GEOTECHNICAL ENGINEERING REPORT

NVF Yorklyn Properties
NVF Yorklyn Site (DE-0071)
Yorklyn, Delaware

Schnabel Reference 12615019
June 27, 2012

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June 27, 2012

Mr. Dennis J. Hogan, PE
Black & Veatch Special Projects Corporation
1617 John F. Kennedy Boulevard, Suite 1690
Philadelphia, PA 19103

Subject: **Project 12615019, Geotechnical Engineering Report, NVF Yorklyn Properties, NVF Yorklyn Site (DE-0071), Yorklyn, Delaware**

Dear Mr. Hogan:

SCHNABEL ENGINEERING CONSULTANTS, INC. (Schnabel) is pleased to submit our geotechnical engineering report for this project. This document includes attached figures, tables and appendices with relevant data collected for this study. This study was performed in accordance with our contract dated May 2, 2012, as authorized by Mr. Joseph Slykerman on May 9, 2012.

EXECUTIVE SUMMARY

We are providing this executive summary solely for purposes of overview. Any party that relies on this report must read the full report. This executive summary omits several details, any one of which could be very important to the proper application of the report.

Spread footings bearing on disintegrated rock are recommended for support of the proposed bridge abutments. Footings founded on suitable natural soils may be designed for a factored bearing resistance of 10.0 kips per square foot (ksf). Footings should be founded below a depth of three feet from final grade for frost considerations. Groundwater should be anticipated when excavating for foundations. Alternating layers of hard and soft rock were observed during drilling activities, and rock excavation techniques may be required to complete foundation excavations. Recommendations for equivalent fluid pressures for wingwalls and abutments are provided herein; however, AASHTO stipulates that an equivalent fluid earth pressure of at least 0.030 H ksf (where H is the height of the wall in feet) be considered for design.

The geotechnical engineer should review the settlement and bearing capacity calculations once the bridge dimensions and structural loads are made available.

SCOPE

Our agreement dated May 2, 2012, defines the scope of this study. Our services include subsurface exploration, field engineering, soil laboratory testing, and development of geotechnical engineering recommendations. The objective of this study is to evaluate the subsurface conditions and provide recommendations regarding the design of foundations and earthwork construction for this project.

Services not described in our agreement are not included in this study. We would be happy to provide additional support services to the design team as the project demands.

SITE DESCRIPTION

The NVF Site is located at 1166 Yorklyn Road in Yorklyn, New Castle County, Delaware, approximately two miles south of the Pennsylvania and Delaware state line. The site is bordered on the north, east, and south by Red Clay Creek and Route 82; and Yorklyn Road to the west. The Bridge #1 site is located east of Benge Road Bridge crossing over Red Clay Creek. Site grades within the limits of the proposed abutments at Bridge #2 are about EL 178. The Bridge #2 site is an existing timber plank bridge on Farm Lane which we understand is founded on historic masonry abutments.

We obtained the site information from the topographic site plans dated January 6, 2012, prepared by Black & Veatch, and through our site visits. A Vicinity Map is included as Figure 1.

PROPOSED CONSTRUCTION

We understand that the site development will create a Delaware Department of Natural Resources and Environmental Control (DNREC) park connecting the Auburn Heights Preserve and Oversee Farm properties. As part of this development, two new stream crossings are planned. Bridge #1 will be a new bridge downstream of the Benge Road Bridge crossing over Red Clay Creek. Bridge #2 will be the replacement of an existing timber plank bridge on Farm Lane. Both bridges will be one lane, prefabricated spans to hold light vehicular traffic and pedestrians. We understand that preliminary plans indicated that the proposed bridges will be supported on shallow foundations. Structural loading and proposed bearing elevations were not available at the time of this report.

Mr. Michael Naugther, PE (Black & Veatch) provided the project details.

SUBSURFACE CONDITIONS

Geology

We reviewed existing geologic data and information in our files. Based on this review, the geologic stratigraphy consists of residual soils derived from the chemical and physical weathering of the underlying gneiss bedrock of the Wissahickon Formation. In the immediate vicinity of the project site, some of the above strata have been eroded or excavated and have commonly been replaced with recent alluvial deposits or fill.

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Data Collection Techniques

We performed test borings and soil laboratory testing on samples collected to develop our geotechnical recommendations. Appendix A includes our summary of soil laboratory test results and laboratory test curves. Appendix B includes the logs from our subsurface exploration.

Our geotechnical laboratory conducted tests on selected samples obtained in the borings. This testing aided in the classification of soils encountered in the subsurface exploration, and provided data for use in the development of foundation and earthwork recommendations. The logs in Appendix B show the natural moisture content values of selected soil samples. Appendix A presents the results of the remaining laboratory tests.

Connelly & Associates, Inc. of Dover, Pennsylvania, drilled four borings at this site under our observation. Appendix B includes specific observations, remarks, and logs for the borings; classification criteria; and sampling protocols. Figures 2 & 3 show the approximate boring locations. We will retain soil samples up to 45 days beyond the issuance of this report, unless you request other disposition.

Generalized Subsurface Stratigraphy

We have characterized the following generalized subsurface soil stratigraphy based on the boring and data presented in Appendix B:

Ground Cover:

The ground cover consisted of 1 to 2 inches of topsoil at Test Borings B-1 and B-4. Six inches of crushed stone was observed at B-2.

Stratum A: Existing Fill

Below the ground cover, the borings encountered existing fill soils probably placed during the construction of the original bridge abutments and roadway. Fill soils were observed to depths up to 7 ft below existing grade. In general, the soil is consistent with natural soil in the region ranging from brown silty sand to sandy silt with varying amounts of gravel and rock fragments. Based on the Standard Penetration Tests performed, this stratum is generally loose to medium dense: N = 2 to 21.

We conducted California Bearing Ratio (CBR) tests on bulk samples collected from this stratum at depths from 0 to 5 ft below existing ground surface. Bulk samples from B-1 and B-2 as well as B-3 and B-4 were combined to form two samples for testing. The results of the CBR testing are summarized in Table 1.

Table 1: CBR Test Results

Boring Number	Test Depth (ft)	USCS Classification	CBR Value	Swell Value (%)
B-1/B-2	0 to 5	SILTY SAND with GRAVEL (SM)	16.0	0.5
B-3/B-4	0 to 5	SILTY SAND	23.3	0.1

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Stratum B: Alluvial Soils

Below the fill soils of Stratum A, Test Borings B-1 and B-3 encountered an alluvial deposit consisting of brown, fine to coarse poorly graded sand with silt and gravel (SP-SM) to silty gravel (GM) with varying amounts of subrounded to subangular gravel to depths of 9 to 11.5 ft.
Based on the Standard Penetration Tests performed, this stratum is generally medium dense: N = 13 to 23.

Stratum C: Residual

Below the fill soils of Stratum A and alluvial soils of Stratum B, Test Borings B-2 and B-4 encountered residual soils consisting of brown, fine to coarse silty sand (SM) with varying amounts of gravel-sized rock fragments to depths of 9 to 11 ft. Based on the Standard Penetration Tests performed, this stratum is generally medium dense to dense: N = 13 to 41.

Stratum D: Disintegrated Rock

Disintegrated rock is defined as residual material with N values in excess of 60 blows per foot and less than 100 blows for two inches of penetration. Penetration resistance of 100 blows or more per two inches is designated as refusal. Auger refusal was encountered in all of the test borings at depths between 10 and 21 ft below the existing ground surface. The disintegrated rock stratum varies significantly in composition. As indicated, auger refusal was observed at all of the boring locations and rock coring was performed in an attempt to collect core samples. In general, the REC and RQD values were generally less than 10 percent; however, several of the core runs recovered gneiss rock indicating alternating layers of hard and soft weathered rock.

Groundwater

The logs note groundwater level readings obtained in the borings during and after completion. We obtained groundwater level readings in Test Borings B-1 and B-2 at a depth of about 8 ft, EL 174. We obtained groundwater level readings in Test Borings B-3 and B-4 at depths of 7 and 13 ft, EL 171 and EL 165, respectively. These levels may or may not represent stabilized water level readings as the borings were backfilled upon completion for safety.

The groundwater levels on the logs show an estimate of the hydrostatic water table at the time of drilling. The final design should anticipate fluctuations in the hydrostatic water table depending on variations in precipitation, surface runoff, pumping, stream levels, evaporation, leaking utilities, and similar factors.

GEOTECHNICAL RECOMMENDATIONS

We based our geotechnical engineering analysis on the information developed from our subsurface exploration and soil laboratory testing, along with the project development plans and site plans furnished to our office. We recommend shallow spread footings for support of the proposed bridges based on our analysis. The following sections of the report provide our detailed recommendations.

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Spread Footings

We consider shallow spread footings suitable for support of the proposed structure. Footings should be supported on suitable disintegrated rock of Stratum D. Footings may be designed for a factored bearing resistance, q_R, of 10.0 ksf. This factored bearing resistance was calculated in accordance with the AASHTO LRFD Bridge Specifications, Fifth Addition 2010 (AASHTO) Section 10.6.3.1.3 semiempirical procedure for bearing resistance utilizing a resistance factor of 0.45. This assumes that the proposed abutment and wingwall footings will be located a minimum of 3 ft below final grade and a minimum footing width (B) of 2 ft. Table 2 summarizes the highest anticipated bearing elevations at the test boring locations.

Table 2: Summary of Bearing Elevations

Boring Number	Estimated Ground Surface Elevation (EL)	Highest Anticipated Disintegrated Rock Elevation (EL)
B-1	182	173
B-2	183	172
B-3	178	167
B-4	178	169

Settlements of shallow foundations supported on suitable disintegrated rock/rock are not expected to exceed about one inch. Differential settlements between similarly loaded footings are not expected to exceed about half this value. Settlements were evaluated using the elastic half space method as described in AASHTO Section 10.6.2.4, as well as AASHTO Section 10.6.2.4.4 Settlement of Footings on Rock. Settlements were evaluated assuming a vertical applied stress at the base of the footing of 10.0 ksf. A maximum footing width (B) of 10 ft was considered for the settlement evaluation. Footings, or those which may be exposed to climate variation, should be founded below a depth of 3 ft for frost considerations.

Once the preliminary bridge designs are completed, and the proposed footing dimensions and structural loading are established, settlement and bearing capacity should be reviewed by the geotechnical engineer.

The contractor should place footing concrete as soon as possible after excavation to limit the potential for moisture changes at the foundation level. Similarly, the contractor should backfill abutments as soon as possible to reduce the potential for infiltration of water into the soils beneath the footings. Backfilling should follow the recommendations for placement of compacted structural fill.

Seismic Site Classification

The Seismic Site Class for this project is evaluated according to IBC Section 1613 (2009). We recommend Site Class C for seismic design on this project. This Site Class is based on Standard Penetration Test N-values and extrapolation of the soil parameters to 100 ft.

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Lateral Earth Pressures

We considered that the proposed abutments will be designed for the drained condition, and our design parameters do not consider hydrostatic pressure. The design should consider surcharge loads using a rectangular earth pressure distribution. The surcharge pressure ordinate should be obtained by multiplying the surface surcharge pressure, q, by K_o or K_a for at-rest or active conditions, respectively. Tables 3 and 4 summarize the parameters that should be used for lateral earth pressure design.

Table 3: Abutments (Fully Braced) K_o Conditions

Material Type	Moist Unit Weight (pcf)	Friction Angle (deg)	K_o Level Backfill	K_o 3H:1V Backfill	K_o 2H:1V Backfill
AASHTO No. 57 Aggregate	105	38	0.384	0.506	0.556
Compacted Structural Fill	120	30	0.500	0.658	0.724
Natural In Situ Soil	120	32	0.470	0.619	0.680

Table 4: Wingwalls (Active) K_a Conditions

Material Type	Moist Unit Weight (pcf)	Friction Angle (deg)	K_a Level Backfill	K_a 3H:1V Backfill	K_a 2H:1V Backfill
AASHTO No. 57 Aggregate	105	38	0.218	0.275	0.324
Compacted Structural Fill	120	30	0.297	0.406	0.547
Natural In Situ Soil	120	32	0.276	0.368	0.470

In accordance with AASHTO, an equivalent fluid earth pressure not less than 0.030 H ksf (where H is the height of the wall in feet) should be considered in the design. Where required, a higher fluid pressure should be considered to account for sloping backfill, braced conditions, etc.

Free-draining backfill should consist of non-plastic material classifying SP, SW, GP or GW according to ASTM D2487. This classification includes open-graded crushed stone, such as AASHTO M43 No. 78 or No. 57. The on-site soils excavated to expose the foundation soils are not expected to meet these criteria and, as a result, a processed material will need to be imported. The contractor should place free-draining backfill in maximum 8-inch thick loose lifts, and compact each lift to at least 95 percent of maximum dry density per AASHTO T-99, or to 70 percent relative density per ASTM D4253 and D4254. The contractor should place crushed stone backfill in maximum 12-inch thick lifts, and compact each lift using suitable vibratory equipment.

Only light hand-operated equipment should be used to compact backfill against walls. The Structural Engineer of Record should approve the size of the compaction equipment.

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Earthwork

The proposed bridge abutments should be founded on suitable disintegrated rock/rock. The following earthwork recommendations are provided for reuse of on-site materials and backfilling around the proposed abutments.

The contractor may use the non-organic portions of material excavated as compacted structural fill if stripping and earthwork operations occur during an extended period of warm, dry weather. The use of these materials as compacted structural fill will depend on the soil moisture content, and the contractor's ability to limit contamination of these materials with organic matter during stripping and undercutting.

Some existing structures may be present on the site. Therefore, excavation activities may encounter buried foundations and other associated debris. We recommend the complete removal of existing foundations from within the proposed bridge abutment areas.

Compacted structural fill should consist of material classifying CL, ML, SC, SM, SP, SW, GC, GM, GP, or GW per ASTM D2487. Non-organic, on-site soils are expected to meet this criterion. If off-site borrow soils are needed, they should classify as SC, SM, SP, SW, GC, GM, GP or GW per ASTM D2487.

Successful reuse of the excavated, on-site soils as compacted structural fill will depend on their natural moisture contents during excavation. Natural moisture content values of Strata A, B and C soils varied from about 5 percent below to about 5 percent above optimum for the soil types tested. Therefore, we anticipate scarifying and drying of portions of the on-site soils to achieve the recommended compaction. Drying of these soils will likely result in some delay, and drying may not be possible during late fall, winter and early spring. Therefore, we recommend that the earthwork be performed during the warmer, drier times of the year from about May to October.

Compacted structural fill should be placed in maximum eight-inch thick horizontal, loose lifts and should be compacted to at least 95 percent of maximum dry density per ASTM D698, Standard Proctor. The contractor should bench compacted structural fill subgrades steeper than 4H:1V to allow placement of horizontal lifts.

CONSTRUCTION CONSIDERATIONS

Rock Excavation

Test boring data and planned foundation grades indicate that disintegrated rock and rock will be encountered during excavation. Actual conditions during excavation may be different as some variation was observed in the surface of disintegrated rock and rock over relatively short distances, and estimated disintegrated rock and rock surfaces are based on interpolation. Therefore, it may be prudent to include unit rock excavation prices in the contract documents.

A sample definition of rock for excavation specifications is provided below:

> *For mass excavation, rock is defined as any material that cannot be dislodged by a Caterpillar Model No. D-8 heavy-duty tractor, or equivalent, equipped with a hydraulically operated, single-*

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> *tooth power ripper without the use of hoe-ramming or blasting. For trench, footing and pit excavations, rock excavation shall be defined in terms of a Caterpillar Model No. 330 hydraulic excavator, or equivalent. This classification does not include material such as loose rock, concrete, cemented gravel, or other materials that can be removed by means other than hoe-ramming or blasting, but which for reasons of economy in excavating, the contractor chooses to remove by hoe-ramming or blasting. Rock does not include boulders less than one cubic yard in volume. Boulders larger than one cubic yard in volume will be considered rock for payment purposes.*

Where the rock cannot be removed with conventional excavation equipment, special means of excavation may be necessary. Removal of this rock may require the use of air-powered tools, rock splitters, large hoe rams, or rippers.

Spread Footings

The contractor should exercise care during excavation for spread footings so that as little disturbance as possible occurs at the foundation level. The contractor should carefully clean loose or soft soils from the bottom of the excavation before placing concrete. The Geotechnical Engineer should observe actual footing subgrades during construction to evaluate whether subgrade soils meet the requirements as recommended in this report.

Footing subgrades needing undercut may be concreted at the elevation of undercut or backfilled to the original design subgrade elevation with an open-graded crushed stone such as No. 57 aggregate. Crushed stone should extend at least 12 inches laterally beyond the footing in all directions. Concreting should take place the same day as excavation of footings.

The contractor should anticipate groundwater during excavation for footings at this site.

Earthwork

The on-site soils are susceptible to moisture changes, will be easily disturbed, and will be difficult to compact under wet weather conditions. Drying and reworking of the soils are likely to be difficult during wetter winter months. We recommend that the earthwork phases of this project be performed during the warmer, drier times of the year to limit the potential for disturbance of on-site soils.

Traffic on stripped or undercut subgrades should be limited to reduce disturbance of underlying soils. Also, using lightweight, track-mounted dozer equipment for stripping will limit the disturbance of underlying soils and rock, and may reduce the undercut volume needed. The contractor should provide site drainage to maintain subgrades free of water and to avoid saturation and disturbance of the subgrade soils before placing compacted structural fill, pavement base course or moisture barrier material. This will be important during all phases of the construction work. The contractor should be responsible for reworking of subgrades and compacted structural fill that were initially considered suitable, but were later disturbed by equipment and/or weather.

We expect the subgrade soils in the low-lying areas of the site to be wet and easily disturbed. The contractor may need crushed stone and stabilization geotextile working platforms to provide a base on

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which to place compacted structural fill. The Geotechnical Engineer can make recommendations for working platforms in the field, based on observation of subgrade conditions.

Excavation activities will likely encounter groundwater during excavation for footings and abutments, based on water level readings and our observations. Therefore, the contractor will likely need to provide temporary dewatering such as trenching and/or pumping from sumps to control the surface and/or groundwater.

Engineering Services During Construction

The engineering recommendations provided in this report are based on the information obtained from the subsurface exploration and laboratory testing. However, conditions on the site may vary between the discrete locations observed at the time of our subsurface exploration. The nature and extent of variations between borings may not become evident until during construction.

To account for this variability, we should provide professional observation and testing of actual subsurface conditions revealed during construction as an extension of our engineering services. These services will also help in evaluating the contractor's conformance with the plans and specifications. Because of our unique position to understand the intent of the geotechnical engineering recommendations, retaining Schnabel for these services will allow us to provide consistent service throughout the project construction.

General Specification Recommendations

An allowance should be established to account for possible additional costs that may be required to construct earthwork and foundations as recommended in this report. Additional costs may be incurred for a variety of reasons including variation of soil between borings, greater than anticipated unsuitable soils, need for borrow fill material, wet on-site soils, obstructions, rock excavation, temporary dewatering, etc.

We recommend that the construction contract include unit prices for scarifying and drying wet and/or loose subgrade soils, and provide an allowance for this work. In addition, the construction contract should include an allowance for undercutting soft or loose, near-surface soils, and replacement with compacted structural fill. Add/deduct unit prices should also be established in the contract, so adjustments can be made for the actual volume of materials handled.

The project specifications should indicate the contractor's responsibility for providing adequate site drainage during construction. Inadequate drainage will most likely lead to disturbance of soils by construction traffic and increased volume of undercut.

This report may be made available to prospective bidders for informational purposes. We recommend that the project specifications contain the following statement:

> *Schnabel Engineering Consultants, Inc. has prepared this geotechnical engineering report for this project. This report is for informational purposes only and is not part of the contract documents. The opinions expressed represent the Geotechnical Engineer's interpretation of the subsurface conditions, tests, and the results of analyses conducted. Should the data contained in this report*

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> *not be adequate for the Contractor's purposes, the Contractor may make, before bidding, independent exploration, tests and analyses. This report may be examined by bidders at the office of the Owner, or copies may be obtained from the Owner at nominal charge.*

The contract documents should include the boring data provided in Appendix B.

Additional data and reports prepared by others that could have an impact upon the contractor's bid should also be made available to prospective bidders for informational purposes.

LIMITATIONS

We based the analyses and recommendations submitted in this report on the information revealed by our exploration. We attempted to provide for normal contingencies, but the possibility remains that unexpected conditions may be encountered during construction.

We prepared this report to aid in the evaluation of this site and to assist in the design of the project. We intend it for use concerning this specific project. We based our recommendations on information on the site and proposed construction as described in this report. Substantial changes in loads, locations, or grades should be brought to our attention so we can modify our recommendations, as needed. We would appreciate an opportunity to review the plans and specifications as they pertain to the recommendations contained in this report, and to submit our comments to you based on this review.

We have endeavored to complete the services identified herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions as this project. No other representation, express or implied, is included or intended, and no warranty or guarantee is included or intended in this report, or any other instrument of service.

We appreciate the opportunity to be of service for this project. Please call us if you have any questions regarding this report.

Sincerely,

SCHNABEL ENGINEERING CONSULTANTS, INC.

James M. Beideman, PE
Senior Engineer

Darrell Wilder

Darrell Wilder, PE
Senior Associate

JB:DW:clp

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Figures
Appendix A: Soil Laboratory Test Data
Appendix B: Subsurface Exploration Data

Distribution:

Black & Veatch Special Projects Corporation (1)
Attn: Mr. Dennis J. Hogan, PE

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FIGURES

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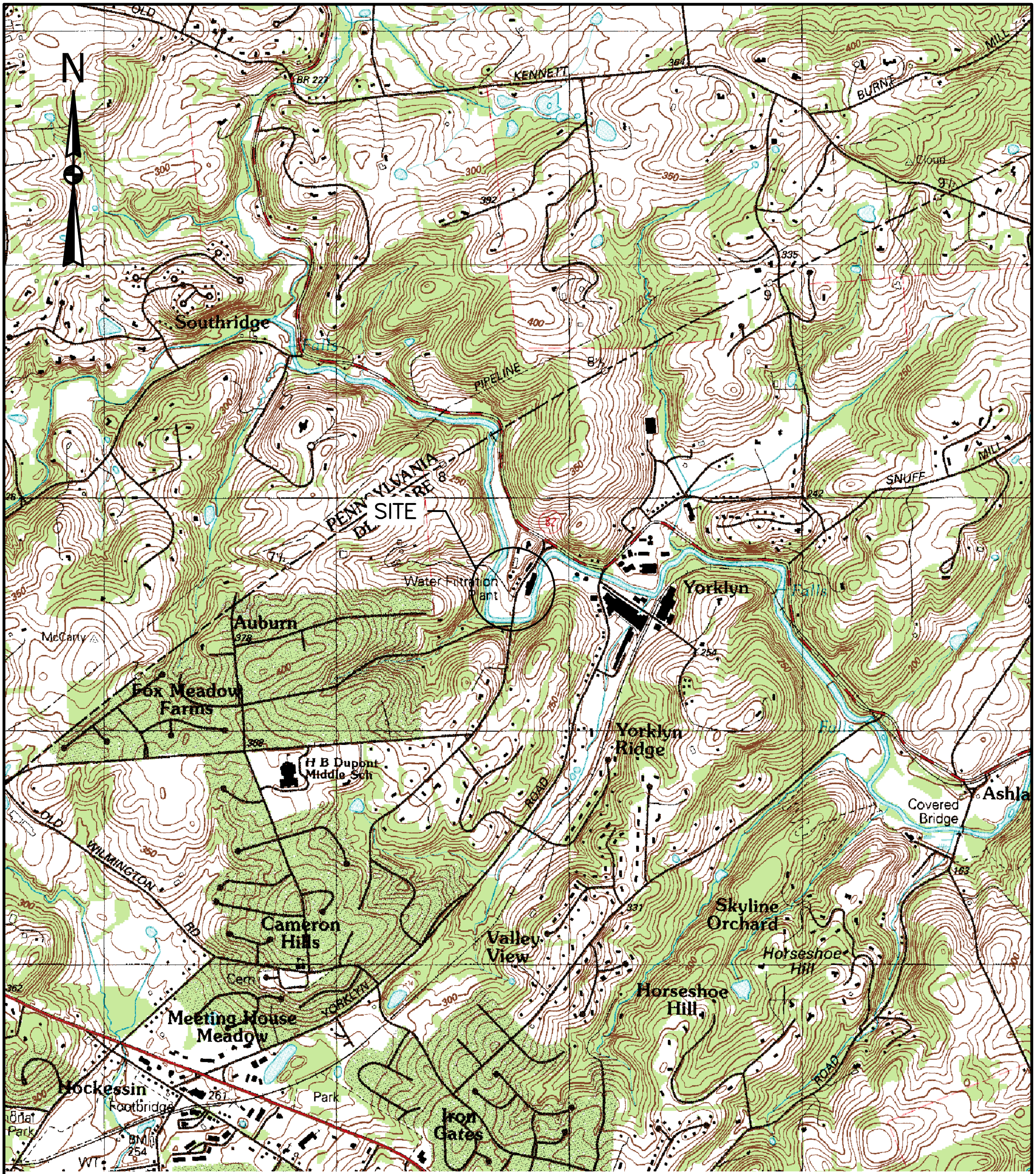

REFERENCE: USGS 7.5 MINUTE QUADRANGLE KENNETT SQUARE, PA.-DEL. 1993

SCALE: 1"=2000'

0 2000' 4000'

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NVF PROPERTIES
NVF YORKLYN SITE (DE-0071)
YORKLYN, DELAWARE
PROJECT NO. 12615019.00

VICINITY MAP

FIGURE 1

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LEGEND:

APPROXIMATE TEST BORING LOCATION
B-1

SCALE: 1"=20'
0 20' 40'

REFERENCE: BLACK & VEATCH provided the base plan for this drawing.

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NVF PROPERTIES
NVF YORKLYN SITE (DE-0071)
YORKLYN, DELAWARE
PROJECT NO. 12615019.00

TEST BORING LOCATION PLAN
BRIDGE #1

FIGURE 2

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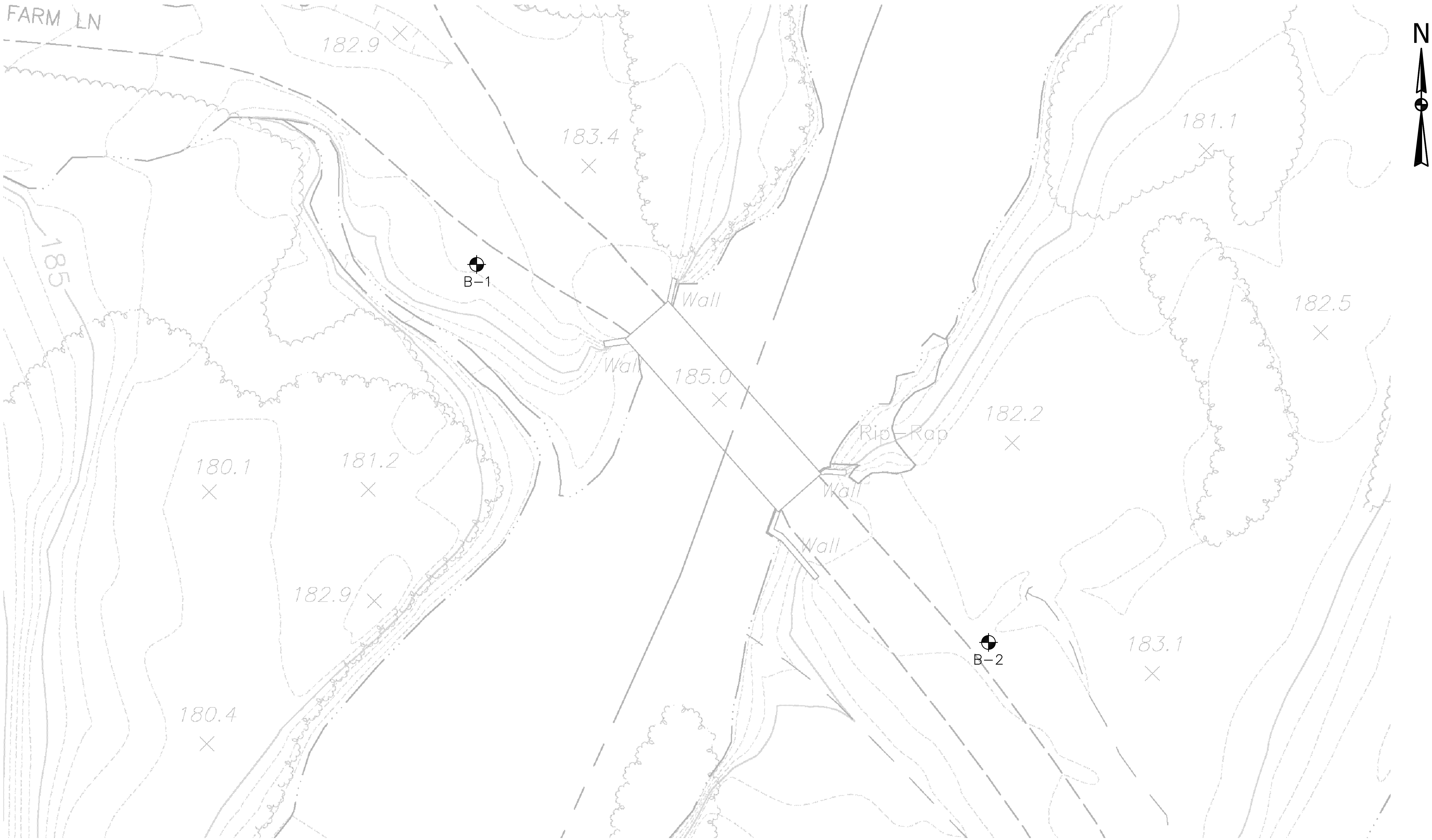

LEGEND:

B-1 APPROXIMATE TEST BORING LOCATION

SCALE: 1"=20'
0 20' 40'

REFERENCE: BLACK & VEATCH provided the base plan for this drawing.

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NVF PROPERTIES
NVF YORKLYN SITE (DE-0071)
YORKLYN, DELAWARE
PROJECT NO. 12615019.00

TEST BORING LOCATION PLAN
BRIDGE #2

FIGURE 3

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APPENDIX A

SOIL LABORATORY TEST DATA

Summary of Laboratory Tests (1)
Gradation Curves (2)
Moisture Density Relationship (2)
California Bearing Ratio Test (2)

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Summary Of Laboratory Tests

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Natural Moisture (%)	Percent Gravel	Percent Sand	Percent Fines	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Proctor Test Method	CBR Value
Bulk 1+2	0.0 - 5.0	Bulk	SILTY SAND with GRAVEL (SM)	11.0	31.6	41.2	27.2	123.2	10.9	698C	16.0
Bulk 3+4	0.0 - 5.0	Bulk	SILTY SAND (SM)	15.2	0.6	71.0	28.4	119.7	12.3	698C	23.3
B-1	7.0 - 9.0 / 175.0 - 173.0	Jar	POORLY GRADED SAND with SILT and GRAVEL (SP-SM)	10.1	37.2	54.1	8.7	--	--	--	--
B-2	5.0 - 7.0 / 178.0 - 176.0	Jar	SILTY SAND with GRAVEL (SM)	17.2	19.8	52.7	27.5	--	--	--	--
B-3	7.0 - 9.0 / 171.0 - 169.0	Jar	POORLY GRADED SAND with SILT and GRAVEL (SP-SM)	11.5	46.3	47.9	5.8	--	--	--	--
B-3	9.0 - 11.0 / 169.0 - 167.0	Jar	POORLY GRADED SAND with SILT and GRAVEL (SP-SM)	10.1	42.3	47.1	10.6	--	--	--	--
B-4	7.0 - 9.0 / 171.0 - 169.0	Jar	SILTY SAND with GRAVEL (SM)	12.4	32.6	53.8	13.6	--	--	--	--

Notes:
1. Soil tests in general accordance with ASTM standards.
2. Soil classifications are in general accordance with ASTM D2487(as applicable), based on testing indicated and visual classification.
3. Key to abbreviations: NP=Non-Plastic; -- indicates no test performed

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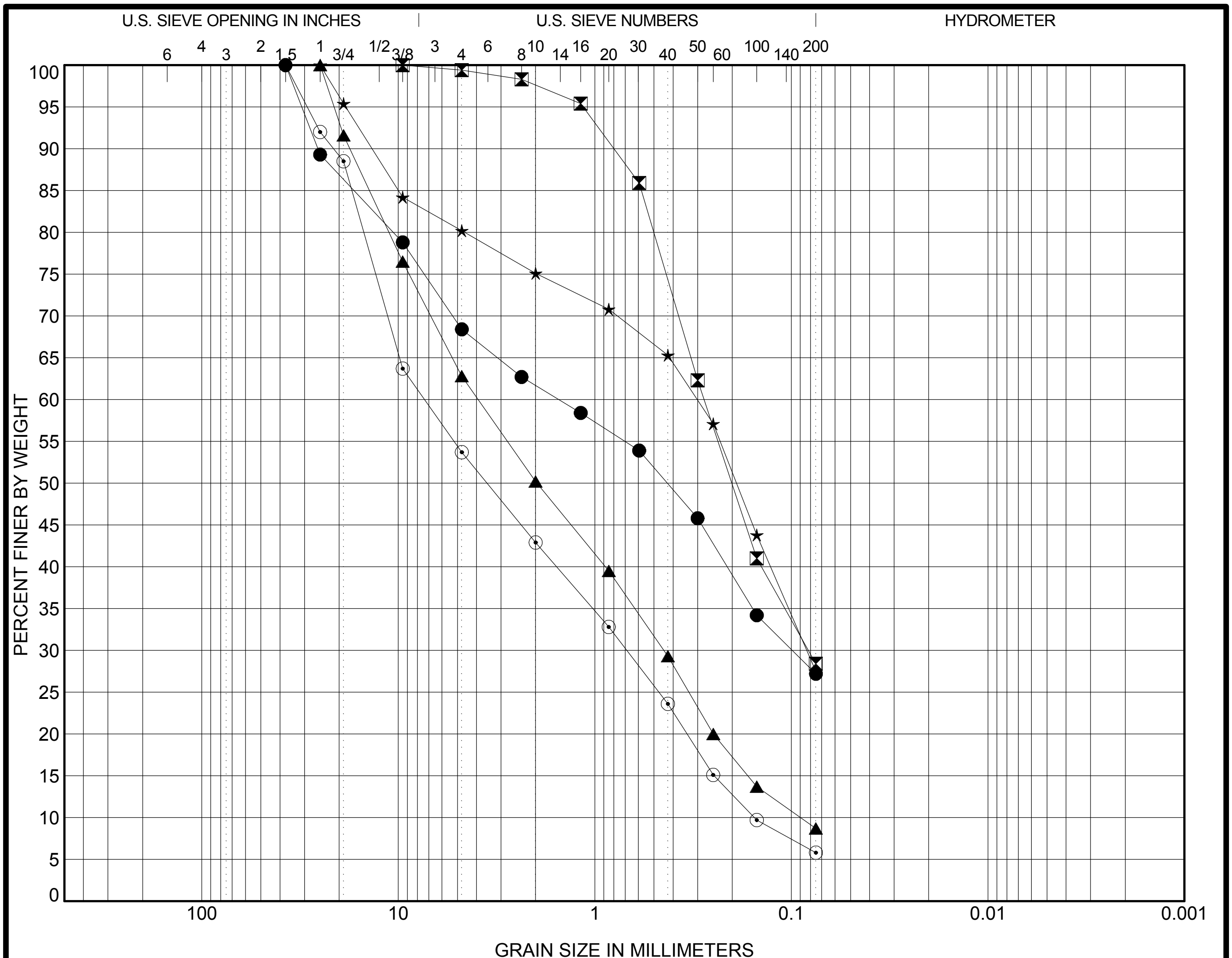
Project: NVF Bridges
NVF Yorklyn Site (DE-0071)
Yorklyn, DE



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen		Sample Description	LL	PL	PI		
●	**Bulk 1+2**	**0.0 ft**	**SILTY SAND with GRAVEL (SM)**	--	--	--		
⧗	**Bulk 3+4**	**0.0 ft**	**SILTY SAND (SM)**	--	--	--		
▲	**B-1**	**7.0 ft**	**POORLY GRADED SAND with SILT and GRAVEL (SP-SM)**	--	--	--		
★	**B-2**	**5.0 ft**	**SILTY SAND with GRAVEL (SM)**	--	--	--		
⊙	**B-3**	**7.0 ft**	**POORLY GRADED SAND with SILT and GRAVEL (SP-SM)**	--	--	--		

	Specimen		Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**Bulk 1+2**	**0.0 ft**	**ASTM D422**	**37.5**	**1.527**	**0.099**		**31.6**	**41.2**	**27.2**	
⧗	**Bulk 3+4**	**0.0 ft**	**ASTM D422**	**9.5**	**0.278**	**0.082**		**0.6**	**71.0**	**28.4**	
▲	**B-1**	**7.0 ft**	**ASTM D422**	**25**	**3.919**	**0.446**	**0.09**	**37.2**	**54.1**	**8.7**	
★	**B-2**	**5.0 ft**	**ASTM D422**	**25**	**0.302**	**0.083**		**19.8**	**52.7**	**27.5**	
⊙	**B-3**	**7.0 ft**	**ASTM D422**	**37.5**	**7.351**	**0.688**	**0.154**	**46.3**	**47.9**	**5.8**	

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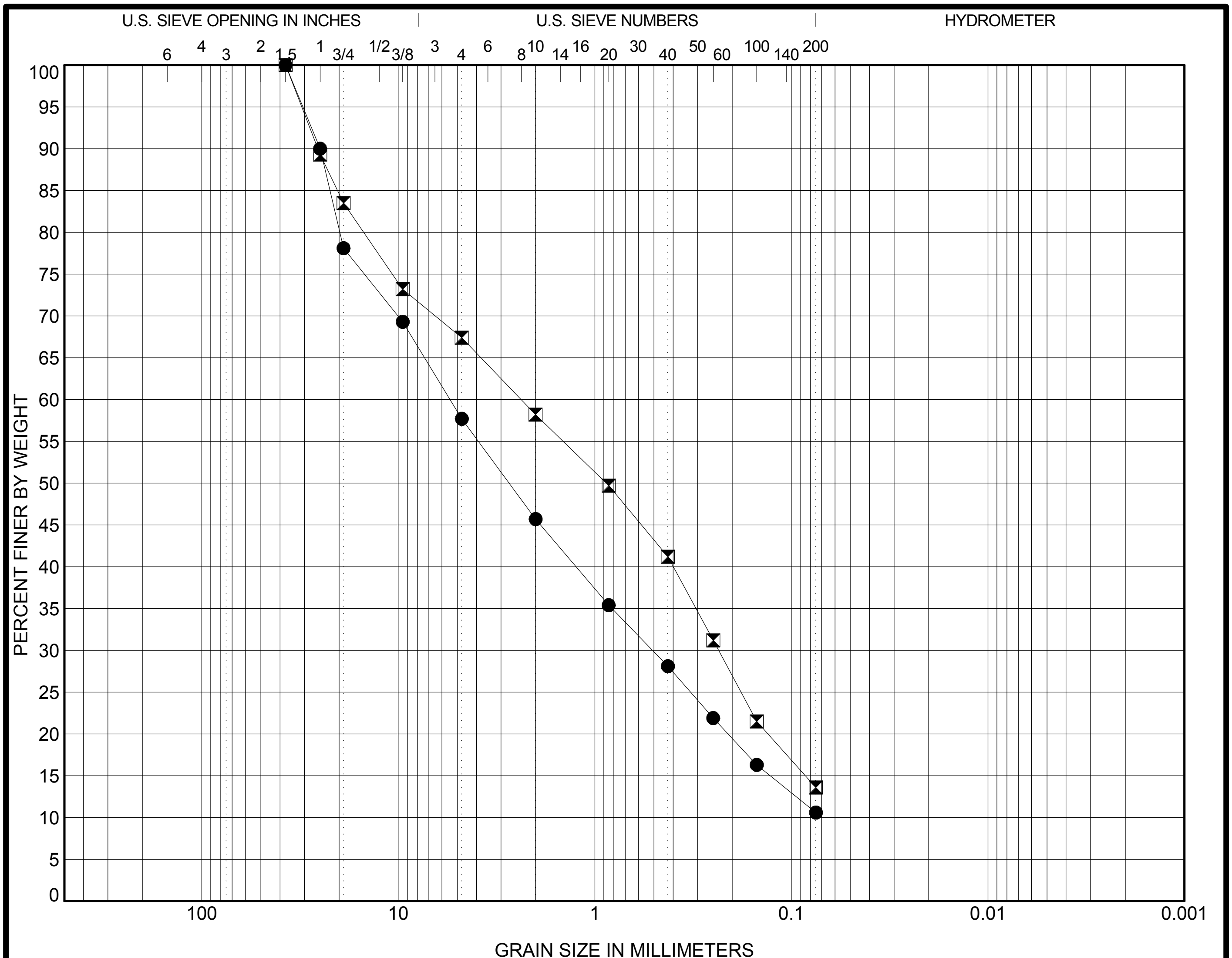
GRADATION CURVES

Project: NVF Bridges
NVF Yorklyn Site (DE-0071)
Yorklyn, DE

Contract: 12615019

SIEVE 5 SHEET 12615019 NVF BRIDGES.GPJ SCHNABEL DATA TEMPLATE 2008_04_22.GDT 6/22/12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen		Sample Description	LL	PL	PI		
●	B-3	9.0 ft	POORLY GRADED SAND with SILT and GRAVEL (SP-SM)	--	--	--		
⧗	B-4	7.0 ft	SILTY SAND with GRAVEL (SM)	--	--	--		

	Specimen		Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-3	9.0 ft	ASTM D422	37.5	5.45	0.509		42.3	47.1	10.6	
⧗	B-4	7.0 ft	ASTM D422	37.5	2.369	0.235		32.6	53.8	13.6	

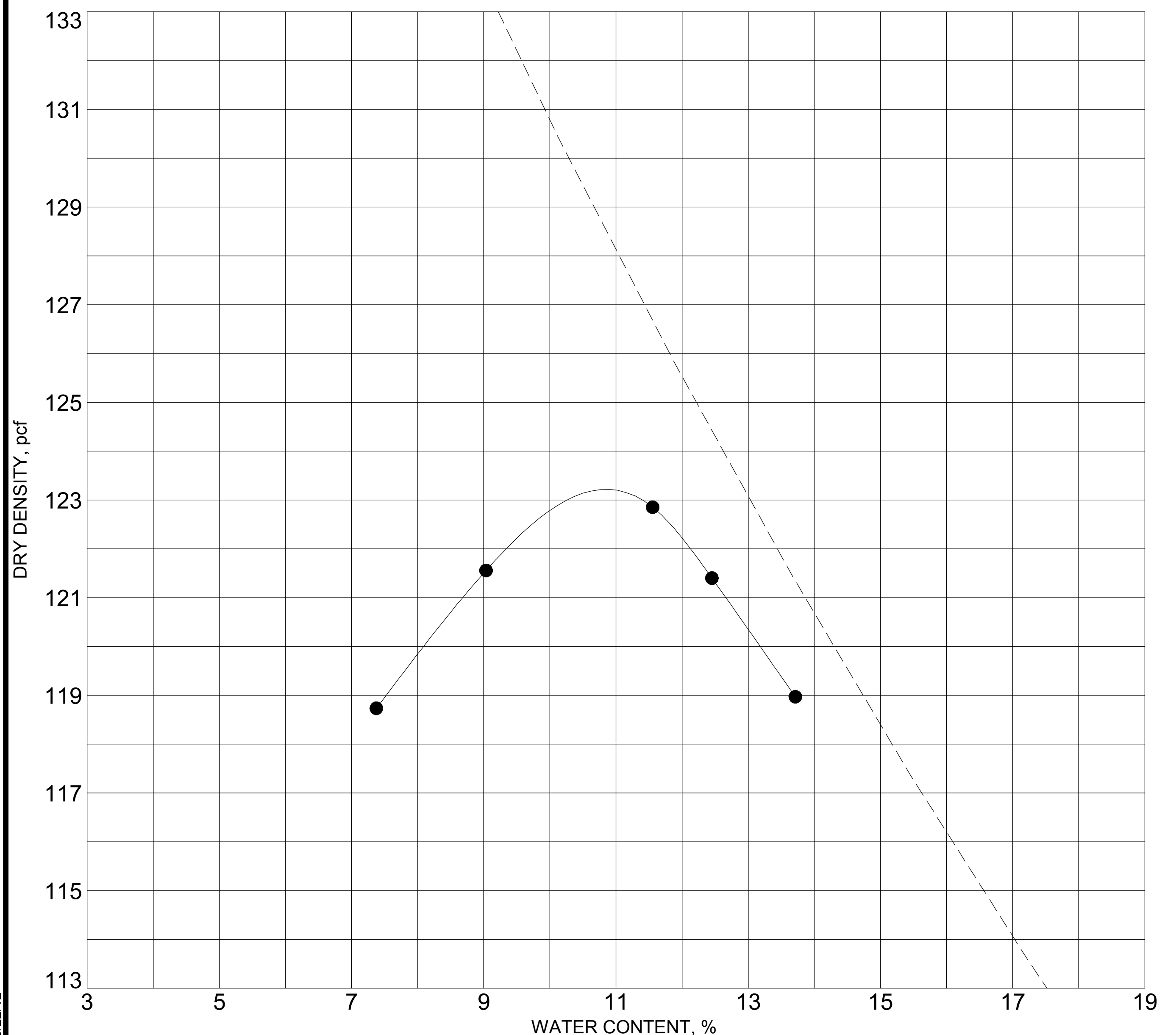
Schnabel ENGINEERING

GRADATION CURVES

Project: NVF Bridges
NVF Yorklyn Site (DE-0071)
Yorklyn, DE

Contract: 12615019

SIEVE 5 SHEET 12615019 NVF BRIDGES.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 6/22/12



Sample Description: SILTY SAND with GRAVEL (SM)

Sample Source: Bulk 1+2, 0.0 ft

Test Methods: ASTM D698 Method C

Assumed Specific Gravity: 2.65

Max. Dry Density (pcf): 123.2

Opt. Moisture (%): 10.9

Liquid Limit (LL): --

Plasticity Index (PI): --

% Retained #4 Sieve: 31.6

% Passing # 200 Sieve: 27.2

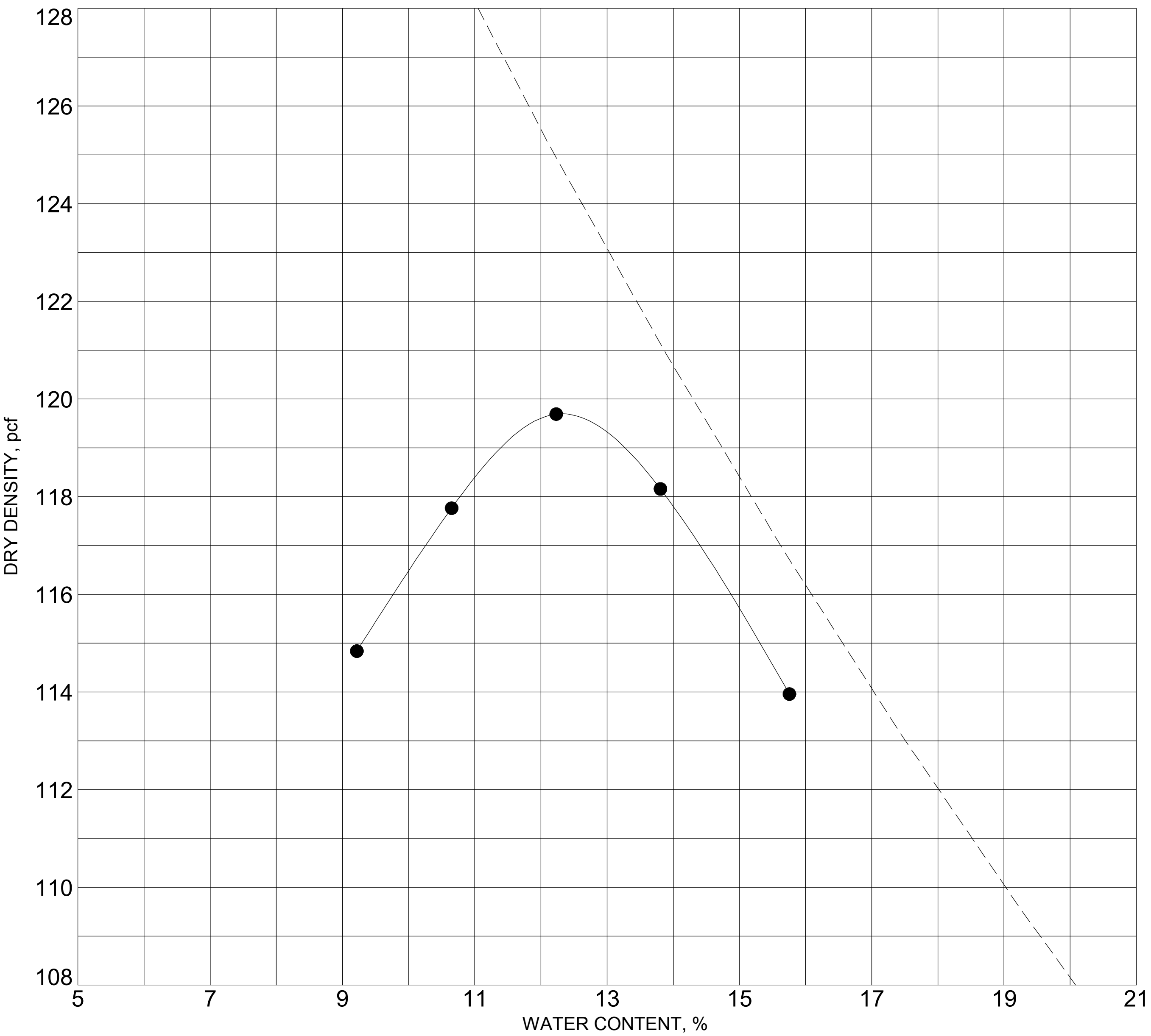
Comments:

Schnabel ENGINEERING

MOISTURE DENSITY RELATIONSHIP

Project: NVF Bridges
NVF Yorklyn Site (DE-0071)
Yorklyn, DE

Contract: 12615019



Sample Description: SILTY SAND (SM)

Sample Source: Bulk 3+4, 0.0 ft

Test Methods: ASTM D698 Method C

Assumed Specific Gravity: 2.65

Max. Dry Density (pcf): 119.7

Opt. Moisture (%): 12.3

Liquid Limit (LL): --

Plasticity Index (PI): --

% Retained #4 Sieve: 0.6

% Passing # 200 Sieve: 28.4

Comments:

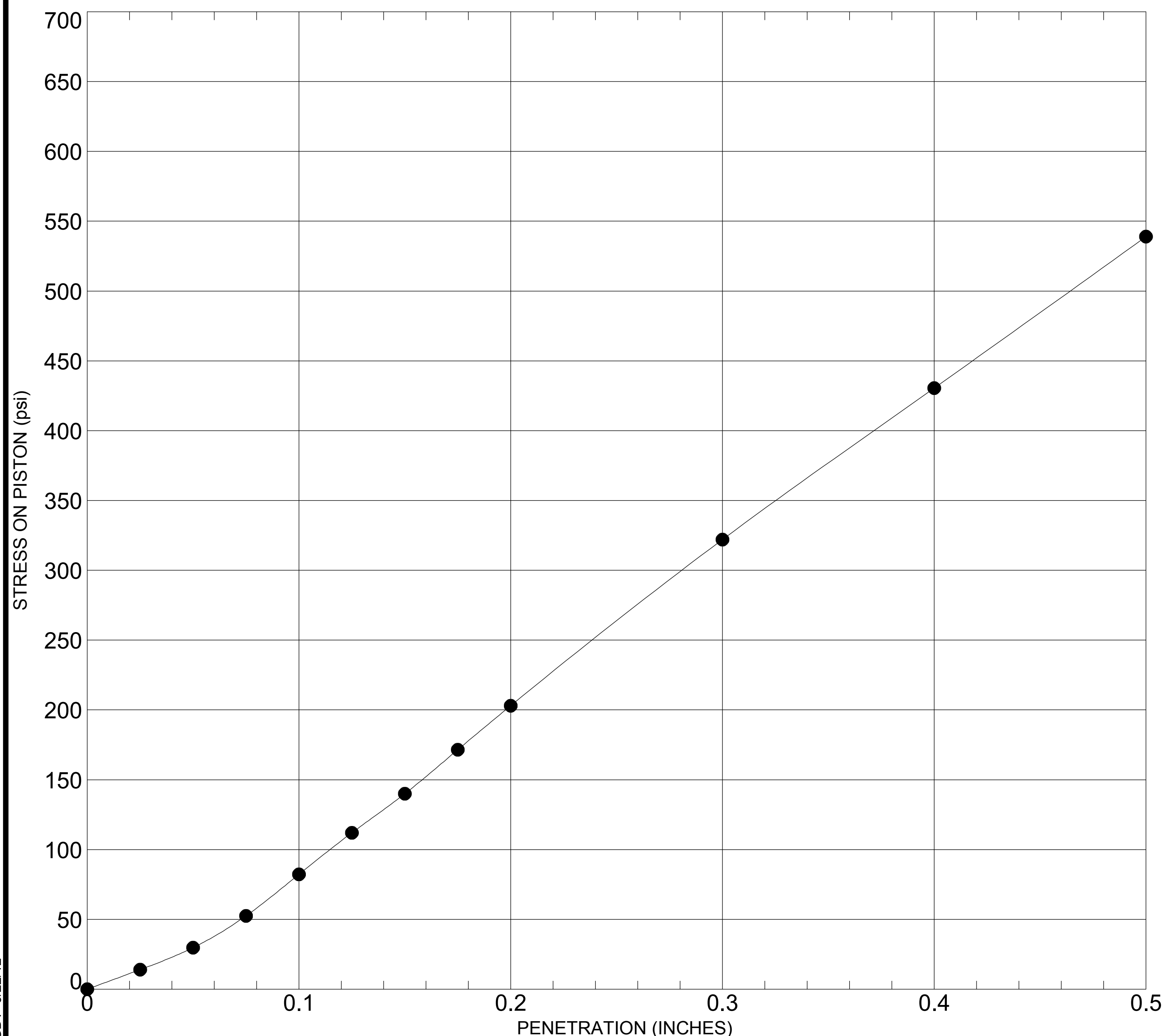
Schnabel ENGINEERING

MOISTURE DENSITY RELATIONSHIP

Project: NVF Bridges
NVF Yorklyn Site (DE-0071)
Yorklyn, DE

Contract: 12615019

COMPACTION 12615019 NVF BRIDGES.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 6/22/12



Sample Description:	SILTY SAND with GRAVEL (SM)
Sample Source:	Bulk 1+2
Sample Depth:	0.0 ft
Test Method:	

Dry Density Before Soaking (pcf):	123.0
Dry Density After Soaking (pcf):	122.4
Maximum Dry Density (pcf):	123.2
Moisture Content Before Soaking (%):	11.2
Moisture Content After Soaking (Avg) (%):	12.5
Moisture Content Top Inch After Soak (%):	12.8
Optimum Moisture Content (%):	10.9

Liquid Limit (LL):	--
Plasticity Index (PI):	--
% Retained #4 Sieve:	31.6
% Passing # 200 Sieve:	27.2

CBR:	16, Soaked
Surcharge (psf):	50
Swell (%):	0.5

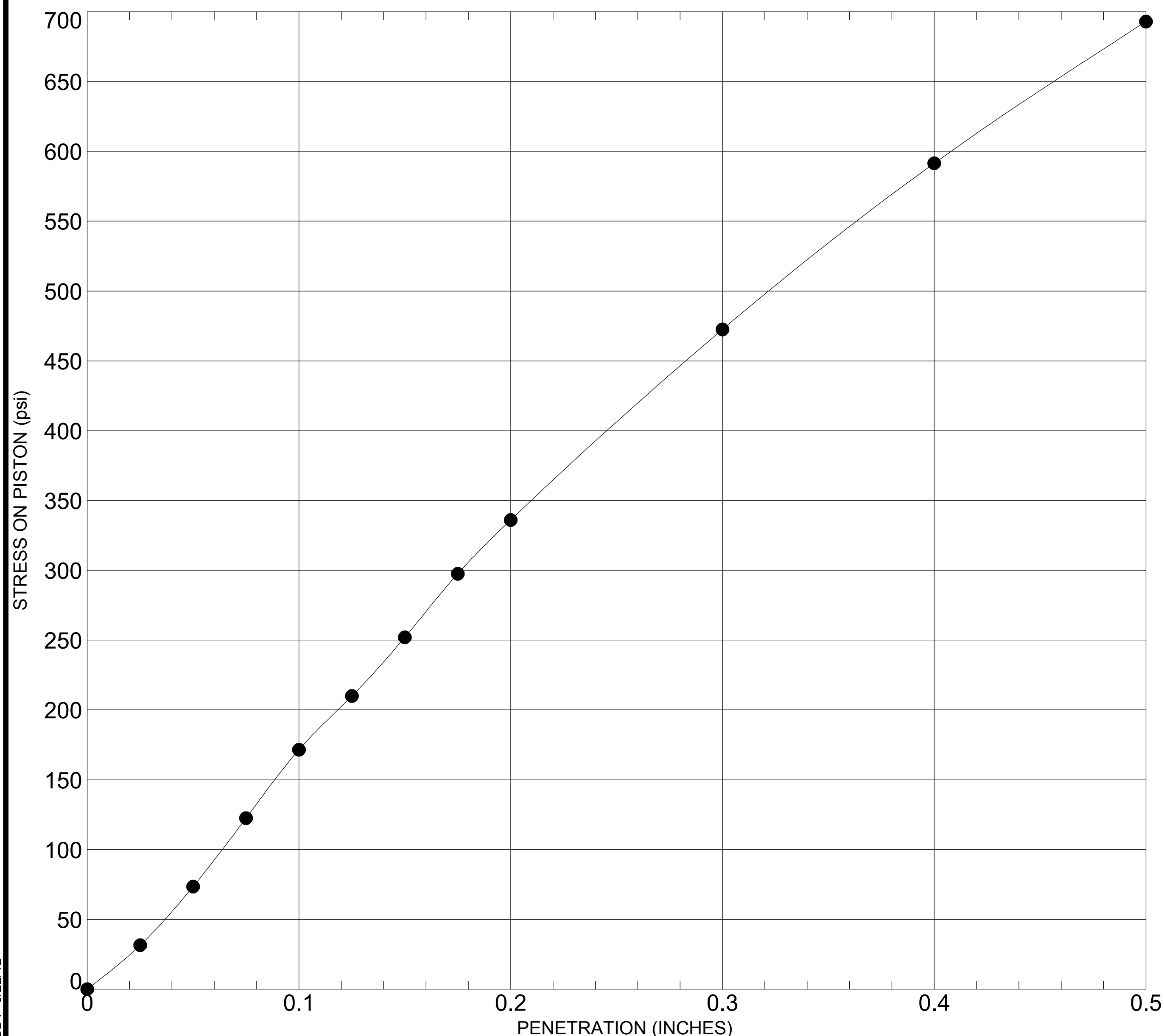
Schnabel ENGINEERING

CALIFORNIA BEARING RATIO TEST

Project: NVF Bridges
NVF Yorklyn Site (DE-0071)
Yorklyn, DE

Contract: 12615019

CBR SINGLE POINT 12615019 NVF BRIDGES.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 6/22/12



Sample Description:	SILTY SAND (SM)
Sample Source:	Bulk 3+4
Sample Depth:	0.0 ft
Test Method:	

Dry Density Before Soaking (pcf):	115.6
Dry Density After Soaking (pcf):	115.5
Maximum Dry Density (pcf):	119.7
Moisture Content Before Soaking (%):	12.3
Moisture Content After Soaking (Avg) (%):	14.7
Moisture Content Top Inch After Soak (%):	13.9
Optimum Moisture Content (%):	12.3

Liquid Limit (LL):	--
Plasticity Index (PI):	--
% Retained #4 Sieve:	0.6
% Passing # 200 Sieve:	28.4

CBR:	23.3, Soaked
Surcharge (psf):	50
Swell (%):	0.1

Schnabel ENGINEERING

CALIFORNIA BEARING RATIO TEST

Project: NVF Bridges
NVF Yorklyn Site (DE-0071)
Yorklyn, DE

Contract: 12615019

APPENDIX B

SUBSURFACE EXPLORATION DATA

Subsurface Exploration Procedures
General Notes for Subsurface Exploration Logs
Identification of Soil
Descriptive Criteria for Rock Core Logging
Supplemental Rock Descriptive Terms
Boring Logs, B-1 through B-4

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SUBSURFACE EXPLORATION PROCEDURES

Boring Procedures

Drillers advanced the borings using hollow-stem augers. A plug device blocked off the center opening in the hollow-stem auger to prevent cuttings from entering the augers during drilling. At the designated depth, drillers removed the plug and performed the Standard Penetration Test. Water or drilling fluid was not introduced into the boring using this procedure, unless indicated on individual logs. The logs indicate water level data.

Standard Penetration Test Results

The numbers in the Sampling Data column of the boring logs represent Standard Penetration Test (SPT) results. Each number represents the blows needed to drive a 2-inch O.D., 1⅜ inch I.D. split-spoon sampler 6 inches, using a 140-pound hammer falling 30 inches. The sampler is typically driven a total of 18 or 24 inches. The first 6-inch interval usually represents a seating interval. The total of the number of blows for the second and third 6-inch intervals is the SPT "N value." When the blow count reaches 100 before the full driving distance, we determine the SPT N value based on extrapolation of the blows recorded. The SPT is conducted according to ASTM D1586.

Rock Coring

Rock was cored with NQ size core barrels. Recovery (REC) and Rock Quality Designation (RQD) are noted on the test boring logs, as applicable.

Soil Classification Criteria

The group symbols on the logs represent the Unified Soil Classification System Group Symbols (ASTM D2487) based on visual observation and limited laboratory testing of the samples. Criteria for visual identification of soil samples are included in this appendix. Some variation may be expected between samples visually classified and samples classified in the laboratory.

Disintegrated rock is residual material with SPT N values between 60 blows per foot and refusal. Refusal is a penetration rate of 100 blows per two inches or less penetration.

Test Boring Locations and Elevations

Our personnel staked the borings by taping from existing features. Figures 2 and 3 show the approximate test boring locations. We scaled ground surface elevations at the test boring locations from the site plans by Black & Veatch dated January 6, 2012. Project planning should consider these locations and elevations no more accurate than the methods and plans used to obtain them.

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GENERAL NOTES FOR SUBSURFACE EXPLORATION LOGS

1. Numbers in sampling data column next to Standard Penetration Test (SPT) symbols indicate blows required to drive a 2-inch O.D., 1⅜-inch I.D. sampling spoon 6 inches using a 140 pound hammer falling 30 inches. The Standard Penetration Test (SPT) N value is the number of blows required to drive the sampler 12 inches, after a 6-inch seating interval. The Standard Penetration Test is performed in general accordance with ASTM D1586.

2. Visual classification of soil is in accordance with terminology set forth in "Identification of Soil." The ASTM D2487 group symbols (e.g., CL) shown in the classification column are based on visual observations.

3. Estimated groundwater levels indicated on the logs are only estimates from available data and may vary with precipitation, porosity of the soil, site topography, and other factors.

4. Refusal at the surface of rock, boulder, or other obstruction is defined as an SPT resistance of 100 blows for 2 inches or less of penetration.

5. The logs and related information depict subsurface conditions only at the specific locations and at the particular time when drilled or excavated. Soil conditions at other locations may differ from conditions occurring at these locations. Also, the passage of time may result in a change in the subsurface soil and groundwater conditions at the subsurface exploration location.

6. The stratification lines represent the approximate boundary between soil and rock types as obtained from the subsurface exploration. Some variation may also be expected vertically between samples taken. The soil profile, water level observations, and penetration resistances presented on these logs have been made with reasonable care and accuracy, and must be considered only an approximate representation of subsurface conditions to be encountered at the particular location.

7. Key to symbols and abbreviations:

S-1, SPT	- Sample No., Standard Penetration Test
5+10+1	- Number of blows in each 6-in increment
UD-1, UNDIST	- Sample No., 2" or 3" Undisturbed Tube Sample
REC=24", 100%	- Recovery in inches, Percent Recovery
C-1, CORE	- Core No., Rock Core
Run = 5.0 ft	- Run Length in feet
REC = 60" 100%	- Recovery in inches, Percent Recovery
RQD = 60" 100%	- RQD in inches, Percent RQD
MC	- Moisture Content
PP	- Pocket Penetrometer Reading (tsf)
FID	- Flame Ionization Detector Reading (ppm)
PID	- Photoionization Detector Reading (ppm)
GP	- Geostick Penetration Reading (inches)
LL	- Liquid Limit
PL	- Plastic Limit
TPH	- Total Petroleum Hydrocarbons

IDENTIFICATION OF SOIL

I. DEFINITION OF SOIL GROUP NAMES (ASTM D-2487)

			SYMBOL	GROUP NAME
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels – More than 50% of coarse fraction retained on No. 4 sieve Coarse, ¾" to 3" Fine, No. 4 to ¾"	Clean Gravels Less than 5% fines	GW	WELL GRADED GRAVEL
			GP	POORLY GRADED GRAVEL
		Gravels with fines More than 12% fines	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	Sands – 50% or more of coarse Fraction passes No. 4 sieve Coarse, No. 10 to No. 4 Medium, No. 40 to No. 10 Fine, No. 200 to No. 40	Clean Sands Less than 5% fines	SW	WELL GRADED SAND
			SP	POORLY GRADED SAND
		Sands with fines More than 12% fines	SM	SILTY SAND
			SC	CLAYEY SAND
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays – Liquid Limit less than 50 Low to medium plasticity	Inorganic	CL	LEAN CLAY
			ML	SILT
		Organic	OL	ORGANIC CLAY
				ORGANIC SILT
	Silts and Clays – Liquid Limit 50 or more Medium to high plasticity	Inorganic	CH	FAT CLAY
			MH	ELASTIC SILT
		Organic	OH	ORGANIC CLAY
				ORGANIC SILT
Highly Organic Soils	Primarily organic matter, dark in color and organic odor		PT	PEAT

II. DEFINITION OF SOIL COMPONENT PROPORTIONS (ASTM D-2487)

			Examples
Adjective Form	GRAVELLY SANDY	>30% to <50% coarse grained component in a fine-grained soil	GRAVELLY LEAN CLAY
	CLAYEY SILTY	>12% to <50% fine grained component in a coarse-grained soil	SILTY SAND
"With"	WITH GRAVEL WITH SAND	>15% to <30% coarse grained component in a fine-grained soil	FAT CLAY WITH GRAVEL
	WITH GRAVEL WITH SAND	>15% to <50% coarse grained component in a coarse-grained soil	POORLY GRADED GRAVEL WITH SAND
	WITH SILT WITH CLAY	>5% to <12% fine grained component in a coarse-grained soil	POORLY GRADED SAND WITH SILT

III. GLOSSARY OF MISCELLANEOUS TERMS

SYMBOLS .... Unified Soil Classification Symbols are shown above as group symbols. A dual symbol "-" indicates the soil belongs to two groups. A borderline symbol "/" indicates the soil belongs to two possible groups.

FILL .... Man-made deposit containing soil, rock and often foreign matter.

PROBABLE FILL .... Soils which contain no visually detected foreign matter but which are suspect with regard to origin.

DISINTEGRATED ROCK (DR) .... Residual materials with a standard penetration resistance (SPT) between 60 blows per foot and refusal. Refusal is defined as a SPT of 100 blows for 2" or less penetration.

PARTIALLY WEATHERED ROCK (PWR)......................... Residual materials with a standard penetration resistance (SPT) between 100 blows per foot and refusal. Refusal is defined as a SPT of 100 blows for 2" or less penetration.

BOULDERS & COBBLES..... Boulders are considered rounded pieces of rock larger than 12 inches, while cobbles range from 3 to 12 inch size.

LENSES................................ 0 to ½ inch seam within a material in a test pit.

LAYERS .... ½ to 12 inch seam within a material in a test pit.

POCKET .... Discontinuous body within a material in a test pit.

MOISTURE CONDITIONS..... Wet, moist or dry to indicate visual appearance of specimen.

COLOR .... Overall color, with modifiers such as light to dark or variation in coloration.

DESCRIPTIVE CRITERIA FOR ROCK CORE LOGGING

Rock is defined as natural subsurface material yielding SPT blow counts of N ≥ 100/2 inches (Martin, 1977). Rock descriptions may include the following descriptive elements, as applicable, generally in the order indicated. Supplemental descriptors may also be used, depending on project performance objectives and available information.

ROCK TYPE, strength, weathering, fracturing, color, recovery, RQD

Rock Type General terms are used following the NRCS (2001) rock type classification chart based on visual identification. Some of the NRCS rock types common to our geographic area of practice are listed below. Mineralogical modifiers may be added where they help define distinct units (e.g., Garnet-Muscovite Schist).

Sedimentary:	Conglomerate, Sandstone, Mudstone, Siltstone, Claystone, Shale, Limestone, Dolomite, Coal, Chert
Igneous:	Pegmatite, Granite, Diorite, Gabbro, Diabase, Rhyolite, Monzonite, Andesite, Basalt
Metamorphic:	Gneiss, Schist, Phyllite, Slate, Quartzite, Marble, Amphibolite, Hornfels

Strength (modified from Hoek, 2001) The estimated Uniaxial Compressive Strength associated with each rock strength term is based on the field strength index test for intact rock samples as follows.

• Extremely Strong	>36,000 psi	Specimen can only be chipped with a geological hammer.
• Very Strong	15,000 - 36,000 psi	Specimen requires many blows of a geological hammer to fracture it.
• Strong	7,500 - 15,000 psi	Specimen requires more than one blow of a geological hammer to fracture it.
• Medium Strong	3,500 - 7,500 psi	Specimen cannot be peeled with a pocketknife, can be fractured with one blow from a geological hammer.
• Weak	700 - 3,500 psi	Specimen can be peeled with a pocketknife with difficulty, shallow indentation made by firm blow with point of a geological hammer.
• Very Weak	150 - 700 psi	Material crumbles under firm blows with point of a geological hammer, can be peeled with a pocket knife.

Weathering (modified from ACOE, 1994; and USBR, 2001)

• Fresh	Mineral crystals appear bright and show no discoloration. Fractures show little or no staining on their surfaces. Discoloration does not extend into intact rock.
• Slightly Weathered	Rock is generally fresh except along fractures. Some fractures are stained and discoloration may extend up to 0.5 inches into rock.
• Moderately Weathered	Significant portions of rock appear dull and discolored. Rock may be significantly weaker than in its fresh state near fractures. Soil zones of limited extent may occur along some fractures.
• Highly Weathered	Rock appears dull and discolored throughout. Majority of rock mass is significantly weaker than in its fresh state. Isolated zones of stronger rock and/or soil may occur throughout.
• Severely Weathered	Significant portions of rock mass essentially weathered to soil. Rock fabric may still be discernable (i.e., saprolite). Isolated zones of stronger rock may occur locally. Quartz may be present as hard, fractured dikes or veins.

Fracturing (from ACOE, 1994)

Very Slightly Fractured	> 6.5 ft
Slightly Fractured	2 ft - 6.5 ft
Moderately Fractured	8 in - 2 ft
Highly Fractured	2.5 in - 8 in
Intensely Fractured	< 2.5 in

Color (from Munsell Color System; and GSA, 1995) Color descriptions include a primary color and up to two shade or secondary color modifiers, and may also include a color pattern term to define the relationship between multiple colors.

Shade: Light, Dark
Secondary: Blackish, Brownish, Grayish, Greenish, Reddish, Yellowish, Orangeish
Primary: Black, Brown, Gray, Green, Red, Yellow, Orange, White
Pattern: and, to, with mottles of, with speckles of, with streaks of, with bands of

- **Recovery** is defined as the total length of recovered core in a core run divided by the total length of the core run, times 100 percent. A core run may be any depth interval of concern. Only natural fractures are considered for determining the length of core pieces. Mechanical breaks formed during or after coring do not count against the length determination. The length of recovered core pieces is measured along the core axis, between fracture midpoints.

- **RQD** (ASTM D-6032, Deere & Deere, 1988, 1989) is defined as the total length of core pieces at least four inches long recovered from a core run divided by the total length of the core run, times 100 percent. A core run may be any depth interval of concern. Only natural fractures are considered for determining the length of core pieces. Mechanical breaks formed during or after coring do not count against the length determination. The length of recovered core pieces should be measured along the core axis, between fracture midpoints. Core pieces that are highly to severely weathered, very weak, or contain numerous pores should not count toward RQD.

SUPPLEMENTAL ROCK DESCRIPTIVE TERMS

In addition to the basic rock descriptive elements provided on the preceding Engineering Descriptions of Rock sheet, rock descriptions may include the following supplemental descriptive elements depending on project performance objectives and available information.

Bedding Thickness & Inclination Bedding is defined as the layered arrangement of sediment deposits in sedimentary rock. Bedding thickness is the average perpendicular distance between bedding surfaces. Bedding thickness intervals follow Bieniawski (1989). Inclination is measured in degrees from a plane perpendicular to the core axis (Figure 1).

Very Thickly Bedded	> 6.5 ft
Thickly Bedded	2 ft - 6.5 ft
Medium Bedded	8 in - 2 ft
Thinly Bedded	2.5 in - 8 in
Very Thinly Bedded	< 2.5 in

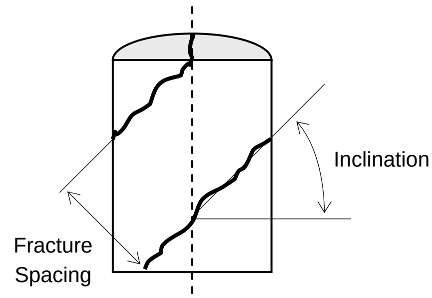

Figure 1: Inclination Measurement

Foliation Character & Inclination Foliation is defined as the planar arrangement of textural features in metamorphic rock. Inclination is measured in degrees from a plane perpendicular to the core axis (Figure 1).

Strongly Foliated	Foliation is easily discernable throughout.
Moderately Foliated	Foliation is discernable with some difficulty.
Poorly Foliated	Foliation is generally not discernable.

Fracture Set Data Individual fractures or fracture sets may be characterized by the following descriptive elements, when applicable and discernable: fracture type, inclination (as per Figure 1), average spacing, roughness and infilling condition. An example fracture set data description for an individual stratum is: *4 joints at 80-90°, moderately spaced, slightly rough, with spotty iron staining and partially filled with pyrite*. If fractures are rare, they can be described individually by listing the depth, followed by the descriptive terms in this section.

FRACTURE TYPE

Fracture	Any natural break in rock. ‘Fracture’ is the general term used for individual breaks that do not fall into any of the following fracture type categories
Joint	A relatively planar fracture without shear displacement; occurs with other similarly oriented joints generally at regularly spaced intervals
Shear	A fracture along which differential movement has taken place parallel to the surface (i.e., shear displacement) sufficient to produce slickensides or polishing
Fault	A major fracture along which there has been appreciable shear displacement accompanied by gouge and/or a severely fractured zone
Bedding Fracture	A fracture along a bedding plane
Foliation Fracture	A fracture along a foliation plane
Vein Fracture	A fracture along the contact of an intrusive vein

Average Spacing (NRCS, 2001)

Very Widely Spaced	> 6.5 ft
Widely Spaced	2 ft - 6.5 ft
Moderately Spaced	8 in - 2 ft
Closely Spaced	2.5 in - 8 in
Very Closely Spaced	< 2.5 in

Roughness (Bieniawski, 1989)

Very Rough	- Most surface asperities extend > 2 mm from the average planar surface.
Rough	- Most surface asperities extend 0.5 to 2 mm from the average planar surface.
Slightly rough	- Most surface asperities extend < 0.5 mm from the average planar surface.
Smooth	- Generally smooth to touch with few surface asperities.
Slickensided	- Infilling material contains slickensides.

Infilling Condition

Coverage	*Type*
Spotty Filling of (≤ 50% coverage)	Calcite
Partially Filled with (50 to 100% coverage)	Chlorite
Filled with (100% coverage)	Clay
	Gypsum
	Iron Staining
	Manganese
	Mica
	Pyrite
	Quartz
	Talc

Schnabel ENGINEERING	**TEST BORING LOG**	**Project:** NVF Bridges NVF Yorklyn Site (DE-0071) Yorklyn, Delaware	**Boring Number:** **B-1** **Contract Number:** 12615019 **Sheet:** 1 of 1

Contractor: Connelly & Associates. Inc.
Dover, Pennsylvania

Contractor Foreman: R. Anderson

Schnabel Representative: J. Beideman

Equipment: CME-550

Method: 4-1/4" I.D. Hollow Stem Auger,
NQ Double Barrel

Hammer Type: Auto Hammer (140 lb)

Dates Started: 5/29/12 **Finished:** 5/29/12

Location: See Location Plan

Ground Surface Elevation: 182± (ft) **Total Depth:** 29.5 ft

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Encountered	5/29	11:35 AM	8.5'	7.0'	---
Casing Pulled	5/29	3:05 PM	3.0'	---	8.0'
End of Day	5/29	4:54 PM	5.5'	---	6.5'
Start of Day	5/30	8:15 AM	5.5'	---	6.5'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.2	2" Topsoil		181.8			S-1, SPT 4+11+10+10 REC=12", 50%		PROBABLE FILL
	FILL, sampled as sandy silt with gravel; moist, dark brown, contains concrete, contains roots	FILL		A				
5.0	SILTY GRAVEL WITH SAND, fine to coarse grained sand, subrounded particles; wet, brown, contains mica	GM	177.0	B	5	S-2, SPT 2+17+6+4 REC=7", 29%		ALLUVIAL
7.0	POORLY GRADED SAND WITH SILT AND GRAVEL, medium to coarse grained sand, subrounded particles; wet, brown, contains mica	SP-SM	175.0			S-3, SPT 2+2+16+22 REC=9", 38%	MC = 10.1% % Passing #200 = 8.7	
9.0	DISINTEGRATED ROCK, sampled as silty gravel with sand, medium to coarse grained sand; wet, brown and black, estimated 50 - 100% rock fragments, relict rock structure	DR	173.0		10	S-4, SPT 38+42+42+12 REC=10", 42%		RESIDUAL
11.0	DISINTEGRATED ROCK	DR	171.0			R-1, CORE Run = 5.0 ft REC=0", 0% RQD=0", 0%		Drill action indicates alternating layers of hard and soft rock.
15.0	DISINTEGRATED ROCK, sampled as; highly weathered, highly fractured, hard gneiss, white with black bands, iron staining	DR	167.0	D	15	R-2, CORE Run = 5.0 ft REC=6", 10% RQD=0", 0%		
20.0	DISINTEGRATED ROCK, sampled as; highly weathered, highly fractured, hard gneiss, black	DR	162.0		20	R-3, CORE Run = 5.0 ft REC=2", 3% RQD=0", 0%		
25.0	DISINTEGRATED ROCK	DR	157.0		25	R-4, CORE Run = 4.5 ft REC=0", 0% RQD=0", 0%		Drill action indicates alternating layers of hard and soft rock.
29.5			152.5					

Bottom of Boring at 29.5 ft.
Auger refusal at 10.0 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.

TEST BORING LOG 12615019 NVF BRIDGES.GPJ SCHNABEL DATA TEMPLATE 2008_07_06.GDT 6/22/12

TEST BORING LOG

Schnabel ENGINEERING

Project: NVF Bridges
NVF Yorklyn Site (DE-0071)
Yorklyn, Delaware

Boring Number: **B-2**
Contract Number: 12615019
Sheet: 1 of 1

Contractor: Connelly & Associates. Inc.
Dover, Pennsylvania

Contractor Foreman: R. Anderson

Schnabel Representative: J. Beideman

Equipment: CME-550

Method: 4-1/4" I.D. Hollow Stem Auger,
NQ Double Barrel

Hammer Type: Auto Hammer (140 lb)

Dates Started: 5/29/12 **Finished:** 5/30/12

Location: See Location Plan

Ground Surface Elevation: 183± (ft) **Total Depth:** 23.0 ft

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Encountered	5/29	3:30 PM	8.0'	6.0'	---
Start of Day	5/30	8:24 AM	12.0'	19.0'	---
Casing Pulled	5/30	10:00 AM	---	---	4.0'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.5	6" Crushed Stone		182.5			S-1, SPT 8+6+3+10 REC=14", 58%		PROBABLE FILL
5.0	FILL, sampled as sandy silt with gravel; moist, dark brown, estimated 15 - 25% rock fragments, contains mica	FILL	178.0	A	5			
11.0	SILTY SAND WITH GRAVEL, fine to medium grained sand, angular particles; moist, orangish brown streaked black, estimated 15 - 25% rock fragments, contains mica, relict rock structure Change: fine to coarse grained sand Change: wet	SM	172.0	C	10	S-2, SPT 4+5+8+20 REC=20", 83% S-3, SPT 3+15+23+23 REC=16", 67% S-4, SPT 17+19+22+26 REC=18", 75%	MC = 17.2% % Passing #200 = 27.5	RESIDUAL
19.0	DISINTEGRATED ROCK, sampled as silty sand with sand, fine to coarse grained sand, angular particles; wet, orangish brown and black, estimated 30 - 45% rock fragments	DR	164.0	D	15	S-5, SPT 23+37+23+24 REC=13", 54% S-6, SPT 22+51 REC=9", 75%		
23.0	DISINTEGRATED ROCK, sampled as; highly weathered, highly fractured, hard gneiss, white with black bands, iron staining	DR	160.0		20	S-7, SPT 4+50/3" REC=6", 67% R-1, CORE Run = 4.0 ft REC=26", 54% RQD=12", 25%		Drill action indicates alternating layers of hard and soft rock.

Bottom of Boring at 23.0 ft.
Auger refusal at 19.0 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.

Schnabel ENGINEERING — TEST BORING LOG	**Project:** NVF Bridges NVF Yorklyn Site (DE-0071) Yorklyn, Delaware	**Boring Number:** **B-3** **Contract Number:** 12615019 **Sheet:** 1 of 1

Contractor: Connelly & Associates. Inc.
Dover, Pennsylvania

Contractor Foreman: R. Anderson

Schnabel Representative: J. Beideman

Equipment: CME-550

Method: 4-1/4" I.D. Hollow Stem Auger,
NQ Double Barrel

Hammer Type: Auto Hammer (140 lb)

Dates Started: 5/30/12 **Finished:** 5/30/12

Location: See Location Plan

Ground Surface Elevation: 178± (ft) **Total Depth:** 20.0 ft

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Encountered ▽	5/30	11:45 AM	7.0'	7.0'	---
Casing Pulled ▼	5/30	1:40 PM	5.0'	---	7.5'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
7.0	FILL, sampled as poorly graded sand with silt, fine to coarse grained sand; moist, brown, contains mica Change: wet	FILL	171.0	A	5	S-1, SPT WOR+1+1+1 REC=22", 92% S-2, SPT 2+1+1+2 REC=24", 100%		PROBABLE FILL
11.0	POORLY GRADED SAND WITH SILT AND GRAVEL, fine to medium grained sand, subrounded to subangular particles; wet, brown Change: fine to coarse grained sand	SP-SM	167.0	B	10	S-3, SPT 4+5+8+13 REC=18", 75% S-4, SPT 5+5+9+13 REC=14", 58%	MC = 11.5% % Passing #200 = 5.8 MC = 10.1% % Passing #200 = 10.6	ALLUVIAL
13.0	DISINTEGRATED ROCK, sampled as silty sand with gravel, fine to coarse grained sand, angular particles; orangish brown, estimated 15 - 25% rock fragments, contains mica, relict rock structure	DR	165.0	D		S-5, SPT 16+32+23+16 REC=18", 75% R-1, CORE Run = 3.5 ft REC=0", 0% RQD=0", 0%		RESIDUAL Drill action indicates alternating layers of hard and soft rock.
15.0		DR	163.0		15			
20.0	DISINTEGRATED ROCK DISINTEGRATED ROCK, sampled as; highly weathered, highly fractured, hard gneiss, black	DR	158.0		20	R-2, CORE Run = 2.0 ft REC=6", 25% RQD=0", 0% R-3, CORE Run = 3.0 ft REC=3", 8% RQD=0", 0%		

Bottom of Boring at 20.0 ft.
Auger refusal at 11.5 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.

TEST BORING LOG

Project: NVF Bridges
NVF Yorklyn Site (DE-0071)
Yorklyn, Delaware

Boring Number: B-4
Contract Number: 12615019
Sheet: 1 of 1

Contractor: Connelly & Associates. Inc.
Dover, Pennsylvania
Contractor Foreman: R. Anderson
Schnabel Representative: J. Beideman
Equipment: CME-550
Method: 4-1/4" I.D. Hollow Stem Auger, NQ Double Barrel
Hammer Type: Auto Hammer (140 lb)
Dates Started: 5/30/12 **Finished:** 5/30/12
Location: See Location Plan
Ground Surface Elevation: 178± (ft) **Total Depth:** 26.0 ft

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Encountered ▽	5/30	3:38 PM	13.0'	18.0'	---
Casing Pulled ▼	5/30	4:45 PM	5.0'	---	16.0'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.1	1" Topsoil		177.9					PROBABLE FILL
	FILL, sampled as sandy silt; moist, brown, contains mica	FILL		A	0	S-1, SPT 1+1+3+2 REC=20", 83%		
					5	S-2, SPT 1+1+2+3 REC=24", 100%		
6.5	SILTY SAND WITH GRAVEL, fine to coarse grained sand; moist, brown and white, estimated 15 - 25% rock fragments	SM	171.5	C		S-3, SPT 10+18+13+23 REC=20", 83%	MC = 12.4% % Passing #200 = 13.6	RESIDUAL
9.0	DISINTEGRATED ROCK, sampled as silty sand with gravel, fine to coarse grained sand, angular particles; wet, brown and white, estimated 15 - 25% rock fragments	DR	169.0	D	10	S-4, SPT 28+30+32+28 REC=14", 58%		
	Change: moist, estimated 30 - 45% rock fragments					S-5, SPT 9+30+28+35 REC=6", 25%		
	Change: wet, relict rock structure				15	S-6, SPT 13+23+23+26 REC=11", 46%		
	Change: contains mica, relict rock structure					S-7, SPT 2+24+50/3" REC=15", 100%		
					20	S-8, SPT 7+17+25+50/3" REC=20", 95%		
22.9	DISINTEGRATED ROCK	DR	155.1		25	R-1, CORE Run = 4.0 ft REC=0", 0% RQD=0", 0%		Drill action indicates alternating layers of hard and soft rock.
26.0			152.0					

Bottom of Boring at 26.0 ft.
Auger refusal at 21.0 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.