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GEOTECHNICAL ENGINEERING STUDY
HARVIE OPEN SPACE PARK FACILITIES
NORTH SIDE OF MAINSTREET WEST OF POPE ROAD
TOWN OF PARKER, COLORADO

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PURPOSE AND SCOPE

This report presents the findings of a geotechnical study and recommendations for facilities to be developed at Harvie Open Space Park an approximate 71.5-acre site located on the north side of Mainstreet west of Pope Road in Parker, Colorado. The site location is shown on Figure 1. The purpose of the study was to develop recommendations for shelter foundations and subgrade treatment for a gravel surfaced parking lot gravel surfaced lot.

A field exploration program consisting of six exploratory borings and a site reconnaissance was conducted to obtain information on the existing surface and subsurface conditions. Samples of the subsoils obtained during the field exploration were tested in the laboratory to determine their classification and other engineering characteristics. The results of the field exploration and laboratory testing were analyzed to develop recommendations for the proposed shelter structures and gravel parking lot. This report summarizes the data obtained during the study and presents our conclusions, design recommendations and other geotechnical engineering considerations based on the proposed construction and the subsoil conditions encountered.

PROPOSED CONSTRUCTION

The Town of Parker plans to develop this vacant ground into an Open Space Park. Picnic shelters, shade structures, a bridge at isolated locations. The shelters canopies will be subject to uplift due to wind loading. Grading will be minimal due to covenant restrictions. Trails and high use areas will have crushed fines for a surface. Other trails will be graded and left to natural overgrowth.

SITE CONDITIONS

The project area is located in a northeast section of Parker. It is a 71.5 acre parcel bordered by Mainstreet to the south, Pope Road to the east and residential homes along East Quail Creek Drive to the west. The ground surface has a moderate slope up to the north. The slope steepens on the north and east ends where a shade structure and trailside seating will be built. A small rise occurs where the group of trees are located on the southwest side. A small drainage flows south through the center of the site. The trail bridge spans this feature. Vegetation generally consists of native grass, weeds, and isolated groups of deciduous and evergreen trees..

FIELD EXPLORATION

The field exploration consisting of a site reconnaissance and 6 subsurface borings was conducted on December 12, 2017. The boring locations are shown on Figure 2. The borings were drilled using a truck mounted CME-55 drill rig powering 4 inch diameter continuous flight augers. The borings were logged by a representative of H-P/Kumar. Samples of the subsurface materials were obtained with a nominal 2-inch I.D. California sampler. The sampler was driven into the subsoils at various depths with blows from a 140-pound hammer falling 30 inches. This test is similar to the standard penetration test described by ASTM D-1586. Penetration resistance values are an indication of the relative density of cohesionless soils or consistency of cohesive soils. Depths at which the samples were taken and the penetration resistance values are shown on the Boring Logs, Figure 3. The legend and notes relating to the logs are shown on Figure 4. The samples were returned to our laboratory for review by the project engineer and testing.

SUBSURFACE CONDITIONS

The soil found at the site consists of a thin layer of top soil overlying clay and clayey sand that in turn overlies sandstone and claystone bedrock at depth 3 to 15 feet to the maximum depth drilled, 25 feet.

The sandy clay was found only in Borings B-2, B-4 and B-6. Clayey sand was found in all borings, however the percent of minus # 200 sieve (silt and clay) was close to the 50 percent amount making the two soils similar. Some of the clays had Liquid Limits near or over 50 percent making them highly plastic. Swell/compression test results shown on Figures 5 & 6 indicate moderate to high expansive potential. The sample from Boring 1, Parking Lot, swelled almost 10 percent when wetted under a surcharge pressure of 200 psf. This would require swell mitigation if a paved surface were proposed. Sampled from Boring 4, the Farmstead and Boring 5, a Seating Area, had moderately high swell, expansion of 3.6 and 3.7 percent, see Figures 5 & 6. Some samples showed compression on wetting, Figure 6. Gradation test results are plotted on Figures 7 and 8 and show the sand constituent to be fine to course with some gravel sized fraction. The laboratory test results are shown on the Boring Logs, Figures 5 to 8 and summarized on Table 1.

Based on the blow counts required for 12 inches of sampler penetration, the clay was stiff to very stiff, the clayey sand was loose to medium dense and the sandstone and claystone were hard to very hard.

Groundwater was encountered at the time of drilling only in Boring B-1 at depth 23 feet and when checked one day later. It is anticipated that the depth to ground water will fluctuate with time based on seasonal, climatic, and other factors including irrigation.

Seismic design Class C may be used.

PARKING LOT SURFACE DESIGN RECOMMENDATIONS

General: This lot is to be covered with aggregate and little subgrade treatment is required as opposed to a paved surface. There are several treatments that could be performed to improve the subgrade, such as chemical stabilization or importing better soil, however for a gravel surface used for parking it is not cost effective to do those treatments. Parker Pavement Design criteria were reviewed, but there is nothing specific for gavel surfacing.

We recommend scarifying 12 inches of the subgrade, moisture conditioning to between optimum moisture to 3 percent above optimum and compacting to 95 percent of the maximum standard Proctor density. Then place 12 inches of aggregate base course material in two 6-inch lifts and compact to 95 percent of the maximum modified Proctor density. Grade and replace lost material as discussed below under maintenance.

Traffic: Traffic is expected to be automobiles and light pickup type maintenance trucks. The surface should also be capable of supporting very occasional fire trucks.

Subgrade Soils: The subgrade soil in Boring B-1 is a clayey sand with an AASHTO classification of A-7-6 and a Group Index of 8. The in-situ soil is considered to be poor for subgrade support and should be covered with adequate thicknesses of base material. A default R value of 5 is assumed.

Aggregate Surface: Aggregate used as the surface course should conform to the requirements of AASHTO M147 and to Section 703.03 of the Colorado Department of Transportation (CDOT) *Standard Specifications for Road and Bridge Construction.* The aggregate should meet Class 6 grading and quality as defined by the CDOT specifications. The aggregate should have a minimum R-value of 78. The aggregate should also meet the Town of Parker criteria. The aggregate should be moisture condition within 2% optimum moisture content and compacted to at least 95% of the maximum Modified Proctor density. Recycled concrete is suitable for use assuming it meets the wear and gradation specifications.

Subgrade Soil Preparation: The subgrade should be scarified for a depth of 12 inches, moisture conditioned to between optimum and +3 percent and compacted to at least 95 percent of the maximum standard Proctor density.

Proof Roll: Before placing the aggregate, the subgrade should be proof rolled with a heavily loaded, pneumatic-tired vehicle. The vehicle should have a gross vehicle weight of at least 50,000 pounds with a loaded single axle weight of 18,000 pounds and a tire pressure of 100 psi. Areas which deform excessively under heavy wheel loads are not stable and should be removed and replaced to achieve a stable subgrade prior to placement of the aggregate surface course.

Drainage: The collection and diversion of surface drainage away from paved areas is extremely important for the satisfactory performance of pavement. Drainage design should provide for the removal of water from paved areas and prevent wetting of the subgrade soils.

Maintenance: Due to the expansive soils and aggregate surface, more maintenance will be required. Grading and replacing distressed areas will be more frequent than for a hard surface pavement.

SHELTER FOUNDATION RECOMMENDATIONS

Picnic and trailside shade locations will be provided with shelter structures. Columns or common points will support these facilities. Based on the structures and soil conditions, drilled pier foundations will be the most suitable foundation system. Gravity loads are expected to be light, but uplift loads are expected to be greater. The upper soils are stiff to medium dense and the bedrock is hard, which indicate good resistance to uplift for drilled piers.

Straight Shaft Piers: The following recommendations should be followed for straight shaft pier foundations.

1. Piers bearing into the bedrock should be designed end bearing of 25,000 psf and side shear of 2,500 psf for the portion in bedrock or 1,000 psf in the upper soils below 5 feet from the surface.
2. For uplift 75 percent of the skin friction plus the weight of the pier can be used to resist uplift.
3. Straight shaft piers should penetrate 6 feet into the sandstone or claystone bedrock to counter act the potential heave of the upper clay and to resist structural uplift. Piers should have a minimum length of 15 feet.
4. Piers should be reinforced to overcome lateral forces and uplift due to soil heave based on a force equal in kips to 25 times the pier diameter. The following LPILE values have been assigned for the soils encountered at this site and are considered typical for the soil type. The values are presented in the units used in LPILE.

LPILE PARAMETERS

Soil Type	Total Unit Weight (pci)	Static Soil Modulus Parameter k (pci)	Friction Angle φ (degrees)	Cohesion c (psi)	ε_{50}
Sandy Clay Clayey Sand	0.066	100*	-	7	0.005
Claystone Bedrock	0.075	1000*	-	40	0.004
Sandstone Bedrock	0.074	225*	35	N/A	N/A

*For cyclic loading, use 40% value

5. The lower 5 feet of the pier shaft should be artificially roughened with the limitation that the procedure does not deteriorate the shaft.
6. A minimum pier diameter of 12 inches is recommended.
7. Concrete should be a fluid mix with a slump between 5 to 7 inches and should be placed the same day as the shaft is drilled.
8. If a pier cap is used a 6-inch void form should be used to separate the concrete from the soil. Also care should be taken not to allow an enlargement of the shaft at the top.

9. A representative of our firm should observe the pier drilling on a full time basis.

Helical Piers: The use of helical piers is acceptable. The lower helix should be at least 12 feet deep and have a torque equivalent to a bearing capacity of 30 kips or twice the structural uplift force whichever is greater. A specialty contractor experienced with helical piers should be engaged for the installation.

BRIDGE FOUNDATION

The proposed bridge may be founded on Drilled piers as recommended above or spread footings as the following recommendations.

1. Footings bearing on the clayey sand should be designed for an allowable bearing capacity of 2,500 psf.
2. Footings should be at least 36 inches below grade for frost protection.
3. Continuous footings should be at least 16 inches wide and isolated footings 24 inches wide.
4. Resistance to sliding may be taken as 0.30 times the normal (vertical) dead weight.
5. Walls should be designed to resist lateral earth pressure based on an equivalent fluid weighing 50 pcf. Passive pressure should be based on an equivalent fluid pressure of 250 pcf for backfill compacted to 95 percent of the SPD.
6. Backfill against the footings should be compacted to at least 95 percent the maximum Proctor density.
7. A representative of the geotechnical engineer should observe and test the fill placement for compliance and confirm the bearing surface is satisfactory.

SULFATE RESISTANT CONCRETE

The concentration of water-soluble sulfates was found to be from 0.035 percent to 0.085 percent in the samples tested. This range of the sulfate concentration indicates negligible attack on cement. Type I/II cement with a water cement ratio less than 0.45 is commonly used in this area.

DESIGN AND CONSTRUCTION SUPPORT SERVICES

H-P/KUMAR should be retained to review the project plans and specifications for conformance with the recommendations provided in our report. We are also available to assist the design team in preparing specifications for geotechnical aspects of the project, and performing additional studies if necessary to accommodate possible changes in the proposed construction.

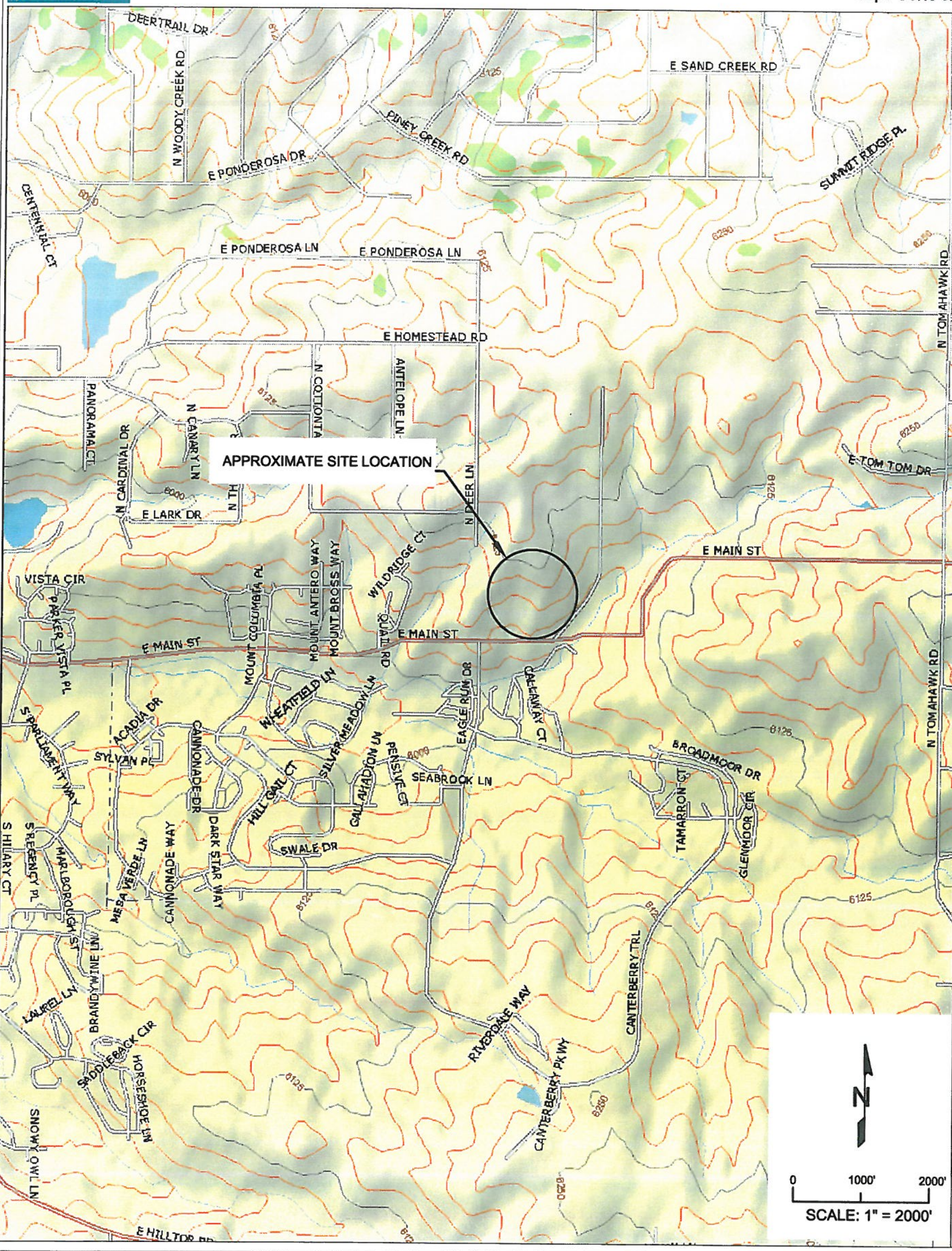
We recommend that H-P/KUMAR be retained to provide construction observation and testing services to document that the intent of this report and the requirements of the plans and specifications are being followed during construction. This will allow us to identify possible variations in subsurface conditions from those encountered during this study and to allow us to re-evaluate our recommendations, if needed. We will not be responsible for implementation of the recommendations presented in this report by others, if we are not retained to provide construction observation and testing services.

LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practices in this area for exclusive use by the client for design purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings at the locations indicated on Figure 2, and the proposed type of construction. This report may not reflect subsurface variations that occur between the exploratory borings, and the nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, H-P/KUMAR should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. H-P/KUMAR is not responsible for liability associated with interpretation of subsurface data by others.

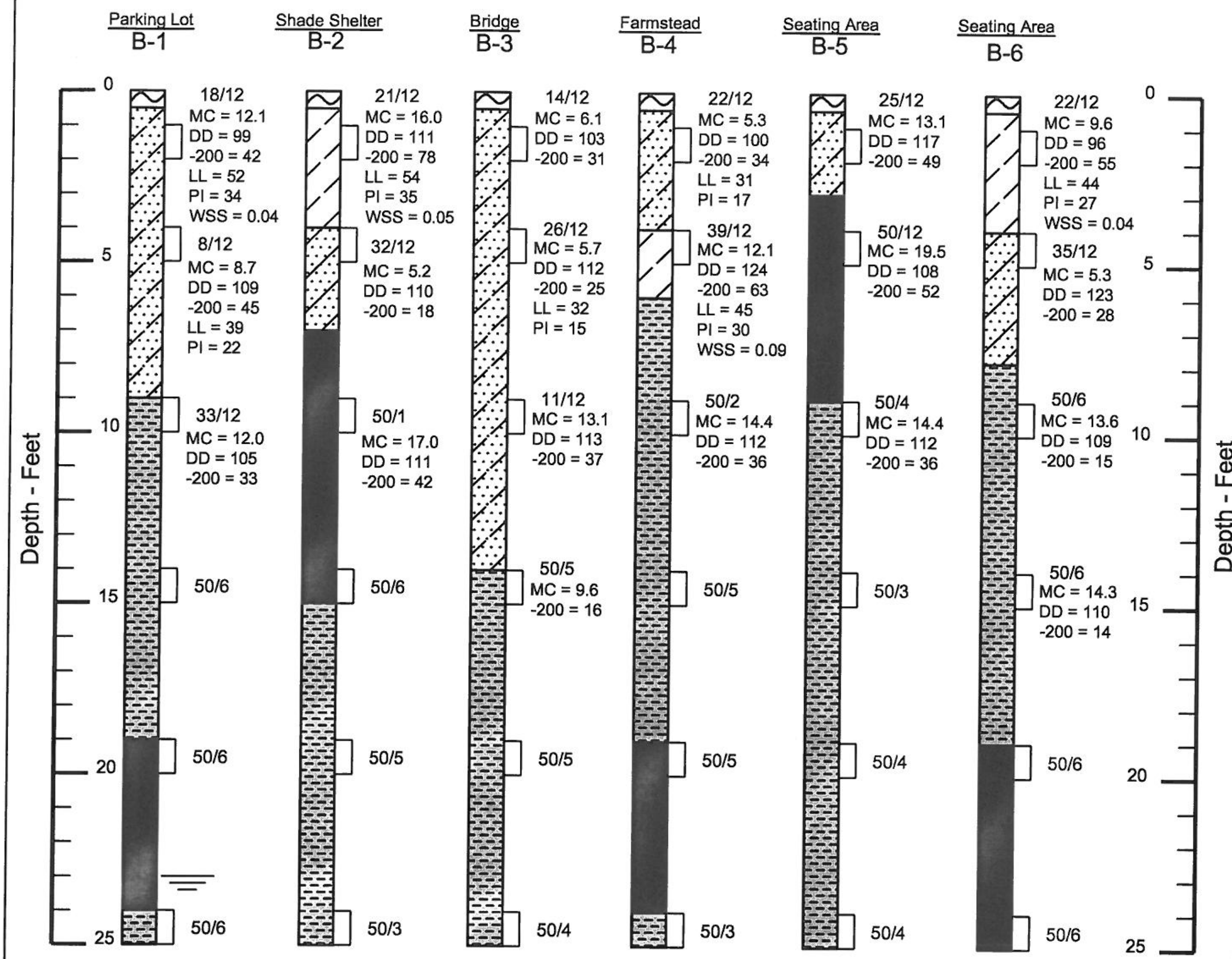
The scope of services for this project does not include any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken.
H-P/KUMAR

Topo USA® 6.0



17-8-335	HP/KUMAR	HARVIE OPEN SPACE SITE LOCATION	FIG.1

17-8-335	H-P/KUMAR	HARVIE OPEN SPACE BORING LOCATIONS	FIG. 2



17-8-335	HP/KUMAR	HARVIE OPEN SPACE BORING LOGS	FIG.3

LEGEND

Top soil.

Sand (SC) clayey, fine to coarse grained, low to medium plasticity, loose to dense, moist, light brown.

Sand (SC) silty, fine to coarse grained, low to medium plasticity, medium dense to dense, moist, brown.

Clay (CL), sandy, medium to high plasticity, stiff to hard, moist, brown.

Sandstone, fine to coarse grained, low plasticity, medium hard to very hard, moist to wet, brown to white.

Claystone, fine to medium grained, high plasticity, very hard, green.

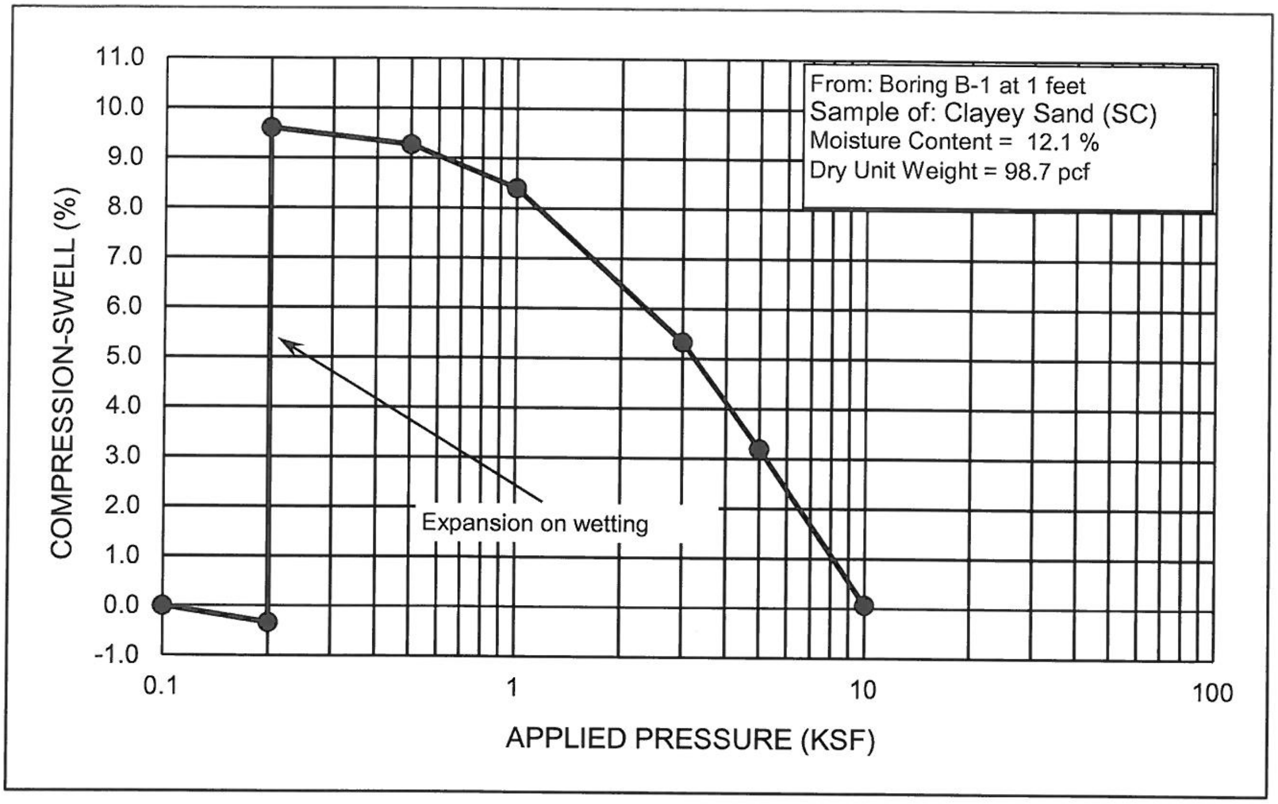
Indicates depth to water level.

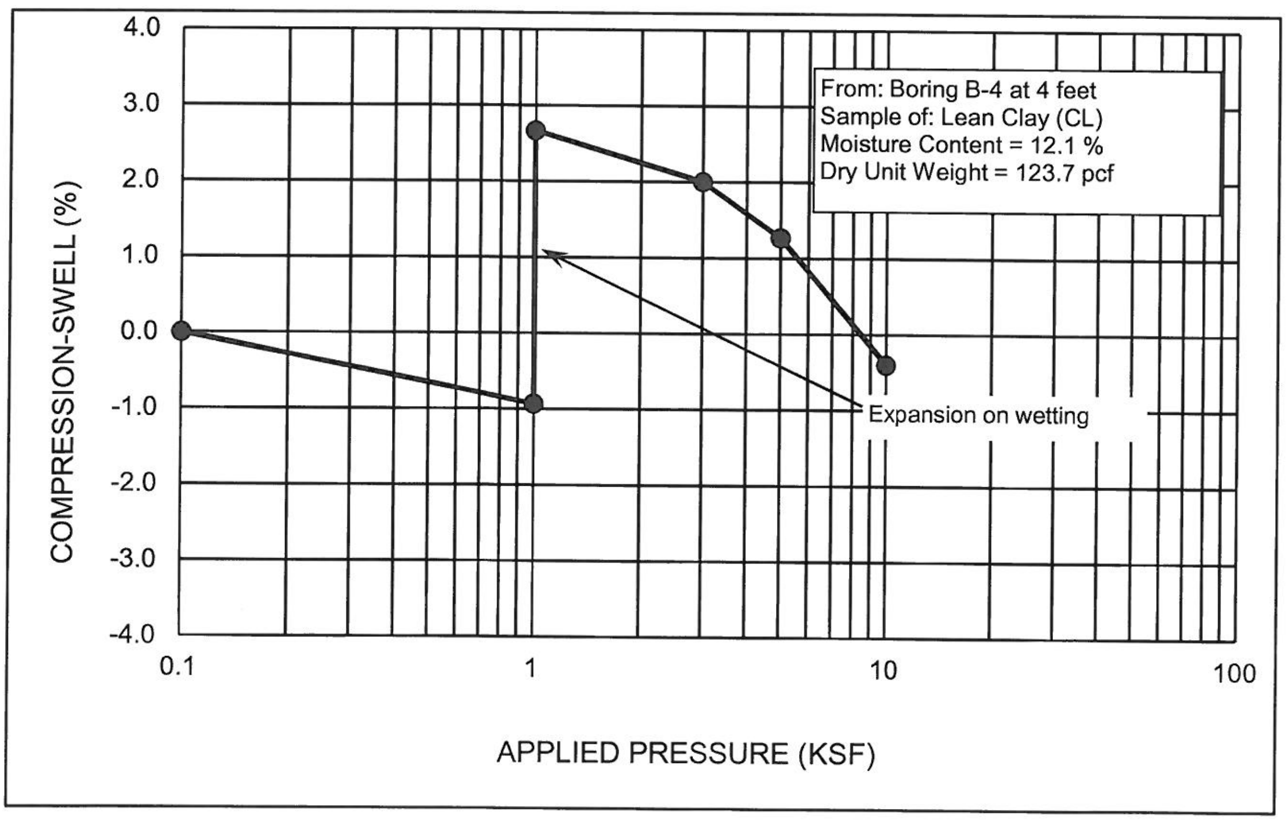
20/12

Indicates 2-inch I.D. California sampler. 20/12 indicates 20 blows of a 140-pound hammer falling 30 inches were required to drive the sampler 12 inches.

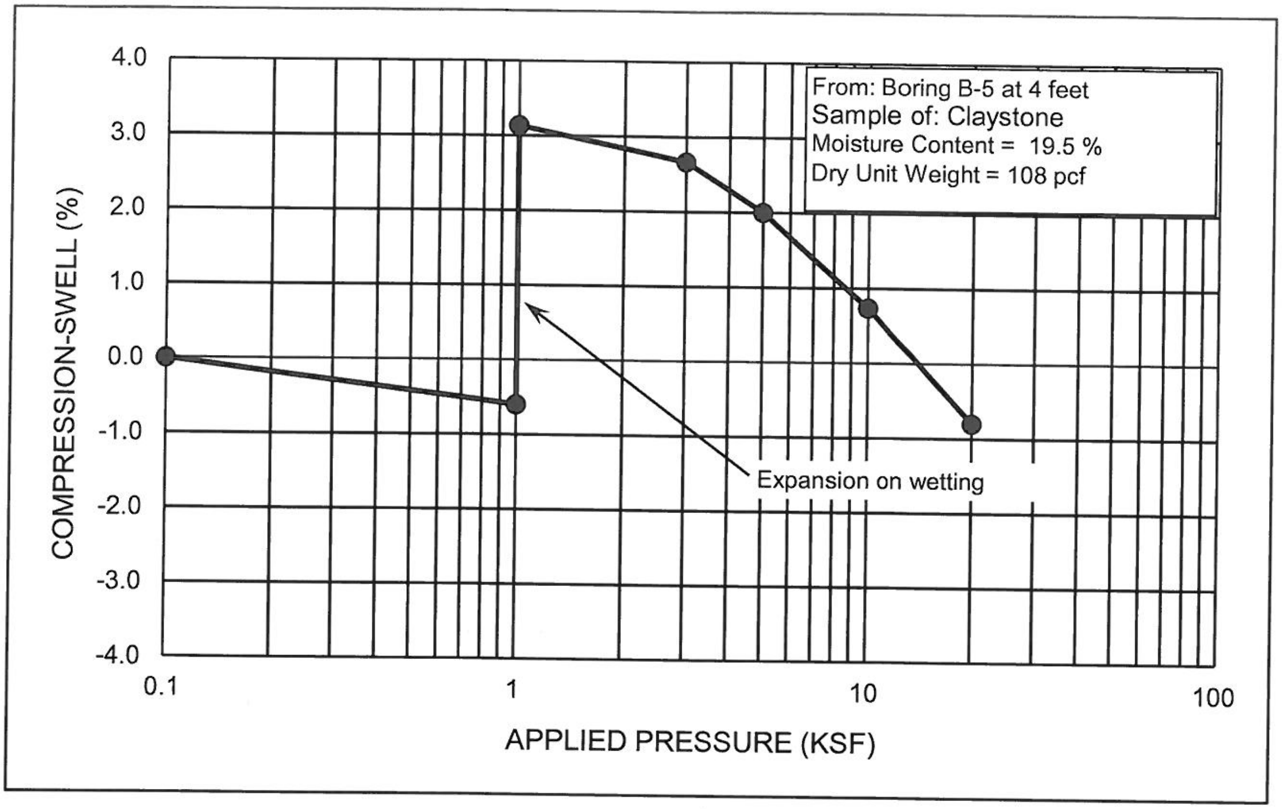
NOTES:
1. Field work was conducted on December 12, 2017. Borings were drilled and sampled using a truck mounted CME-55 Drill Rig equipped with an automatic hammer.
2. Locations of borings shown on Figure 2 are approximate.
3. Elevations of borings were not measured during our site visit.
4. The lines between strata represent approximate boundaries and transitions may be gradual.
5. Water was encountered during drilling and when checked the following day. Water table is expected to fluctuate seasonally, and with changes in climate.
6. Laboratory Testing Results:
   WC = moisture content of sample in percent of the dry weight.
   DD = dry unit weight of sample in pcf.
   -200 = percent of silt and clay fraction.
   LL = liquid limit.
   PI = plasticity index.
   WSS = water soluble sulfates percent.

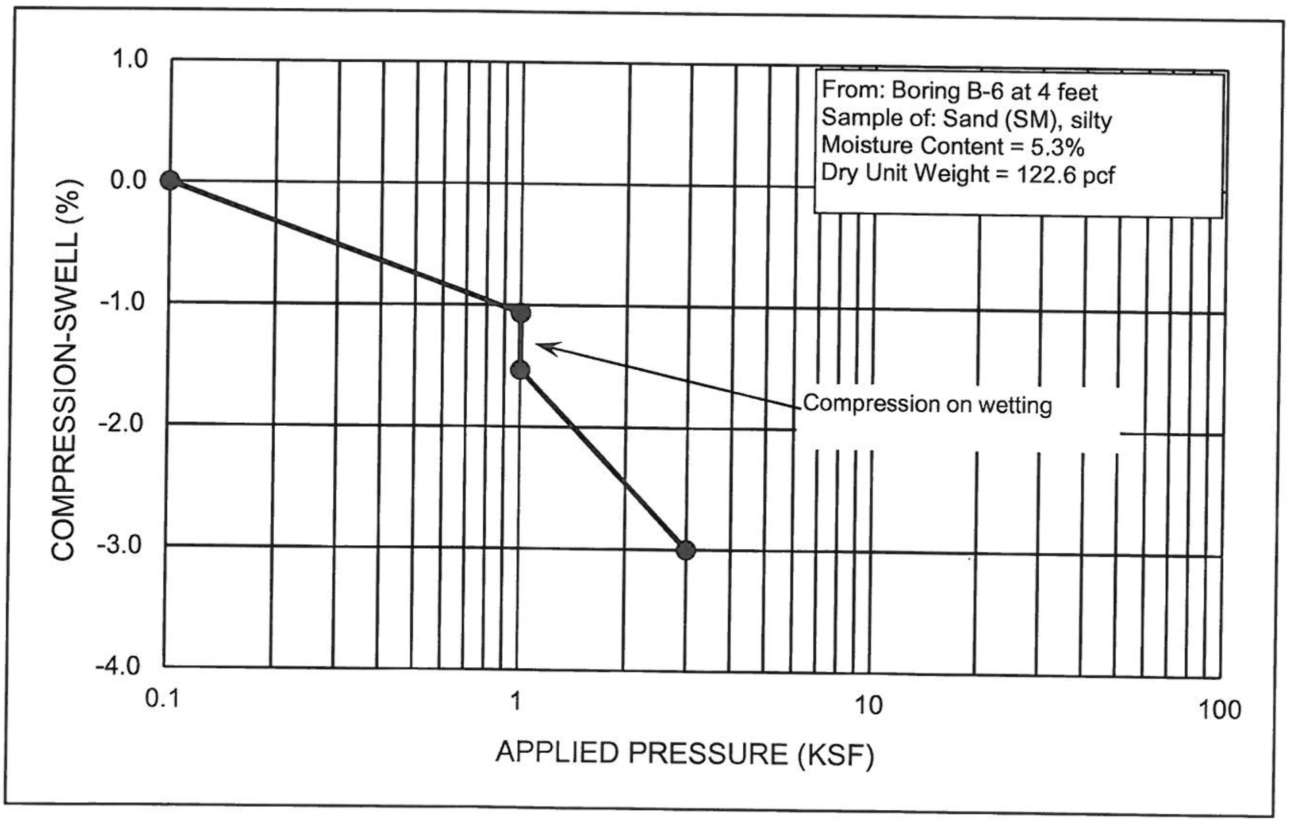
17-8-335	HP/KUMAR	HARVIE OPEN SPACE LEGEND AND NOTES	FIG. 4



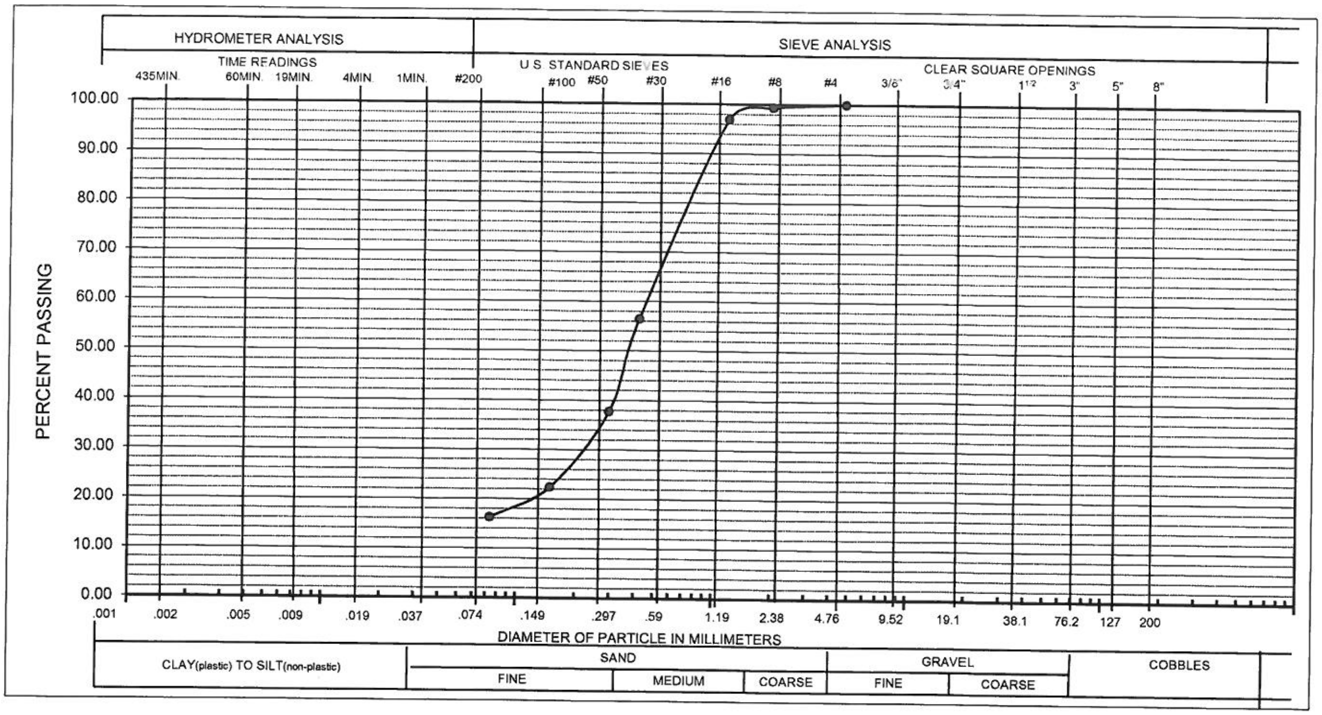


17-8-335	H-P/KUMAR	HARVIE OPEN SPACE SWELL-COMPRESSION TEST RESULTS	FIG. 5

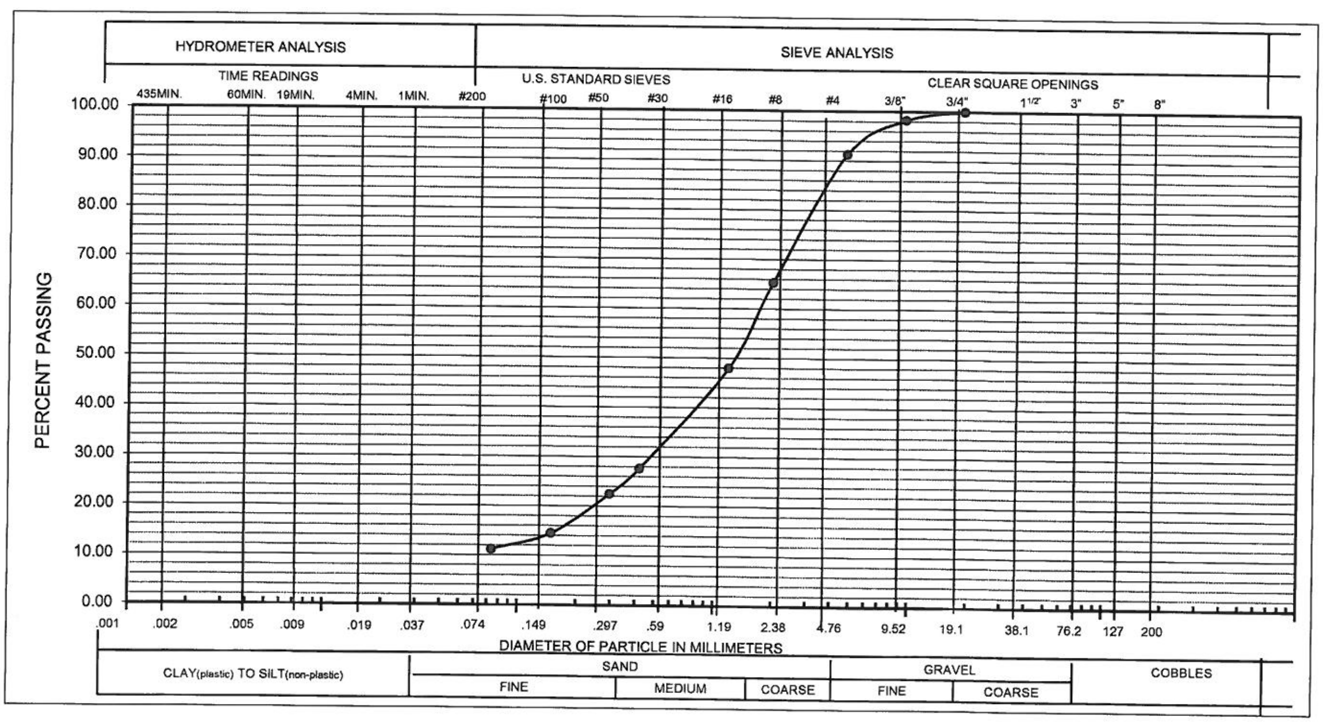




17-8-335	H-P/KUMAR	HARVIE OPEN SPACE SWELL-COMPRESSION TEST RESULTS	FIG. 6

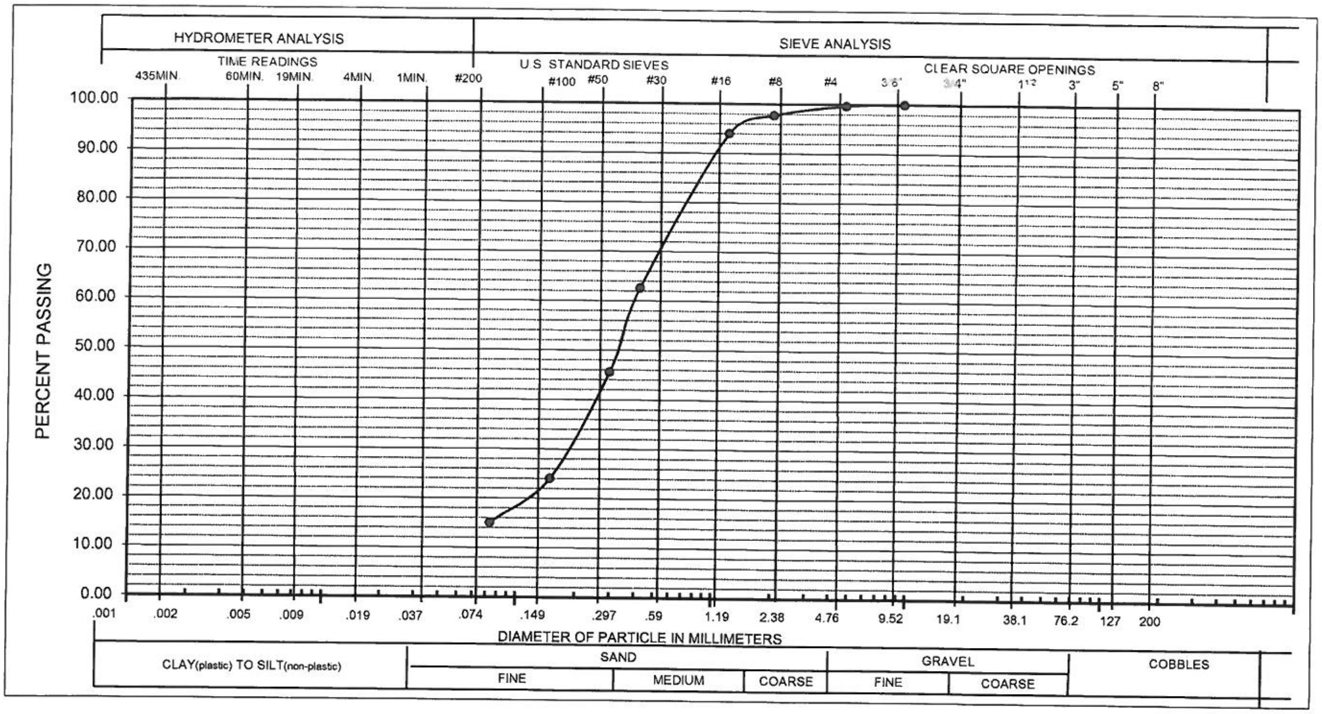


GRAVEL:	0%	SAND:	84%	SILT AND CLAY:	16%
LIQUID LIMIT:				PLASTICITY INDEX:	
SAMPLE OF:	SANDSTONE			FROM:	B3 @ 14 feet



GRAVEL:	9%	SAND:	80%	SILT AND CLAY:	11%
LIQUID LIMIT:				PLASTICITY INDEX:	
SAMPLE OF:	SANDSTONE			FROM:	B4 @ 9 feet

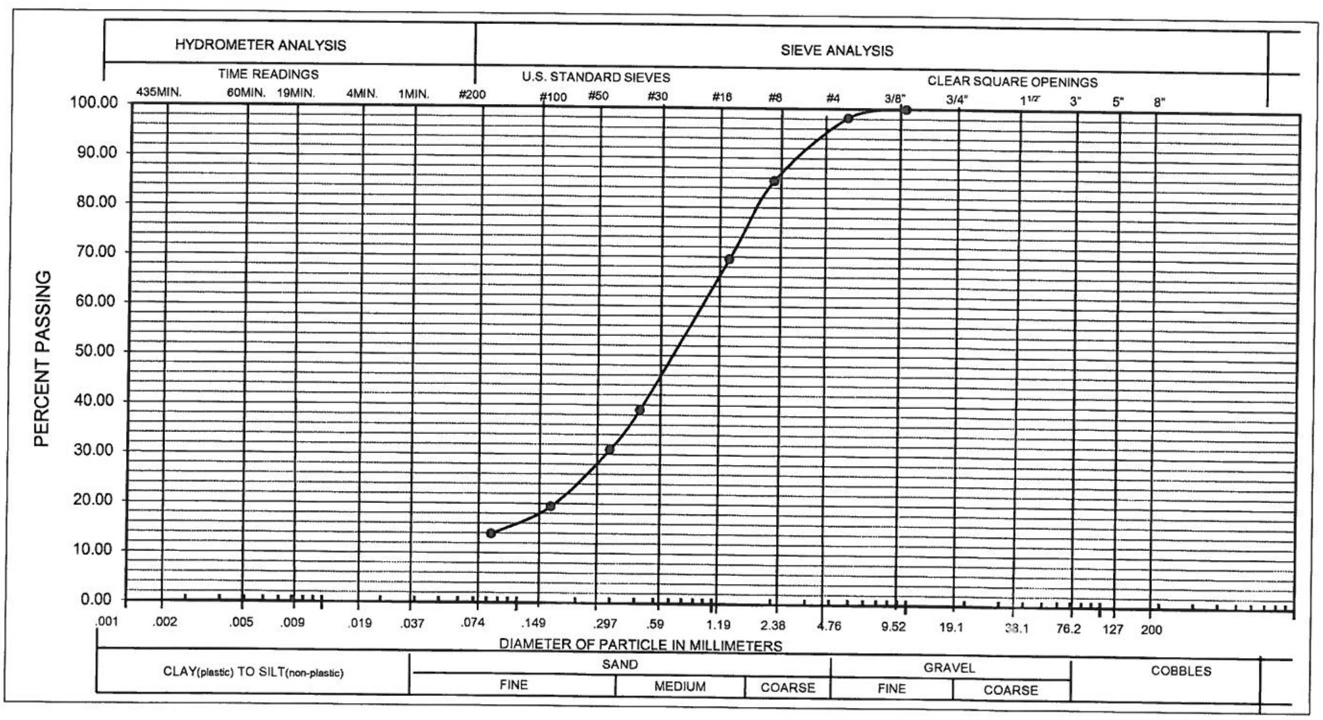
17-8-335	H-P/KUMAR	HARVIE OPEN SPACE GRADATION ANALYSIS	FIG. 7



GRAVEL: 0% SAND: 85% SILT AND CLAY: 15%

LIQUID LIMIT: PLASTICITY INDEX:

SAMPLE OF: SANDSTONE FROM: B6 @ 9 feet



GRAVEL: 2% SAND: 84% SILT AND CLAY: 14%

LIQUID LIMIT: PLASTICITY INDEX:

SAMPLE OF: SANDSTONE FROM: B6 @ 14 feet

17-8-335	H-P/KUMAR	HARVIE OPEN SPACE GRADATION ANALYSIS	FIG. 8

H-P Kumar and Associates

JOB NO. 17-8-335

PROJECT: HARVIE OPEN SPACE

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT	NATURAL DRY UNIT WEIGHT	GRADATION			ATTERBERG LIMITS		SWELL/COMP WITH 1,000 psf SURCHARGE	UNCONFINED COMPRESSIVE STRENGTH	WATER SOLUBLE SULFATES	AASHTO CLASSIFICATION	SOIL OR BEDROCK TYPE (USCS CLASSIFICATION)
BORING	DEPTH (feet)	(%)	(PCF)	GRAVEL (%)	SAND (%)	SILT & CLAY (%)	LIQUID LIMIT (%)	PLASTIC INDEX (%)	(%)	(psf)	(%)	(GI)	
B-1	1	12.1	99		58	42	52	34	9.9*		0.040	A-7-6 (8)	(SC) Clayey sand
	4	8.7	109		55	45	39	22				A-6 (6)	(SC) Clayey sand
	9	12.0	105		67	33							Sandstone
B-2	1	16.0	111		22	78	54	35			0.045		(CH) Fat clay with sand
	4	5.2	110		82	18							(SC-SM) Silty clayey sand
	9	17.0	111		59	42							Sandstone
B-3	1	6.1	103		69	31							(SC) Clayey sand
	4	5.7	112		75	25	32	15					(SC) Clayey sand
	9	13.1	113		63	37				4,625			Sandstone
	14	9.6			84	16							Sandstone
B-4	1	5.3	100		66	34	31	17					(SC) Clayey sand
	4	12.1	124		37	63	45	30	3.6		0.085		(CL) Sandy lean clay
	9	7.7	116	9	80	11							Sandstone
B-5	1	13.1	117		51	49							(SC) Clayey sand
	4	19.5	108		48	52			3.7				Claystone
	9	14.4	112		64	36							Sandstone
B-6	1	9.6	96		45	55	44	27			0.035		(CL) Sandy lean clay
	4	5.3	123		72	28			-0.5				(SC) Clayey sand
	9	13.6	109	0	85	15							Sandstone
	14	14.3		2	85	14							Sandstone

Notes: * Indicates surcharge pressure of 200 psf.
Negative swell indicates compression upon wetting.