Appendix 3: MFWF – 2013 Geotechnical Investigation

GEOTECHNICAL INVESTIGATION
MIDDLE FORK WATER TREATMENT IMPROVEMENTS
GARFIELD COUNTY, COLORADO

September 9, 2013

Prepared For:

Mr. Michael Sanville
Encana Oil & Gas (USA), Inc.
143 Diamond Avenue
Parachute, CO 81635

Prepared By:

Yeh and Associates, Inc.
1525 Blake Avenue
Glenwood Springs, CO 81601
Phone (970) 384-1500
Fax (970) 384-1501

Project No. 213-169

TABLE OF CONTENTS

1.0 PROJECT INFORMATION 1
1.1 Purpose and Scope 1
1.2 Proposed Construction 1
1.3 Site Conditions 1
1.4 Site Geology 2

2.0 SITE INVESTIGATION 2
2.1 Subsurface Investigation 2
2.2 Subsurface Conditions 3
2.2.1 Groundwater 3

3.0 SITE GRADING 4

4.0 FOUNDATION RECOMMENDATIONS 4

5.0 SLABS ON GRADE 5

6.0 SEISMIC CONSIDERATIONS 5

7.0 LIMITATIONS 6

LIST OF TABLES

Table 1 – Seismic Design Parameters 5
Table 2 – Seismic Design Parameters for Site Class D 6

LIST OF FIGURES

Figure 1 – Approximate Site Location
Figure 2 – Approximate Test Hole Locations
Figure 3 – Drill Log and Legend
Figures 4 through 8 – Laboratory Test Results
Summary Table and Laboratory Test Results

1.0 PROJECT INFORMATION

1.1 Purpose and Scope

This report presents the results of our geotechnical investigation for the proposed building adjacent to Pump House No. 1 at the Middle Fork Water Treatment Plant within the Middle Fork Compressor Station in Garfield County, Colorado (Figure 1). The investigation was performed to provide recommendations for foundation design and construction of a building at this site.

The site investigation consisted of geologic reconnaissance and exploratory test hole drilling to investigate subsurface conditions. Test hole drilling was observed by a representative of Yeh and Associates. One test hole was drilled as close as possible to the proposed structure and the location was dependant on existing utilities. Samples obtained during the field exploration were examined by the project personnel and representative samples were subjected to laboratory testing to determine the engineering characteristics of materials encountered. This report summarizes our field investigation, the results of our analyses, and our conclusions and recommendations based on the proposed construction, site reconnaissance, subsurface investigation and results of the laboratory testing.

1.2 Proposed Construction

We believe the proposed construction will be a single-story structure consisting of steel and metal. We anticipate building construction will be slab-on-grade construction with the finish floor elevation close to the existing floor slab elevation of the adjacent Pump House No. 1. Foundation loads will likely be on the order of 1,000 to 3,000 pounds per linear foot. The structure will enclose existing piping and valves. Based on a grading plan provided, a proposed cut slope on the north side of the proposed structure is assumed to be between 1.5H and 2H:1V.

1.3 Site Conditions

The Middle Fork Compressor Station is located approximately 11 miles north of Interstate 70 at Parachute, Colorado on Garfield County Road 215 (Figure 1). The site address is posted as 10652 County Road 215. Middle Fork Compressor Station is a fully operational gas gathering facility complete with structures and equipment necessary for natural gas production, collection and distribution. The proposed site was located north of the existing HDPE lined pond and immediately west of Pump House No. 1. The site consisted of existing above grade piping and valves. Numerous underground utilities were present. The site sloped moderately down to the

southeast at a grade of about 8 percent and was approximately 5849 feet above mean sea level. The site is surrounded by existing structures, ponds and piping to the east, west and south. The north edge of the site is bounded by an access road situated at the toe of an existing slope. The site had been previously graded and was barren of vegetation. Access to the site was gained on an unimproved, dirt access road.

1.4 Site Geology

The project area was located in the Roan Plateau area of the northern Piceance Basin of western Colorado, a major gas production area made up of high plateaus, mesas, ridges and deep valleys. The site was on the valley floor of the Parachute Creek drainage, near of the confluence of East Fork and Middle Fork of Parachute Creek, and approximately one-fourth mile northeast of the confluence of West Fork and Parachute Creek. The site was bounded to the north by the southwest edge of Long Ridge and to the south by Lindauer Point. The proposed building site was located on commercial/industrial property that is the location of the Encana Oil and Gas Middle Fork Compressor Station.

The project area was located on alluvium, which included material ranging in size from clay and silt to gravel. Underlying the site and in the hillsides in all directions from the site, was the gray shale and marlstone of the Tertiary age Garden Gulch Member of the Green River Formation.

2.0 SITE INVESTIGATION

2.1 Subsurface Investigation

One test hole was drilled on August 14, 2013 at a location as close to the proposed structure as possible as dictated by existing underground utilities and at the direction of Encana personnel. Prior to test hole drilling, a soil vacuumed pothole was excavated to a depth of approximately 6 feet, where conventional drilling and sampling methods were performed. The test hole depth was drilled to 46.7 feet below existing grade. The location of the test hole is presented in Figure 2. The test hole was advanced with a CME 55 rubber track rig using 4-inch continuous flight auger to pre-determined depths where a modified California or split-spoon sampler was used to record blow counts and obtain samples.

To perform the modified California penetration resistance tests, a 2.0-inch inside diameter sampler was seated at the bottom of the test hole, then driven up to 12 inches with blows of a standard hammer weighing 140 pounds and falling a distance of 30 inches utilizing a “auto

hammer" (ASTM D1586). The number of blows required to drive the sampler 12 inches or a fraction thereof, constitutes the N-value. The N-value, when properly evaluated, is an index of the consistency or relative density of the material tested. Split-spoon samples were obtained in the same manner with a 1.5-inch inside diameter sampler. The test hole log and legend are presented on Figure 3.

2.2 Subsurface Conditions

Subsurface conditions generally consisted of about 8 feet of clayey, sandy gravel and cobbles over clayey sand to a depth of about 25 feet over clay to a depth of approximately 46 feet. At that depth, weathered bedrock to comparatively unweathered shale bedrock was encountered to the bottom of the test hole at 46.7 feet. The shale bedrock appeared to be strongly cemented. Practical drill rig refusal was encountered at 46.7 feet.

One gravel sample tested had 13 percent fines (material passing the No. 200 sieve). Atterberg limit testing on the gravel sand sample indicated a liquid limit of 37 percent and a plastic index of 17 percent. Three sand samples tested had 39 to 48 percent fines. Atterberg limit testing on two of these sand samples indicated liquid limits of 40 to 43 percent and plastic indices of 17 to 20 percent. One of the sand samples was also subjected to swell/consolidation testing. Test results indicated a low collapse of -0.3 percent when wetted under an applied pressure of 1,000 psf. The sand was very loose to medium dense and classified as an SC according to the Unified Soil Classification System (USCS). The gravel was dense and classified as GC. Results of the laboratory testing are presented in Figures 4 through 8 and are summarized in the Summary of Laboratory Test Results.

2.2.1 Groundwater

Groundwater was encountered at a depth of 17 feet during drilling. Measurement of subsequent groundwater levels was not possible because the test hole was backfilled for safety reasons. Variations in groundwater conditions may occur seasonally. The magnitude of the variation will be largely dependent upon the amount of spring snowmelt, duration and intensity of precipitation, site grading changes, and the surface and subsurface drainage characteristics of the surrounding area.

3.0 SITE GRADING

Cuts of up to 6.5 feet may be necessary along the west and north sides of the building to achieve a level floor elevation. Based on our observations, we believe that material can be excavated by conventional construction equipment. Fills should be minimal. Permanent cut slopes could be constructed at 1.5 to 2H:1V as proposed, but flatter slopes are preferred. Steeper cut and fill slopes have a higher potential for erosion and instability. Measures should be implemented to reduce erosion potential. Surface flows should not be directed over cut or fill slopes.

If fills are required, the on-site cut soils can be used in site grading fills provided the material is substantially free of organic material, debris and particles are no larger than 6 inches. Areas to receive fill should be stripped of vegetation, organic soils and debris. Topsoil is not recommended for fill material. Fill should be placed in thin, loose lifts of 8 inches thick or less. We recommend fill materials be moisture conditioned to within 2 percent of optimum moisture content and compacted to at least 95 percent of maximum standard Proctor dry density (ASTM D 698). Placement and compaction of fill should be observed and tested by a representative of the geotechnical engineer.

4.0 FOUNDATION RECOMMENDATIONS

We believe the structure can be supported on a footing placed on clayey gravelly soils. We anticipate foundation soils would consist of low collapsing soils. We believe there is a low risk of settlement related damage due to collapsible soils and therefore a low risk of foundation movement. We estimate foundation settlement of about 1-inch or less. Foundation recommendations for structures are presented below.

1. Loose, disturbed soils encountered at foundation level should be removed and the foundation should be extended to relatively undisturbed soil and/or properly compacted fill could be placed.

2. Foundations can be designed for a maximum allowable soil pressure of 1,700 psf.

3. Resistance to sliding at the bottom of the mat foundation can be calculated based on a coefficient of friction of 0.30. Passive pressure against the side of the footing can also be considered for the sliding resistance if it is properly compacted. Passive pressure can be estimated based on an equivalent fluid density of 300 pcf for a level backfill. For below grade walls for the sump, an active pressure can be based on an equivalent fluid density of 55 pcf.

4. The soils below foundations should be protected from freezing. We recommend the bottom of foundations be constructed at least 3.5 feet below finished exterior grade or as required by local municipal code.

5. All foundation excavations should be observed by a representative of the geotechnical engineer prior to placement of concrete.

5.0 SLABS ON GRADE

Based on our investigation, slabs will likely be underlain by controlled fill or clayey gravel. We believe there is a low risk of poor slab-on-grade performance due to swelling and collapsible soils. We anticipate similar movements to what was estimated in the foundation section. Onsite material substantially free of organics and debris, may be suitable to support lightly loaded slabs-on-grade. Slabs should be separated from all load bearing walls and columns with expansion joints that allow movement. Control joints should be used to reduce damage from shrinkage cracking. The soils below exterior edges of structural slabs should be protected from freezing. We recommend the bottom of turned down edges or thickened slab be constructed at least 3.5 feet below finished exterior grade or as required by local municipal code. All fill below slabs should be compacted to at least 95 percent of maximum standard Proctor dry density within 2 percent of optimum moisture content.

6.0 SEISMIC CONSIDERATIONS

The project is located at approximate latitude 39.580 and longitude -108.105. The site is classified as Site Class D. The Peak Ground Acceleration (PGA), and the short- and long-period spectral acceleration coefficients (SS and S1 respectively) for the site were obtained using the USGS 2007 Seismic Parameters for an event with a 7% Probability of Exceedance (PE) in 75 years and a Site Class B (reference site). An event with the above probability of exceedance has a return period of about 1,000 years. The values were adjusted using Site Factors for Site Class D in accordance with 2006 International Building Code, Table No. 1613.5.3 (1) and (2). The seismic parameters for this site are shown in the tables below.

Table 1 – Seismic Design Parameters

PGA (0.0 sec)	Ss (0.2 sec)	S1 (1.0 sec)
0.086	0.175	0.041

Table 2 – Seismic Design Parameters for Site Class D

As (0.0 sec)	SDs (0.2 sec)	SD1 (1.0 sec)	Seismic Zone
0.138 g	0.279 g	0.099 g	1

7.0 LIMITATIONS

This study was conducted in accordance with generally accepted geotechnical engineering practices in this area for use by the client for design purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from exploratory test holes, field reconnaissance and anticipated construction. The nature and extent of subsurface variations across the site may not become evident until excavation is performed. If during construction, conditions appear to be different from those described herein; this office should be advised at once so reevaluation of the recommendations may be made. We recommend on-site observation of excavations by a representative of the geotechnical engineer.

The scope of services for this project did not include, specifically or by implication, any environmental or biological (e.g., mold, fungi, and bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions or biological conditions. If the owner is concerned about the potential for such contamination, conditions or pollution, other studies should be undertaken.

The report was prepared in substantial accordance with the generally accepted standards of practice for geotechnical engineering as exist in the site area at the time of our investigation. No warranties, express or implied, are intended or made.

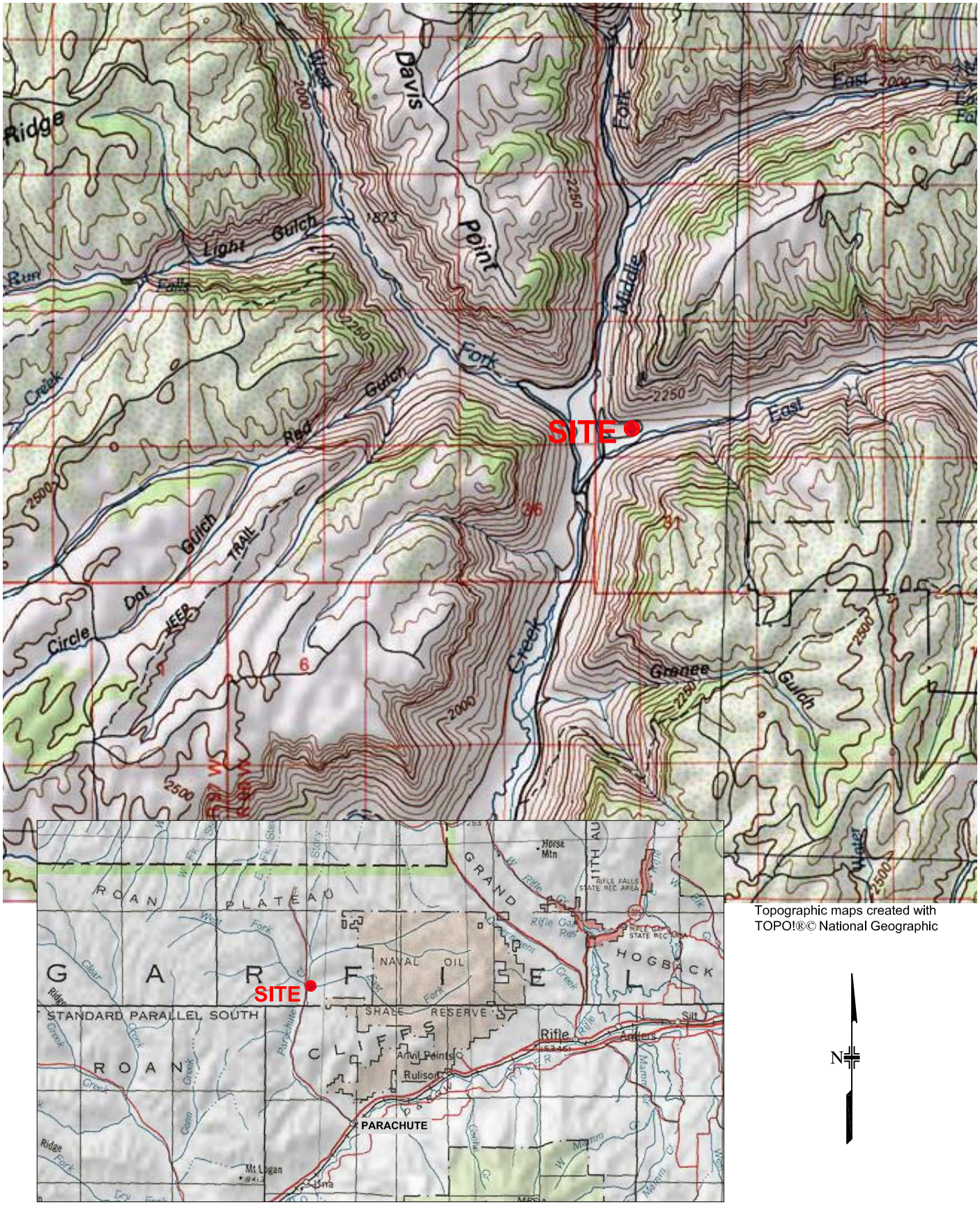
Respectfully Submitted:

YEH AND ASSOCIATES, INC.

Reviewed by:

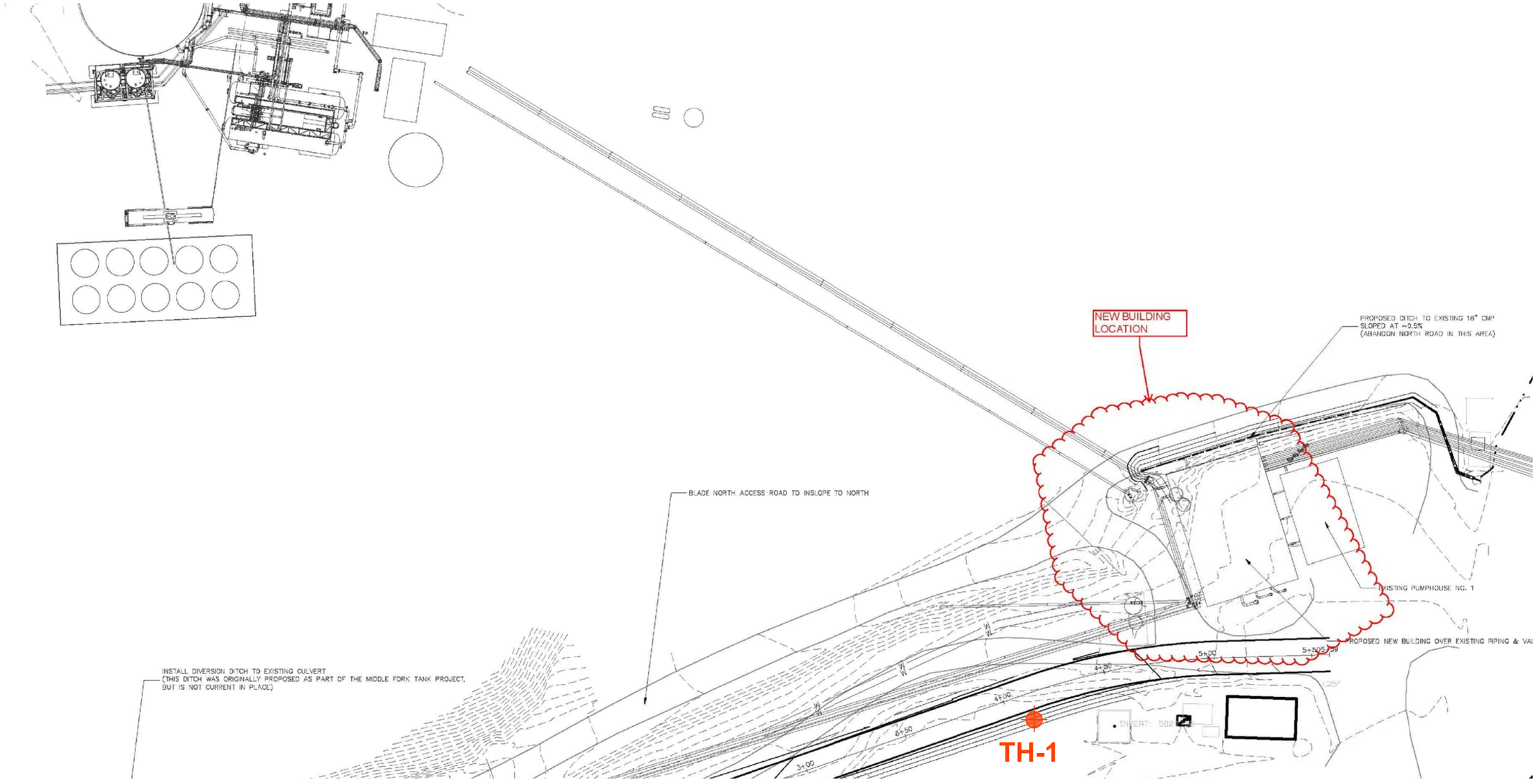
Keith E. Asay
Staff Engineer

Richard D. Johnson, P.E.
Project Manager



Yeh and Associates, Inc. Consulting Engineers & Scientists	DRAWN BY: SW DATE: 8/30/13 CHECKED BY: RDJ DATE: 8/30/13 DESIGNED FOR: Encana Oil & Gas, USA PROJECT NUMBER: 213-169 SCALE HORIZ: NOT TO SCALE VERT: NOT TO SCALE	PROJECT: Middle Fork Water Treatment Plant **Approximate Site Location**

FIGURE
1



Approximate Test Hole Location

TH-1

NOTE:
1. BORING LOCATION WAS NOT SURVEYED AND IS APPROXIMATE.
2. DRAWING BASED ON PLAN SET DATED AUGUST 6, 2013, PROVIDED BY ENCANA OIL & GAS

N

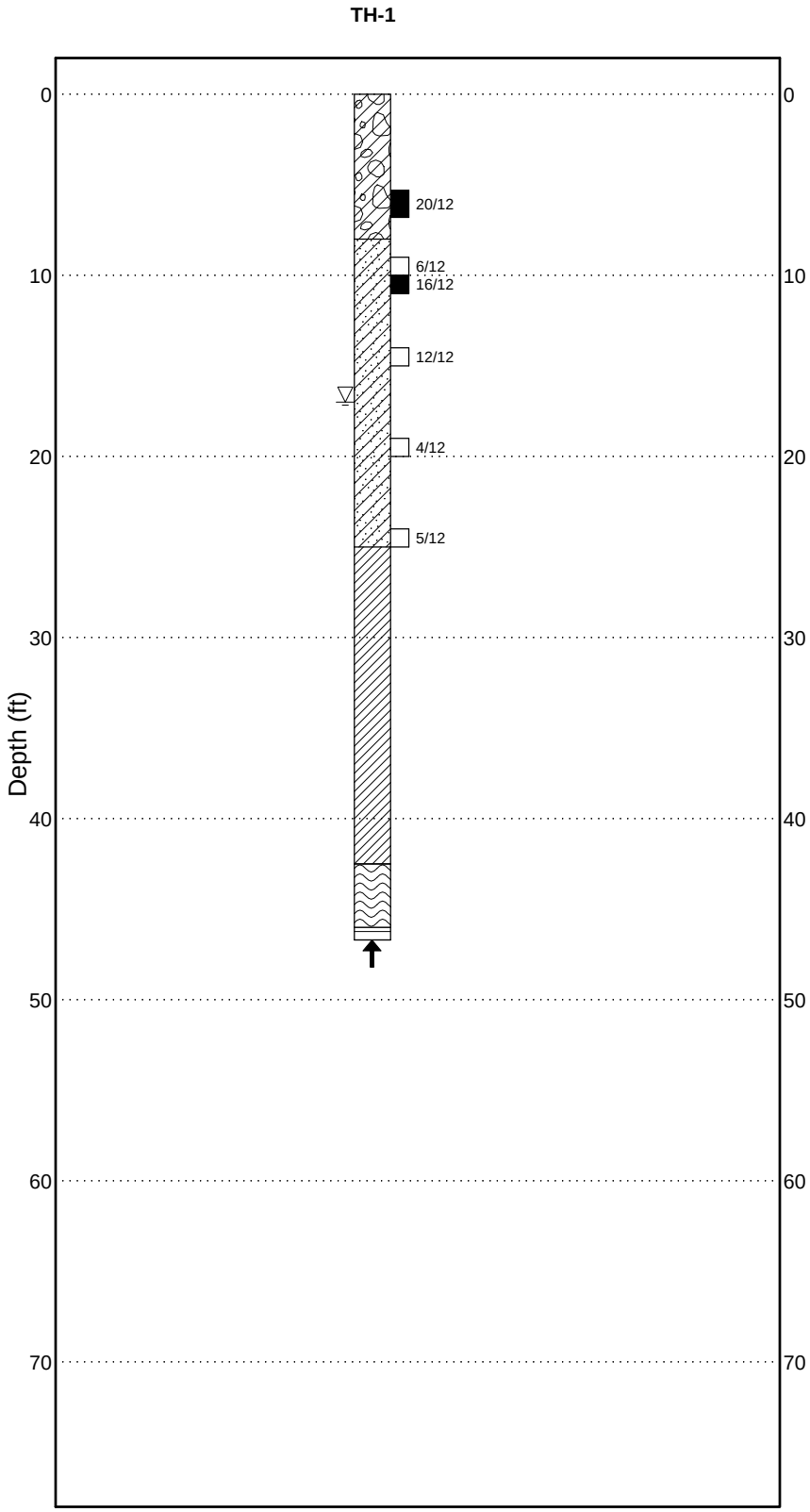
Yeh and Associates, Inc.
Consulting Engineers & Scientists

DRAWN BY: SW	DATE: 8/30/13
CHECKED BY: RDJ	DATE: 8/30/13
DESIGNED FOR: ENCANA OIL & GAS, USA	
PROJECT NUMBER: 212-012	
SCALE	
HORIZ: 1" = 50'	VERT: 1" = 50'
0 25' 50'	

PROJECT:
Middle Fork Water Treatment Plant

Approximate Test Hole Locations

FIGURE 2



Legend

Sample Types

Split Spoon Sampler. The symbol 15/12 indicates that 15 blows from a 140 pound hammer falling 30 inches was used to drive 1.5-inch I.D. sampler 12 inches.

Modified California Sampler. The symbol 16/12 indicates that 16 blows from a 140 pound hammer falling 30 inches was used to drive 2-inch I.D. sampler 12 inches.

Other Symbols

Indicates approximate ground water level at time of drilling

Indicates practical drill rig refusal.

Soil Lithology

GRAVEL, clayey, sandy, with cobbles up to 6-inch diameter, slightly moist, dense, brown, black (GC).

CLAY, wet, medium stiff, gray, brown, rust (CL).

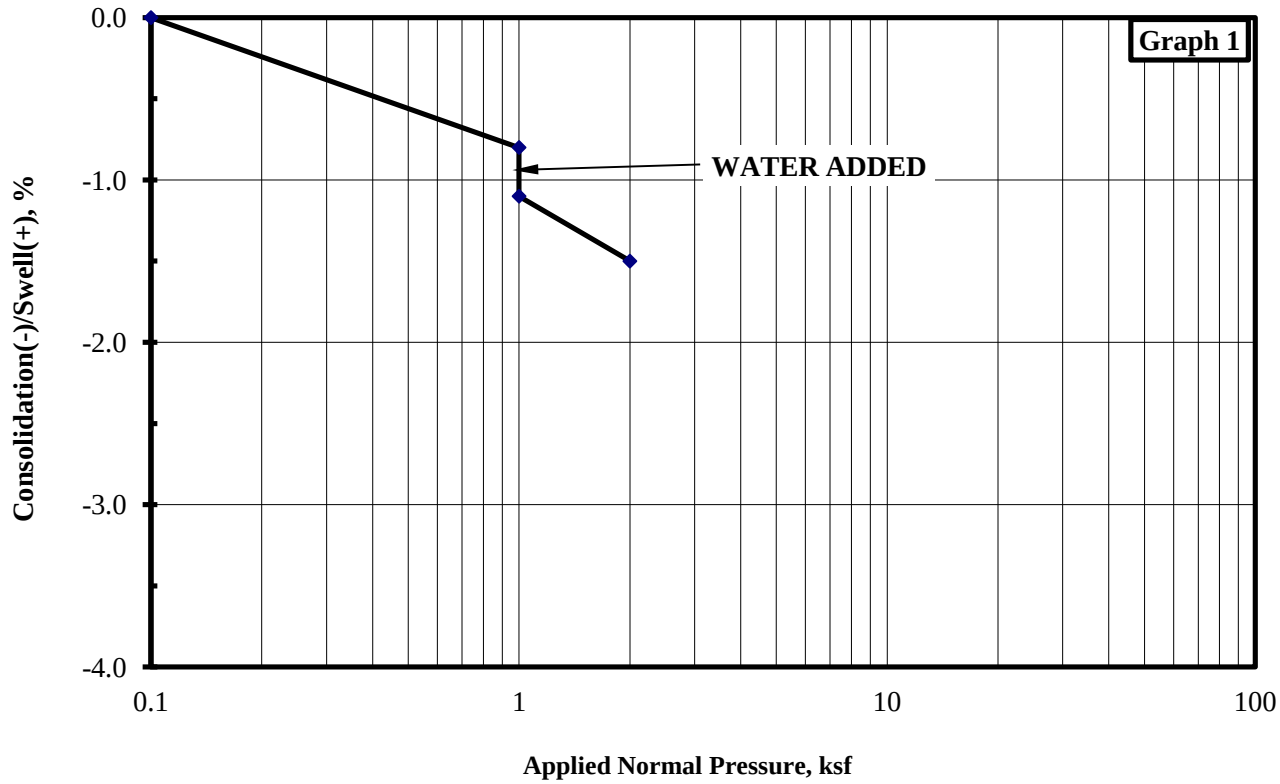
SAND, clayey, occasional gravel, slightly moist to wet, very loose to medium dense, gray, brown, rust (SC).

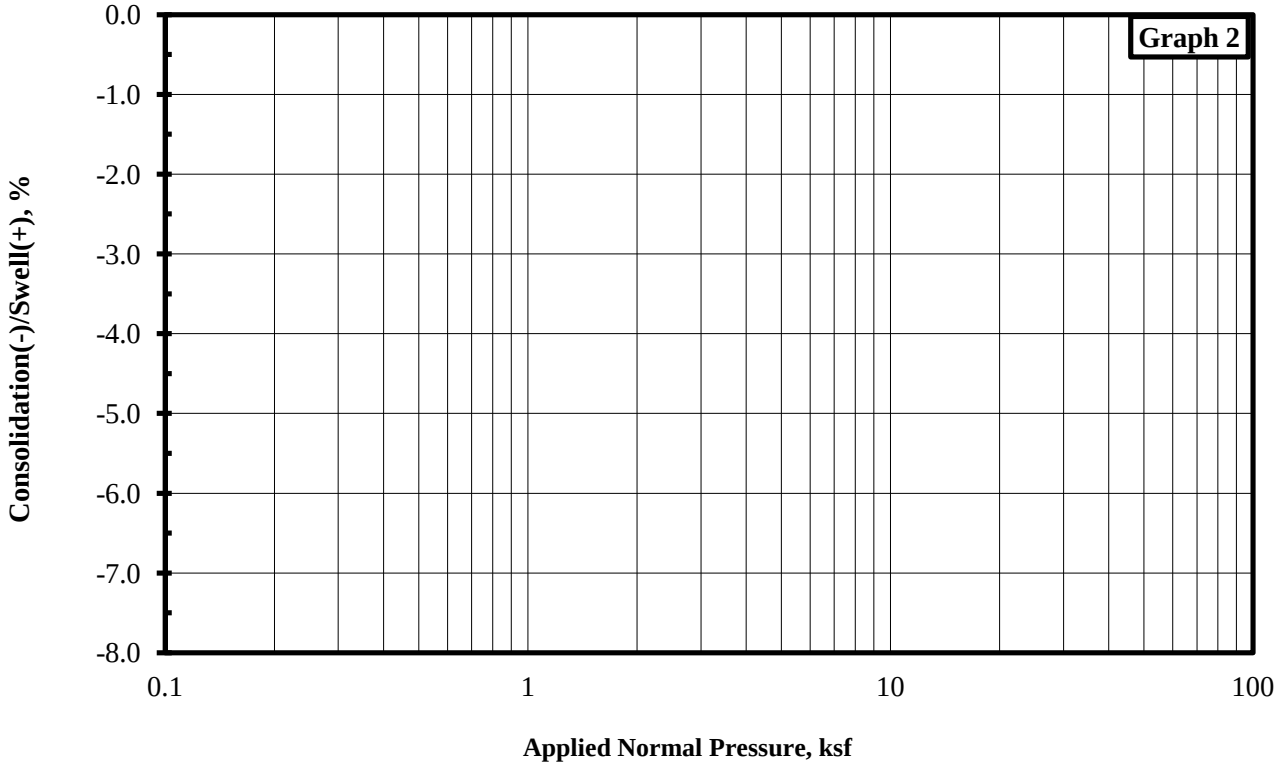
Bedrock Lithology

Weathered Bedrock

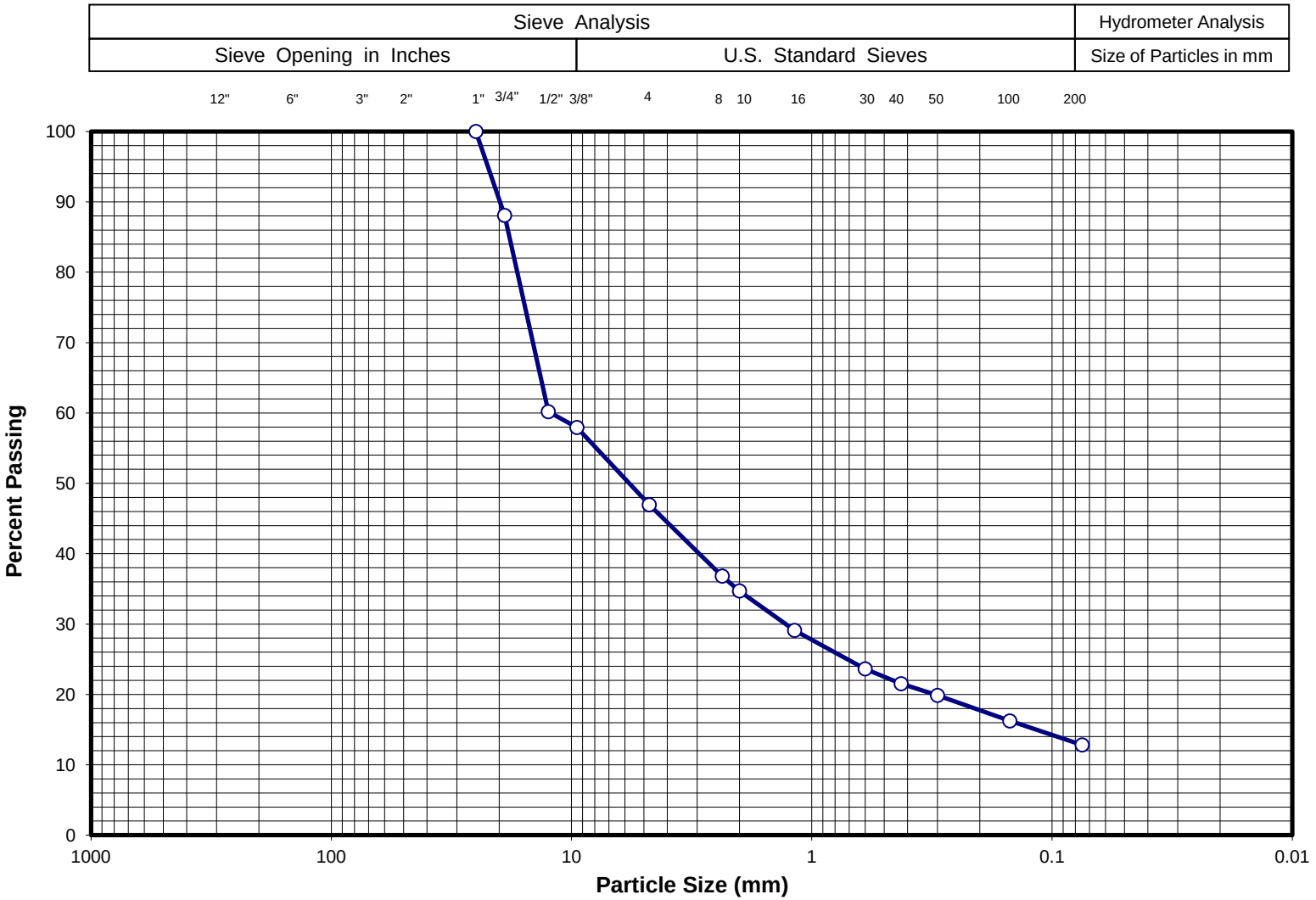
SHALE BEDROCK, hard to very hard, gray.

NOTES:
1. Test hole was drilled on August 14, 2013 with 4-inch continuous flight auger.
2. Test hole descriptions are subject to explanations contained in this report.
3. Test hole locations were hand surveyed in field by Yeh & Associates based on plans provided by client.





Graph Number	Boring Number	Depth (ft)	Natural Dry Density (pcf)	Moisture Content (%)	Swell(+) / Consolidation(-) (%)	Soil Description	SWELL / CONSOLIDATION GRAPH
1	TH-1	14	103	14.8	-0.3	SAND, clayey (SC)	Drawn By: SW
2							Checked By: RDJ
Job No:	213-169	Project Name:	Middle Fork Water Facility Improvements				Figure 4
YEH & ASSOCIATES, INC.							



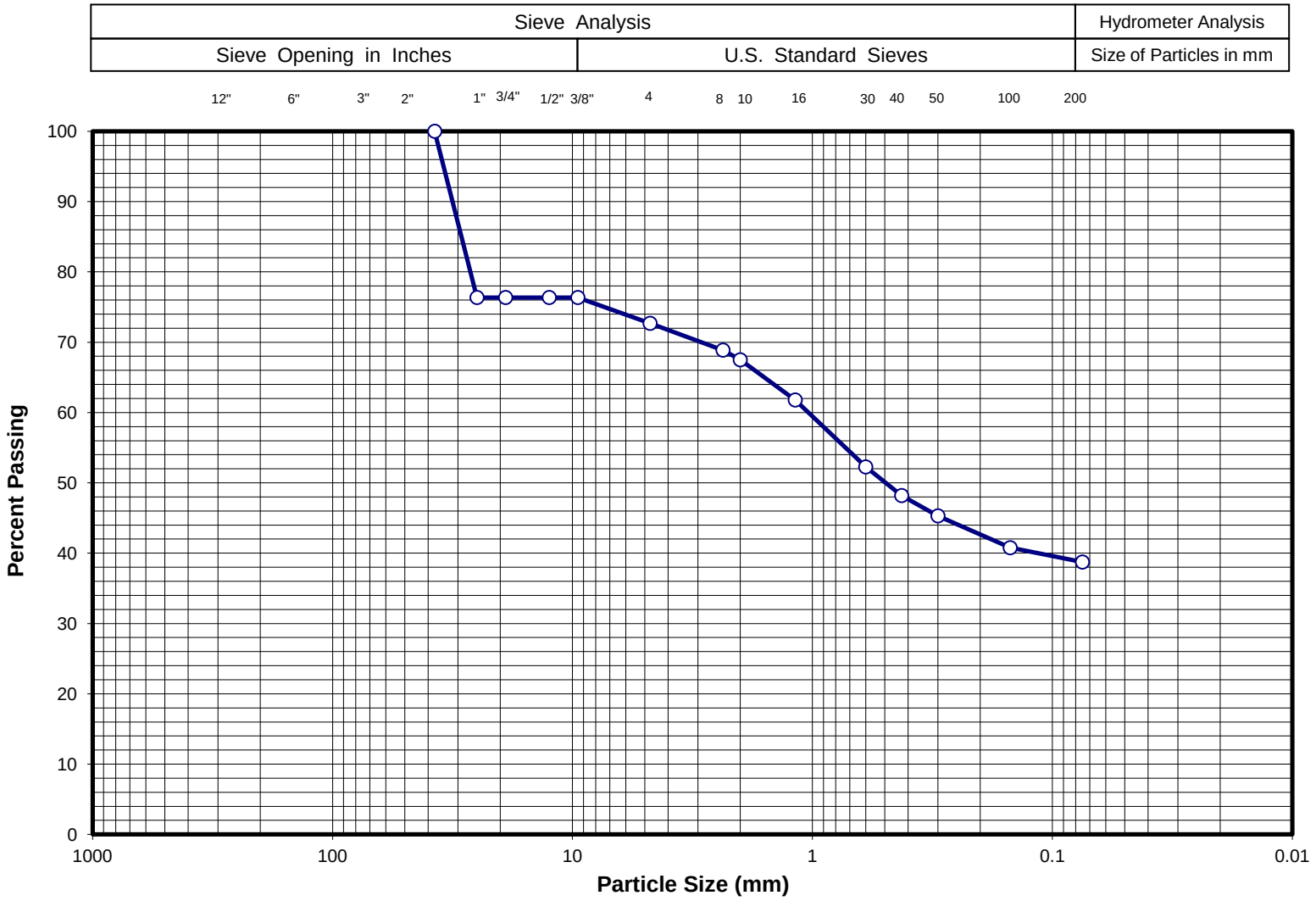
Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	100
¾ "	88
½"	60
⅜"	58
#4	47
#10	35
#40	22
#200	13

Gravel (%)	53	LL	37	Project Name:	Middle Fork Water Facility Improvements
Sand (%)	34	PL	20	Sample ID:	TH-1
Fines (%)	13	PI	17	Sample Depth (ft.):	5
Sample Description:	GRAVEL, clayey (GC)				

Yeh & Associates, Inc.
Geotechnical Engineering Consultants

SIEVE ANALYSIS

Drawn By:	SW	Project No.:	213-169
Checked By:	RDJ	Figure No.:	5



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	100
1"	76
¾ "	76
½"	76
⅜"	76
#4	73
#10	67
#40	48
#200	39

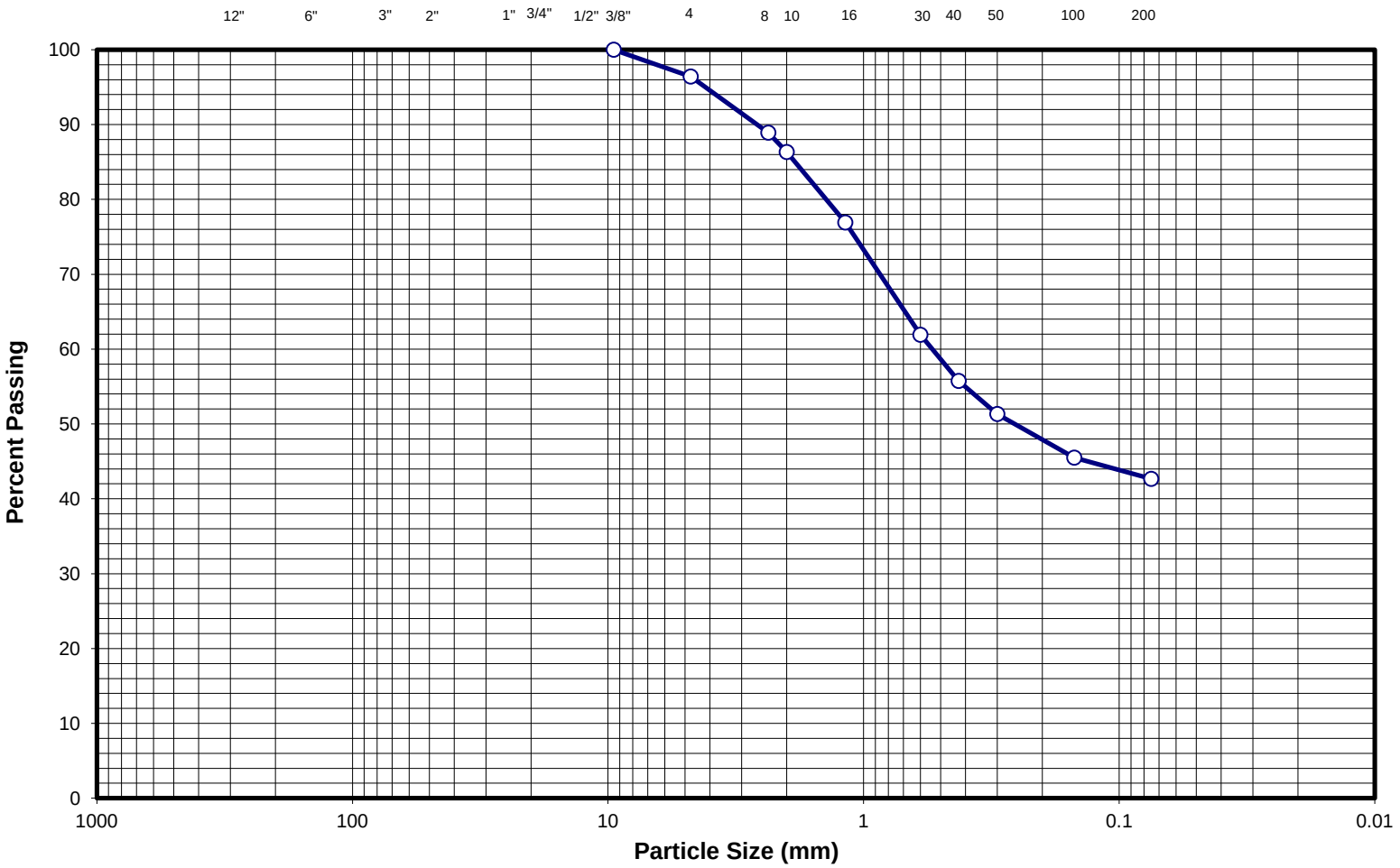
Gravel (%)	27	LL	43	Project Name:	Middle Fork Water Facility Improvements
Sand (%)	34	PL	23	Sample ID:	TH-1
Fines (%)	39	PI	20	Sample Depth (ft.):	14
Sample Description:	SAND, clayey (SC)				

Yeh & Associates, Inc.
Geotechnical Engineering Consultants

SIEVE ANALYSIS

Drawn By:	SW	Project No.:	213-169
Checked By:	RDJ	Figure No.:	6

Sieve Analysis		Hydrometer Analysis
Sieve Opening in Inches	U.S. Standard Sieves	Size of Particles in mm



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	-
¾ "	-
½"	-
⅜"	100
#4	96
#10	86
#40	56
#200	43

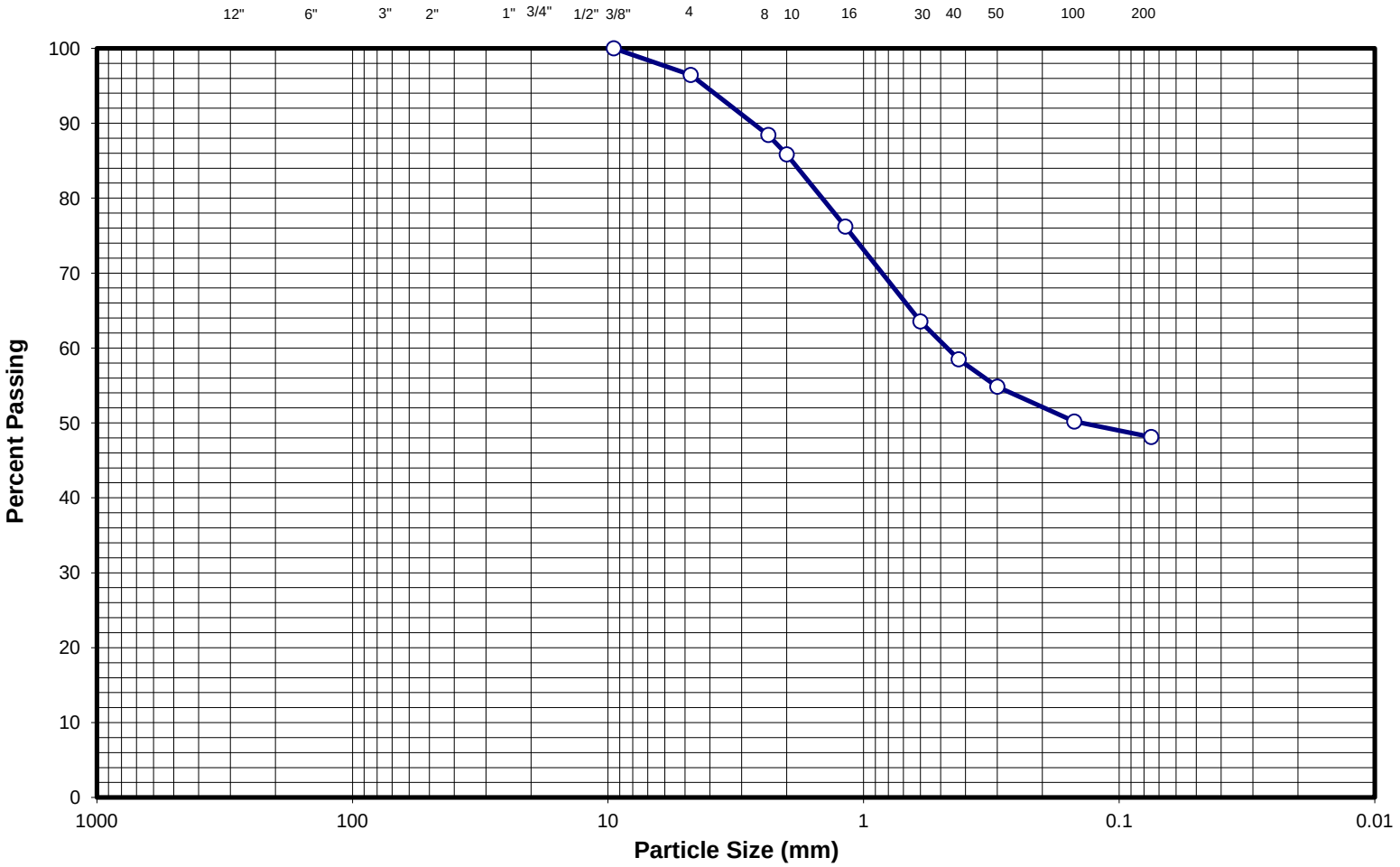
Gravel (%)	4	LL	40	Project Name:	Middle Fork Water Facility Improvements
Sand (%)	53	PL	23	Sample ID:	TH-1
Fines (%)	43	PI	17	Sample Depth (ft.):	19
Sample Description:	SAND, clayey (SC)				

Yeh & Associates, Inc.
Geotechnical Engineering Consultants

SIEVE ANALYSIS

Drawn By:	SW	Project No.:	213-169
Checked By:	RDJ	Figure No.:	7

Sieve Analysis		Hydrometer Analysis
Sieve Opening in Inches	U.S. Standard Sieves	Size of Particles in mm



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	-
¾ "	-
½"	-
⅜"	100
#4	96
#10	86
#40	58
#200	48

Gravel (%)	4	LL	-	Project Name:	Middle Fork Water Facility Improvements
Sand (%)	48	PL	-	Sample ID:	TH-1
Fines (%)	48	PI	-	Sample Depth (ft.):	24
Sample Description:	SAND, clayey (SC)				

Yeh & Associates, Inc.
Geotechnical Engineering Consultants

SIEVE ANALYSIS

Drawn By:	SW	Project No.:	213-169
Checked By:	RDJ	Figure No.:	8

YEH & ASSOCIATES, INC

Summary of Laboratory Test Results

Project No: 213-169 Project Name: Middle Fork Water Treatment Facility Improvements

Sample Location			Moisture Content (%)	Dry Density (pcf)	Grain Size Analysis			Atterberg Limits			Swell (+) / Consolidation (-) at 1,000 psf (%)	Soil Description
Test Hole	Depth (ft)	Sample Type			Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	LL	PL	PI		
TH-1	5	Bulk	6.8		53	34	13	37	20	17		GRAVEL, Clayey, sandy (GC)
	14	CA	14.8	103	27	34	39	43	23	20	-0.3	SAND, clayey with gravel (SC)
	19	CA	31.5	91	4	53	43	40	23	17		SAND, clayey (SC)
	24	CA	27.2	97	4	48	48					SAND, clayey (SC)

CA - Indicates Modified California Sampler