$

D = sliding deformation (cm)
k_y = yield coefficient
T_s = the natural period of the failure mass (sec)
= 4H / V_s (1-dimensional), = 2.6H / V_s (2-dimensional)
$SA_{T=1.5Ts}$ = Spectral acceleration at a period of 1.5*T_s (g)
M_w = Moment magnitude

Saygili and Rathje

lnD	3.944833	
D	51.7 cm	20.3 inches

$$\ln D = 5.52 - 4.43\left(\frac{k_y}{PGA}\right) - 20.39\left(\frac{k_y}{PGA}\right)^2 + 42.61\left(\frac{k_y}{PGA}\right)^3 - 28.74\left(\frac{k_y}{PGA}\right)^4 + 0.72\ln(PGA)$$

$\sigma_{\ln D} = 1.13$

D = sliding deformation (cm)
k_y = yield coefficient (g)
PGA = Peak ground acceleration (g)