GEOTECHNICAL STUDY

Middle Fork Water Treatment Plant
12 MGD Improvements
Abingdon, Virginia

Prepared for:

Washington County Service Authority
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COMMONWEALTH OF VIRGINIA
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INTRODUCTION

The Washington County Service Authority plans to build additions to the Middle Fork Water Treatment Plant located at 18385 Jeb Stuart Highway in Abingdon, Virginia. Construction of the interim improvements are planned to begin in the Spring of 2010. Once the interim improvements are complete, a second expansion will increase the plant capacity to 12 million gallons per day (MGD). We completed a geotechnical study for the interim improvements and the report was dated November 2009. This report addresses the improvements to expand to a 12 MGD plant. The results of the study, presented in outline and tabular form, comprise this report.

Purpose of Study: Provide geotechnical engineering advice and recommendations for foundation design of the structures.

Elements of Study: Ten soil borings were completed during the explorations for the interim improvements. An additional 6 soil borings were completed during this phase of field work. Review of existing data, a site reconnaissance, and an analysis of the collected data were also performed.

SITE DESCRIPTION

Location: The existing plant site is located on the east side of Jeb Stuart Hwy (US 58) just south of the Middle Fork of the Holston River bridge about 3 miles east of Abingdon, Virginia.

Topography: The existing plant site sits about 10 to 20 ft above the low-lying flood plain of the Middle Fork of the Holston River. The structures are surrounded by grassy areas and paved parking. We understand that man-made fill was constructed to prepare the existing site. Surface drainage is considered good to excellent.

PROJECT DESCRIPTION

To reiterate, after construction of the interim improvements are complete, plans are to increase the plant capacity to 12 MGD. This work will further increase the size of the filter plant building. Additionally, a new intermediate booster pump station, a chemical feed building, and construction of additional flocculation basins are planned.

SUMMARY OF SUBSURFACE EXPLORATION

Test Borings – includes borings during field work for interim improvements and 12 MGD expansion			
No. of Borings: 16		**Range in Depth, ft:** 7.9 to 23.7	
Drilling Contractor: S&ME		**Crew:** Dave and Dana, Adam and Brian	
Drill Rig		**Support Vehicles**	
CME ATV		**Water Truck**	
Truck-mounted CME 55		**Front-end Loader**	
Other – Four-wheel ATV	x	**Other** - 1-ton truck	x
Drill Tools			
Hollow-Stem Auger	x		
NQ2" Rock bit & barrel		**NW Casing**	
Type of Borings & Drilling Quantities in ft		**Type of Sampling & Sampling Details**	
Auger Probe		**Standard Penetration Test:** 5-ft intervals or less	
Soil – Intermittent Sampling	227.0	**Extra Samples:**	
Soil - Continuous Sampling		**Shelby Tube:** None	
Boulders		**Bulk:** None	
NQ2" Rock			
NW Casing			

A representative of our firm directed the drill crew regarding boring locations and sampling requirements. He also examined the samples as they were recovered, prepared a field log of the borings, and adjusted the drilling program to fit the conditions encountered. Soil samples were placed in glass jars for temporary storage. **Boring logs and a sketch of the boring locations are in the Appendix.**

Standard Penetration Test - performed by driving a split-barrel sampler (2" O.D., 1.375" I.D.) 1 ft using 140-lb hammer, 30" fall; yields N-value or blow-count in blows per foot that provides relative indication of consistency and density.

SUBSURFACE DESCRIPTION

Strata descriptions are summarized in the tables below. For details of individual strata, please refer to the boring logs in the Appendix. Where possible, the strata descriptions are arranged in descending order. With discontinuous layers, a given layer may directly overlie more than one stratum; or the opposite, more than one layer may rest on a single stratum of broad lateral extent.

Descriptive Tables

Stratum: Brown, tan and red clay with some shale and sandstone fragments, some topsoil (Man-made Fill)		
Thickness ft: 3 to 10	**N-values:** 3 to 50	**Moisture:** Moist to wet
Occurrence: All borings except Borings 8 and 9		
Properties: Fill composition and consistency is variable. Fill varies from soft to very stiff based on N-values, but generally was observed as soft to medium; shear strength is judged low to moderate; compressibility is judged low to high.		

Stratum: Gray organic silt and clay with some brown sand, some gravels (Alluvium)		
Thickness ft: 6 to 10	**N-values:** 3 to 17	**Moisture:** Moist to saturated
Occurrence: Borings 1, 2, 8, 9, 10, 15 and 16		
Properties: Alluvial clay and silt vary from soft to firm consistency and alluvial sands range from very loose to medium in relative density based on N-values; we feel some of the N-values were elevated due to influence of gravel or rock fragments; shear strength is judged as low; compressibility is judged as high.		

Gray weathered to decomposed shale bedrock was encountered in the borings between the depths of 6 and 18 feet.

Groundwater

Water level readings were taken from the open bore holes for up to 24 hours after completion. Measured levels are shown on the boring logs in the Appendix. For clarity, groundwater depths noted in the report refer to depth below existing grade.

The groundwater data is considered a "snapshot." Groundwater levels may change significantly depending on weather conditions and may be influenced by the water level of the river.

GEOTECHNICAL DISCUSSION, OPINIONS, AND RECOMMENDATIONS

Discussion of the proposed structures will be made on an individual basis.

Future Plant Building Expansion

- **Structure:** In plan, the existing filter plant with interim improvements is approximately 105 ft x 36 feet. The proposed expansion will increase the overall size to about 150 ft x 85 feet. To make room for the expansion, several existing features will have to be removed or demolished. These include abandoned sediment basins south of the existing plant, an above ground 48-inch pipeline on the east side of the abandoned basins, a couple of underground tanks, and some water, electric, and chemical feed lines.

  The western 112 ft x 85 ft has a proposed finished floor elevation of 1788 ft, which matches the existing clear well floor elevation. Within this area, up to 10 ft of cut will be required on both the east and west sides of the existing basins (to be removed). The existing basins have a floor elevation of roughly 1793 feet. After demolition, an additional 5 ft of cut will be required within this area.

  The eastern 38 ft x 85 ft will contain adsorption clarifiers and does not have a clear-well floor level. The finished floor elevation for the adsorption clarifiers is 1798 ft (10 ft higher than the clear well floor). To prepare the area, from 2 to 6 ft of fill will be required.

- **Expected Structural Loads:** Generally, foundation loads are expected to be light. Increases in net load are expected to be less than 2000 psf.

- **Subsurface Conditions:** Several soil borings were completed in the eastern portion of the proposed expansion area. No borings were completed in the western portion due to the existing sediment basins and underground utilities in the area.

  Based on our borings, from 3 ft (Boring 13) to 10 ft (Boring 16) of man-made fill has been placed along the east side of the existing sediment basins and plant building. The consistency and the composition of the fill are both variable. The fill ranges from soft to firm and is generally moist to wet. Brown, tan, and red clay with some gravel and weathered shale fragments comprise the fill material.

Based on discussion with plant personnel, some swampy areas used to exist behind the existing plant. We believe we identified some of the swampy soils in Borings 1, 2, 15, and 16. In these borings, we encountered 4 to 10 ft of soft, wet, brown and gray organic clay and silt beneath the fill. We described this zone as alluvium in our Boring Logs.

Gray weathered to decomposed shale bedrock was encountered below the fill and/or alluvium. The weathered shale bedrock was encountered in the borings at depths ranging from 6 ft to 17 feet. These depths yield weathered shale bedrock surface elevations ranging from about 1788 ft to 1776 feet. Generally, the shale bedrock surface tends to be dropping in elevation as you move to the north.

- **Foundation Conditions: (Separate discussion for clearwell and clarifier portions of the expansion due to differences in floor elevation.)**

Clearwell level - Finished Floor Elevation, 1788 feet

1. Based on our borings, weathered shale was encountered near proposed subgrade (ele. 1786.5 ft) with the exception of Boring 2 where the shale layer was deeper. Although not confirmed, we presume that the majority if not all of the existing sediment basins (to be demolished) are founded on weathered to hard shale. Review of a subsurface investigation completed for the original plant design recommended bearing on weathered to hard shale.

2. The weathered shale layer is considered a suitable bearing stratum for the proposed structure; the soft fill and alluvium are considered unsuitable.

3. Where soft soil is encountered, we recommend undercutting and replacing with suitable fill material. Based on our borings, we expect any undercut to be limited to the north east corner of the clearwell-level expansion area (near Boring 2). Dewatering of the excavation may be required. As recommended for the interim improvements construction, we recommend using crushed stone as backfill for any undercut in the area. If groundwater is present, a free-draining aggregate such as VDOT No. 57 stone is proposed. The granular fill should be placed in lifts approximately 12 inches thick and compacted sufficiently to establish a firm stable lift. If groundwater is not present, dense-graded aggregate such as VDOT No. 21A stone is recommended. The dense-graded aggregate should be placed as controlled fill, described later.

4. For shallow foundations bearing on weathered shale bedrock or compacted granular fill, placed as controlled fill, an allowable soil pressure of 2000 psf is recommended for design.

5. When performing any undercut, extreme care will be required to protect from undermining the existing buildings. Based on a review of a geotechnical study completed for the original plant (dated 1973), the existing plant may bear on shale bedrock, but this condition has not been confirmed. The use of sheet piles, staged excavation, and/or other measures may be needed to provide adequate support. As a precaution, we recommend survey monitoring points be established on the existing buildings so that periodic checks for movement can be made.

Clarifier level - Finished Floor Elevation, 1798 feet

1. Based on the variable conditions of the existing fill and the organic soils encountered, it is our opinion that the existing soil conditions are unsuitable to support the proposed fill and the proposed structure using a shallow foundation. We considered undercut and replacement as a remedial solution, but the higher floor elevation makes this alternative less practical. The depth of undercut could approach 19 ft (Boring 15) and would likely average in excess of 10 feet. After the undercut was backfilled, an additional 2 to 6 ft of fill would still be required to reach proposed subgrade.

2. We recommend this portion of the structure be supported by cast-in-place piles bearing on the decomposed shale bedrock. We recommend a pressure-injected pile such as those constructed by Technical Foundations Incorporated, Richmond, Virginia. A pressure-injected pile is installed by drilling to the selected stratum with a large-diameter (12- to 24- inches) hollow-stem auger. High-strength cement grout is then injected into the hole through the auger as it is withdrawn from the hole.

3. We recommend the piles rest on the decomposed shale bedrock. Based on our borings in the area, decomposed shale bedrock was encountered at elevations ranging from 1790 ft to 1775 ft. We presume that the piles will be constructed after the fill has been placed to proposed subgrade. Based on a subgrade elevation of 1996.5 ft, pile lengths are expected to range from about 7 ft to 21 feet. A bearing capacity of 20 tsf is recommended for design of the piles resting on the decomposed shale bedrock.

4. Pile installation requires the work of a specialty subcontractor. We recommend the subcontractor be able to demonstrate experience in successfully completing projects of similar size and scope.

5. An engineer from our office should observe the foundation construction to verify the adequacy of the bearing strata and confirm that the actual soil conditions are consistent with our interpretations and assumptions.

Additionally, we would like the opportunity to review foundation plans and specifications prior to bidding the project.

Intermediate Booster Pump Station

- **Structure:** Intermediate booster pump station will be constructed along the east end of the north wall of Sedimentation Basins 1 and 2. Structure will be approximately 32 ft x 27 ft in plan dimensions. Proposed finished floor elevation is 1799 feet.

- **Expected Structural Loads:** Generally, foundation loads are expected to be light. Increases in net load are expected to be less than 1000 psf.

- **Subsurface Conditions:** The location of the structure has moved since our field work. No borings were completed within the proposed footprint of the structure. Borings 3 and 4 were made about 50 to 100 ft east of the area and Borings 11 and 12 were made about 100 ft west of the area. Each of these borings revealed about 6 to 7 ft of man-made fill above weathered shale bedrock. The fill consisted of tan silty clay with some sand and gravel. The consistency of the fill varied from soft to firm (N-values ranged from 6 to 30) and was moist to wet. No water was encountered in the borings.

- **Foundation Conditions:**

    1. Based on planned floor elevations, little cut or fill is expected. The bulk of the grade work will be required to install the new pumps and water lines. The pumps will require about a 10-ft deep excavation. We recommend all backfill of excavations be placed as controlled fill.
    2. In our opinion, the existing man-made fill is considered as marginal to provide support to the proposed structure and will require evaluation when the excavation is made. To evaluate the existing fill, we recommend proof rolling the area with suitable construction equipment, and/or observing the bottom of the exaction with test pits or using a hand auger. The excavation for the pumps will also afford additional observation of subsurface conditions.
    3. The bottom of the structures should bear on firm existing man-made fill (deemed suitable during construction), new controlled fill, or weathered shale bedrock. We recommend an allowable soil pressure of 2000 psf be used for foundation design.
    4. Establish bottom of structures at least 2 ft below exterior grade.

Flocculation Basins

- **Structure:** Flocculation basins will be constructed on the west side of the existing flocculation basins. Structure will be approximately 47 ft x 22 ft in plan dimensions and has a proposed floor elevation of 1795 feet. Several existing water lines and electrical lines will have to be removed or relocated. Based on estimated floor levels, 8 to 12 ft of cut are expected.

- **Expected Structural Loads:** Generally, foundation loads are expected to be light. Increases in net load are expected to be less than 1000 psf.

- **Subsurface Conditions:** Borings 5 was made near the southwest corner of the proposed basins. No other borings were completed in the area due to underground utilities.

  Boring 5 revealed about 8 ft of man-made fill above weathered shale bedrock. The fill consisted of tan silty clay with some sand and gravel. The fill was judged soft to firm in consistency (N-values ranged from 8 to 13) and moist to wet. Some N-values were thought to be inflated due to gravel in the samples. No water was encountered in Boring 5.

- **Foundation Conditions:**
  1. Several underground utilities will have to be relocated to build the basins. Any backfill for utility relocation should be placed as controlled fill.
  2. Weathered shale, existing man-made fill, and controlled fill are probable bearing strata.
  3. In our opinion, the weathered shale and controlled fill, if placed as directed, are suitable to support the proposed basins. The existing man-made fill is considered marginal and will require evaluation when the excavation is made. To evaluate the existing fill, we recommend proof rolling the area with suitable equipment, or observing the bottom of the exaction with test pits or hand auger.
  4. The bottom of the structures should bear on weathered shale, controlled fill or firm existing man-made fill (deemed suitable during construction). We recommend an allowable soil pressure of 2000 psf be used for foundation design.
  5. Establish bottom of structures at least 2 ft below exterior grade.

Chemical Feed Building

- **Structure:** Chemical feed building will be constructed along the west end of the north wall of Sedimentation Basins 1 and 2. Structure will be approximately 67 ft x 33 ft in plan dimensions. Estimated floor elevation is 1799 feet. Based on estimated floor levels, little cut or fill is expected.

- **Expected Structural Loads:** Generally, foundation loads are expected to be light. Increases in net load are expected to be less than 1000 psf.

- **Subsurface Conditions:** Borings 11 and 12 were made in the area of the proposed structure. From 6 to 7 ft of firm man-made fill were encountered above weathered shale bedrock. The fill consisted of red and brown silty clay with a few gravel.

  No water was encountered in Borings 11 or 12.

- **Foundation Conditions:**
  1. Based on our borings, firm existing man-made fill is probable bearing strata.
  2. In our opinion, the existing firm man-made fill is considered suitable to support the proposed structure using a shallow foundation. Minor undercut and replacement with controlled fill may be needed if soft soil is encountered.
  3. The bottom of the structure should bear on firm existing man-made fill. For design of spread and/or continuous footings, we recommend an allowable soil pressure of 2000 psf be used for foundation design.
  4. Establish bottom of footings at least 2 ft below exterior grade.

General

With the exception of the free-draining granular base to improve foundation conditions discussed above, we recommend any fill placed on the project be placed as controlled fill, described below. Additionally, controlled fill should be placed as backfill when underground utilities and vaults are removed or relocated.

All excavations should adhere to current Occupational Safety and Health Administration (OSHA) requirements.

We recommend an engineer from our office observe the foundation excavation to confirm that conditions encountered are consistent to those observed in the borings.

Based on Table 1615.1.1 of the 2003 International Building Code, we recommend that for seismic design, Site Class C be used.

Controlled Fill

- **Recommendations**

1. Place controlled fill as outlined below:

   a. Remove any topsoil in fill area.

   b. Construct controlled fill under continuous observation and testing of engineering technician from our office. Any fill materials should be approved by the project engineer.

   c. Place fill in 6- to 8-in lifts and compact each lift to at least 95% of maximum density as determined by ASTM Method D 698 (Standard Proctor).

   d. Maintain proper moisture content of fill during placement as determined by technician or engineer.

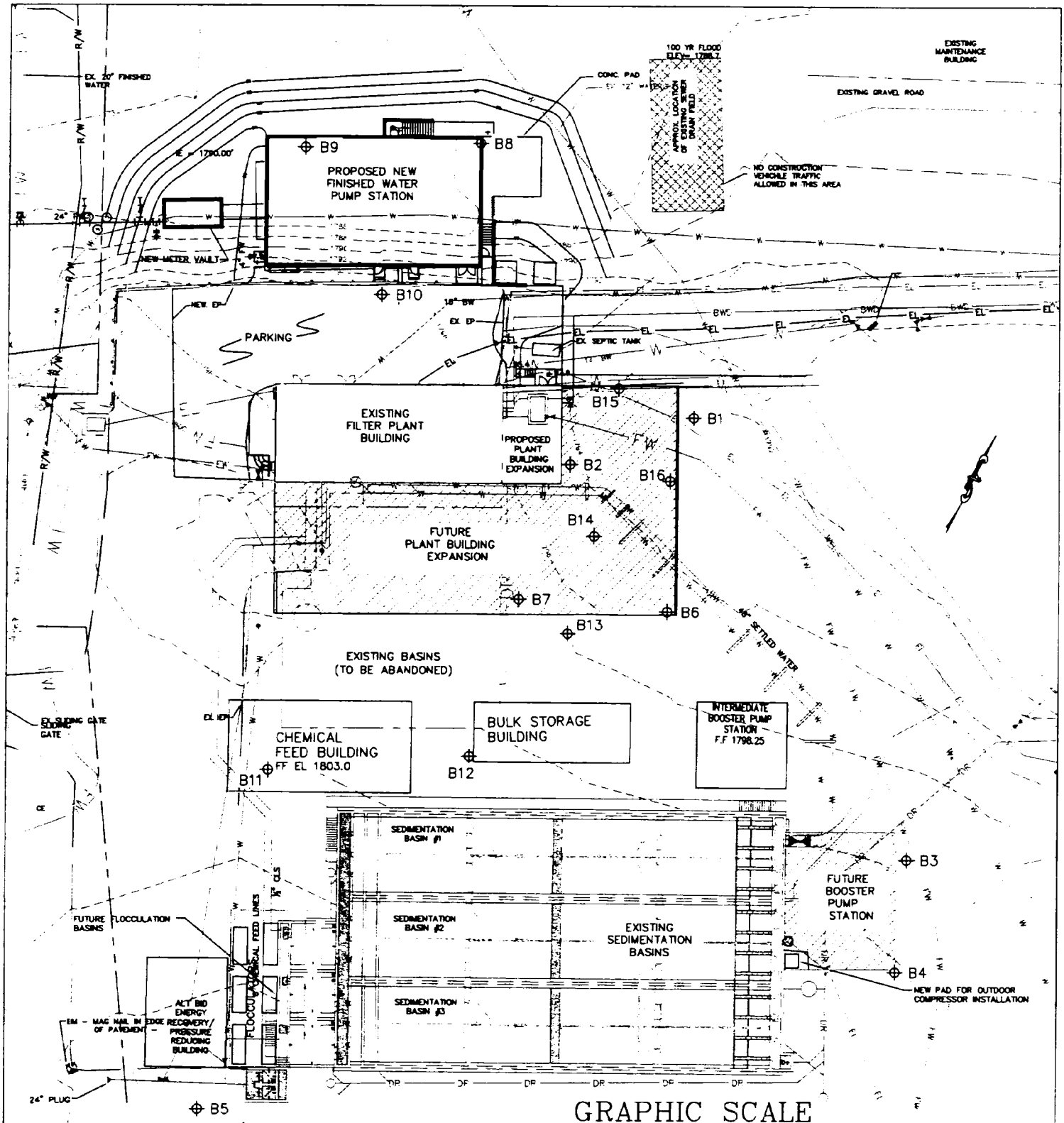
   e. Construct fill during summer or late fall, if possible, to take advantage of favorable weather conditions for soil moisture control.

LIMITATIONS

The analysis and recommendations submitted in this report are based on data obtained from field investigations. This report does not reflect any variations that may occur between locations of subsurface exploration. Such variations may not become apparent until construction is underway. If variations become evident, we should be notified so that immediate recommendations can be rendered.

This report has been prepared for the Washington County Service Authority, Abingdon, Virginia, to be used in foundation design and construction of the proposed additions to the Middle Fork Water Treatment Plant in Abingdon, Virginia. Anyone using this report for any purpose other than the project described herein must draw his own conclusions regarding construction procedures and soil conditions. We disclaim all responsibility and liability for any part that is removed, quoted, or reproduced separately from the entire report.

APPENDIX



NOTES

1. BORINGS ARE PLOTTED TO SCALE; DIMENSIONS ARE ON FILE.
2. SKETCH BASED ON SITE PLAN BY LG.
3. ⊕ INDICATES BORING LOCATION.
4. SCALE: 1" = 50'

GRAPHIC SCALE

0 50 100 150

(IN FEET)

1 inch = 50

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LOCATION OF BORINGS
WCSA 12 MGD IMPROVEMENTS
WASHINGTON COUNTY, VIRGINIA

NO	REVISION DATE	PRO. NO.

Drawn by: MLB
Checked by: LCS
Date: 4/29/2010

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NOTES TO BORING LOGS

These notes refer to and are a part of the accompanying boring logs.

1. The borings were made by a boring contractor under the observation of a representative of our firm. These boring logs were compiled from field logs and the results of visual examination of the soil samples.

2. The logs of the borings apply only at the specific boring locations and on the dates indicated. They are not warranted to be representative of subsurface conditions at other locations and times.

3. The depth of the indicated boundaries between soil strata is approximate. The transition between the strata may be gradual.

4. The groundwater levels shown on the boring log represent average or typical values observed during the period of the boring operation or shortly after completion of a boring. These observations do not reflect seasonal changes in the water table or the effects of intense rainfall or runoff. In any excavation, trickling flow or seepage may be encountered from perched water which is at levels above the water table observed in the borings.

5. "Decomposed rock" is residual material having a standard penetration resistance of 50 blows or more per six inches. Decomposed rock can be an extremely hard and compact mixture of soil and weathered fragments of rock which may require rock excavation methods for removal.

6. "Sound" and/or "relatively sound rock" are non-decomposed rock and rock in which weathering is largely confined to joints. Such rock may be fractured to varying degrees.

7. Soil samples recovered from the borings have been stored at The Lane Group in Chilhowie, Virginia and are available for inspection by appointment. The soil samples will be discarded two months after submission of our report unless a request is received to retain them for a longer period.

8. The locations and elevations of the borings were determined by survey. The locations and elevations of the borings should be considered accurate only to the degree implied by the method used.

LOG OF BORING 1

Project:	Middle Fork Plant Additions	**Location:**	Abingdon, VA
Type of Boring:	Soil Boring - Intermittent Sampling	**Drilling Contractor:**	S & ME
Elevation, ft: 1792	**Date Started:** 10 27 09	**Date Completed:** 10 27 09	**Weather:**

Stratum Description	Depth, ft	BLOWS* REC./RQD**	Sample Description
	0		
Topsoil 1.0 in.			Topsoil 1.0 inch
FILL - brown silty clay		3-4-3	FILL - brown silty clay with gravel
Gray organic SILT and CLAY (ALLUVIUM)	5	1-2-1	Gray organic SILT, wet, soft
		WOH-1-8	Gray slightly organic CLAY, water on spoon
	10	1-1-2	Gray & brown organic SILT & CLAY, wet
Gray & brown organic SILT & CLAY			
		24-50/0.2	Tan CLAY, firm & dark gray weathered SHALE
Gray severely weathered SHALE	15		
	20	23-50/0.4	Gray severely weathered SHALE
Gray decomposed SHALE			
		50/0.2	Ditto
Boring terminated @ 23.7 ft	25		
	30		
	35		

Groundwater Data

Depth, ft	Time, hr	Depth, ft	Time, hr
5.5	0		
3.0	24		

NOTES:

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall
** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation
See NOTES TO BORING LOG which are a part of this log.

LOG OF BORING 2

Project:	Middle Fork Plant Additions	**Location:**	Abingdon, VA
Type of Boring:	Soil Boring - Intermittent Sampling	**Drilling Contractor:**	S & ME
Elevation, ft: 1794	**Date Started:** 10 27 09	**Date Completed:** 10 27 09	**Weather:**

Stratum Description	Depth, ft	BLOWS* REC./RQD**	Sample Description
	0		
Topsoil - 2 inches			
FILL - red & tan clay		4-3-3	FILL - red & tan clay, few limestone fragments, wet
	5	2-2-3	FILL - ditto, soft, wet
		6-4-4	FILL - ditto, limestone fragments, soft, wet
Gray organic SILT (ALLUVIUM)	10	2-2-1	Gray organice SILT, rounded pebbles, soft, wet
Gray weathered SHALE	15	50/0.2	Gray severely weathered SHALE, dry
Auger refusal @ 15.0 ft	20		
	25		
	30		
	35		

Groundwater Data

Depth, ft	Time, hr	Depth, ft	Time, hr
11.0	0		
6.0	24		

NOTES:

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall
** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation
See NOTES TO BORING LOG which are a part of this log.

MFPA-2.ex.

LOG OF BORING 3

Project:	Middle Fork Plant Additions	**Location:**	Abingdon, VA
Type of Boring:	Soil Boring - Intermittent Sampling	**Drilling Contractor:**	S & ME
Elevation, ft: 1799	**Date Started:** 10 27 09	**Date Completed:** 10 27 09	**Weather:**

Stratum Description	Depth, ft	BLOWS* / REC./RQD**	Sample Description
	0		
FILL - tan silty clay		5-4-5	FILL - tan silty clay, sand gravel, firm, moist
	5	4-3-3	FILL - ditto, soft to medium
		22-3-50/0.4	Gray severely weathered SHALE, dry
Gray weathered to decomposed SHALE	10	50/0.2	Gray limey SHALE, dry
			8.5 - 13.5 ft - Hard augering
		50/0.2	Gray decomposed SHALE
Auger refusal @ 14.0 ft	15		
	20		
	25		
	30		
	35		

Groundwater Data

Depth, ft	Time, hr	Depth, ft	Time, hr
Dry	0		
Dry	24		

NOTES:

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall

** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation

See NOTES TO BORING LOG which are a part of this log.

MFPA-3.xls

LOG OF BORING 4

Project: Middle Fork Plant Additions		**Location:**	Abingdon, VA
Type of Boring: Soil Boring - Intermittent Sampling		**Drilling Contractor:**	S & ME
Elevation, ft: 1801	**Date Started:** 10 27 09	**Date Completed:** 10 27 09	**Weather:**

Stratum Description	Depth, ft	BLOWS* / REC./RQD**	Sample Description
	0		
FILL - tan clay & shale fragments		3-3-3	FILL - tan clay & weathered shale fragments, wet
	5	4-14-16	FILL & weathered shale & sandstone fragments,moist
Gray weathered SHALE		33-50	Gray severely weathered SHALE
Auger refusal @ 8.0 ft	10		
	15		
	20		
	25		
	30		
	35		

Groundwater Data			
Depth, ft	Time, hr	Depth, ft	Time, hr

NOTES:
No water encountered

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall
** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation
See NOTES TO BORING LOG which are a part of this log.

LOG OF BORING 5

Project:	Middle Fork Plant Additions	**Location:**	Abingdon, VA
Type of Boring:	Soil Boring - Intermittent Sampling	**Drilling Contractor:**	S & ME
Elevation, ft: 1806	**Date Started:** 10 27 09	**Date Completed:** 10 27 09	**Weather:**

Stratum Description	Depth, ft	BLOWS* / REC./RQD**	Sample Description
	0		
FILL - tan & brown clay		5-3-5	FILL - tan & brown clay, few gravels, moist
	5	3-6-8	FILL - ditto, soft
		3-6-7	FILL - Tan silty CLAY, rounded pebbles, some shale fragments,firm, moist
Gray weathered SHALE	10	5-14-18	Gray severely weathered SHALE
		50/0.1	Gray decomposed SHALE
Auger refusal @ 14.0 ft	15		
	20		
	25		
	30		
	35		

Groundwater Data			
Depth, ft	Time, hr	Depth, ft	Time, hr

NOTES:
No water encountered

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall
** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation
See NOTES TO BORING LOG which are a part of this log.

MFPA-5 ex.

LOG OF BORING 6

Project:	Middle Fork Plant Additions	**Location:**	Abingdon, VA
Type of Boring:	Soil Boring - Intermittent Sampling	**Drilling Contractor:**	S & ME
Elevation, ft:	1796	**Date Started:**	10/27/09
Date Completed:	10/27/09	**Weather:**	

Stratum Description	Depth, ft	BLOWS* REC./RQD**	Sample Description
	0		
FILL - brown & tan clay		2-3-2	FILL - brown & tan clay with limestone fragments, soft to medium, wet
	5	2-4-9	FILL - ditto & silt
Gray weathered SHALE		50	Gray SHALE fragments, dry
	10	50/0.2	Gray decomposed SHALE
Auger refusal @ 10.0 ft	15		
	20		
	25		
	30		
	35		

Groundwater Data

Depth, ft	Time, hr	Depth, ft	Time, hr
Dry	0		
6.0	24		

NOTES:

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall

** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation

See NOTES TO BORING LOG which are a part of this log.

LOG OF BORING 7

Project:	Middle Fork Plant Additions	**Location:**	Abingdon, VA
Type of Boring:	Soil Boring - Intermittent Sampling	**Drilling Contractor:**	S & ME
Elevation, ft: 1798	**Date Started:** 10 27 09	**Date Completed:** 10 27 09	**Weather:**

Stratum Description	Depth, ft	BLOWS* / REC./RQD**	Sample Description
	0		
FILL - red & tan clay		3-3-2	FILL - red & tan clay, trace limestone(?), soft, wet
	5	4-24-24	FILL - gray weathered shale fragments
FILL?? - gray shale fragments		50	FILL?? - Gray shale fragments, dry
	10	10-22-20	FILL?? - Gray weathered shale fragments with clay
Gray weathered SHALE		50/0.2	Gray decomposed SHALE
Auger refusal @ 13.7 ft	15		
	20		
	25		
	30		
	35		

Groundwater Data

Depth, ft	Time, hr	Depth, ft	Time, hr

NOTES:
No water encountered

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall
** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation
See NOTES TO BORING LOG which are a part of this log.

MFPA-7.ex

LOG OF BORING 8

Project:	Middle Fork Plant Additions	**Location:**	Abingdon, VA
Type of Boring:	Soil Boring - Intermittent Sampling	**Drilling Contractor:**	S & ME
Elevation, ft: 1786	**Date Started:** 10/27/09	**Date Completed:** 10/27/09	**Weather:**

Stratum Description	Depth, ft	BLOWS* / REC./RQD**	Sample Description
	0		
Topsoil & brown SILT		2-2-1	Topsoil & brown clayey SILT, soft, saturated
Tan & brown SILT (ALLUVIUM)	5	5-9-8	Tan & brown clayey SILT, fot, wet, rock in shoes
Gray weathered to decomposed SHALE		24-50/0.03	Gray severel weathered SHALE
	10	50/0.2	Ditto, few sandstone fragments
		50/0	Gray decomposed SHALE
Boring terminated at 13.5'	15		
	20		
	25		
	30		
	35		

Groundwater Data

Depth, ft	Time, hr	Depth, ft	Time, hr
0.0	0		
0.0	24		

NOTES:

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall

** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation

See NOTES TO BORING LOG which are a part of this log.

MFPA-8.ex

LOG OF BORING 9

Project: Middle Fork Plant Additions		**Location:**	Abingdon, VA
Type of Boring: Soil Boring - Intermittent Sampling		**Drilling Contractor:**	S & ME
Elevation, ft: 1785	**Date Started:** 10 27 09	**Date Completed:** 10 27 09	**Weather:**

Stratum Description	Depth, ft	BLOWS* / REC./RQD**	Sample Description
	0		
Gray organic SILT (ALLUVIUM)		3-2-3	Gray organic sandy SILT, soft, wet
Brown SAND (ALLUVIUM)	5	4-6-6	Brown silty SAND with rock fragments, some organic, soft, wet
Gray weathered to decomposed SHALE		50/0.3	Gray severely weathered SHALE
		50/0	Graydecomposed SHALE, dry
Auger refusal @ 8.0 ft	10		
	15		
	20		
	25		
	30		
	35		

Groundwater Data

Depth, ft	Time, hr	Depth, ft	Time, hr
2.0	0		
0.0	1		
0.0	24		

NOTES:

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall

** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation

See NOTES TO BORING LOG which are a part of this log.

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LOG OF BORING 10

Project:	Middle Fork Plant Additions	**Location:**	Abingdon, VA
Type of Boring:	Soil Boring - Intermittent Sampling	**Drilling Contractor:**	S & ME
Elevation, ft: 1796	**Date Started:** 10 27 09	**Date Completed:** 10 27 09	**Weather:**

Stratum Description	Depth, ft	BLOWS* / REC/RQD**	Sample Description
	0		
5" Asphalt, 4" stone		2-2-3	FILL - tan & red clay, medium, wet
FILL - tan & red clay	5	2-4-4	FILL - ditto
		WOH-2-1	FILL - ditto, soft
	10	3-3-2	FILL - ditto
Gray SAND	15	4-3-3	Gray silty SAND (alluvium)
Gray weathered to decomposed SHALE	20	50/0.2	Gray decomposed SHALE, dry
		50/0.2	
Boring Terminated @ 23.7'	25		
	30		
	35		

Groundwater Data

Depth, ft	Time, hr	Depth, ft	Time, hr
23.0	0		
10.5	24		

NOTES:

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall
** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation
See NOTES TO BORING LOG which are a part of this log.

LOG OF BORING 11

Project:	Washington County Service Authority - 12 mgd Improvements	**Location:**	Abingdon, VA
Type of Boring:	Soil Boring - Intermittent Sampling	**Drilling Contractor:**	S & ME
Elevation, ft:	**Date Started:** 4 12 10	**Date Completed:** 4 12 10	**Weather:**

Stratum Description	Depth, ft	BLOWS* / REC./RQD**	Sample Description
Topsoil	0		
FILL - Red, brown and tan clay with few weathered shale fragments		4-6-6	FILL - red clay, firm and brown silty clay, firm, moist
	5	3-4-6	FILL - tan silty clay, few weathered shale fragments, moist
		11-25-30	Gray severely weathered SHALE, dry
Gray severely weathered SHALE			Auger refusal @ 7.9 ft
Auger refusal @ 7.9 ft	10		
	15		
	20		
	25		
	30		
	35		

Groundwater Data			
Depth, ft	**Time, hr**	**Depth, ft**	**Time, hr**

NOTES:

No water encountered.
Hole backfilled on completion.

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall
** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation
See NOTES TO BORING LOG which are a part of this log.

LOG OF BORING 12

Project:	Washington County Service Authority - 12 mgd Improvements	**Location:**	Abingdon, VA
Type of Boring:	Soil Boring - Intermittent Sampling	**Drilling Contractor:**	S & ME
Elevation, ft:	**Date Started:** 4 12 10	**Date Completed:** 4 12 10	**Weather:**

Stratum Description	Depth, ft	BLOWS* / REC./RQD**	Sample Description
	0		
		5-7-7	FILL - red clay, firm and brown silty clay, moist
FILL - red and brown clay with few limestone fragments	5	4-5-4	FILL - red clay with few limestone fragments, firm, moist
		17-22	Gray severely weathered SHALE, dry
Gray severely weathered SHALE	10	50/0.3	Gray severely weathered SHALE, dry
Boring terminated @ 8.8 ft	15		
	20		
	25		
	30		
	35		

Groundwater Data

Depth, ft	Time, hr	Depth, ft	Time, hr

NOTES:

No water encountered.
Hole backfilled on completion.

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall
** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation
See NOTES TO BORING LOG which are a part of this log.

LOG OF BORING 13

Project: Washington County Service Authority - 12 mgd Improvements		**Location:** Abingdon, VA	
Type of Boring: Soil Boring - Intermittent Sampling		**Drilling Contractor:** S & ME	
Elevation, ft: 1796	**Date Started:** 4 12 10	**Date Completed:** 4 12 10	**Weather:**

Stratum Description	Depth, ft	BLOWS* / REC./RQD**	Sample Description
FILL - red and tan clay with severely weathered shale fragments	0–4	4-4-7	FILL - red clay and tan CLAY with severely weathered shale fragments
Tan CLAY and severely weathered SHALE	5	15-17-25	Tan CLAY & severely weathered SHALE, dry
Decomposed SHALE		50/0.5	Decomposed SHALE, wet
		50/0.4	No Recovery
	10		
Boring terminated @ 13.7 ft	15	50/0.2	Decomposed and hard SHALE, dry
	20		
	25		
	30		
	35		

Groundwater Data			
Depth, ft	**Time, hr**	**Depth, ft**	**Time, hr**

NOTES:

No water encountered.
Hole backfilled on completion.

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall
** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation
See NOTES TO BORING LOG which are a part of this log.

WCSA 12mgd-13.exl

LOG OF BORING 14

Project: Washington County Service Authority - 12 mgd Improvements		**Location:**	Abingdon, VA
Type of Boring: Soil Boring - Intermittent Sampling		**Drilling Contractor:**	S & ME
Elevation, ft: 1795	**Date Started:** 4 12 10	**Date Completed:** 4 12 10	**Weather:**

Stratum Description	Depth, ft	BLOWS* / REC./RQD**	Sample Description
	0		
		3-3-5	FILL - red clay, gravel & shale fragments, moist
FILL - red clay with gravel and shale fragments	5	34-35	FILL - ditto & gray shale fragments
		6-5-6	FILL - red silty clay with gravel, wet
Gray severely weathered to decomposed SHALE	10	50/0.5	WIS, gray severely weathered shale
	15	50/0.2	WIS, gray decomposed SHALE, dry
Auger refusal @ 15.0 ft			Auger refusal @ 15.0 ft
	20		
	25		
	30		
	35		

Groundwater Data			
Depth, ft	Time, hr	Depth, ft	Time, hr

NOTES:

No water encountered.
Hole backfilled on completion.
WIS - Water in Spoon

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall
** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation
See NOTES TO BORING LOG which are a part of this log.

LOG OF BORING 15

Project:	Washington County Service Authority - 12 mgd Improvements			**Location:**	Abingdon, VA
Type of Boring:	Soil Boring - Intermittent Sampling			**Drilling Contractor:**	S & ME
Elevation, ft:	1795	**Date Started:**	4 12 10	**Date Completed:** 4 12 10	**Weather:**

Stratum Description	Depth, ft	BLOWS* / REC./RQD**	Sample Description
FILL - brown clay with trace of gravel	0	3-5-4	FILL - brown clay, medium, moist to wet
	5	2-1-2	FILL - brown clay, soft to medium, moist to wet
		1-2-1	FILL - ditto and gray organic clay, soft, wet
Gray & brown organic SILT & CLAY (ALLUVIUM)	10	WOH	Gray and brown organic clay and silt with few pebbles
	15	5-6-8	brown & gray clay, rounded gravel
Gray decomposed SHALE	20	50/0.3	Gray decomposed SHALE Auger refusal @ 19.0 ft
	25		
	30		
	35		

Groundwater Data

Depth, ft	Time, hr	Depth, ft	Time, hr
18.0	0		

NOTES:

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall.
** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation
See NOTES TO BORING LOG which are a part of this log.

LOG OF BORING 16

Project:	Washington County Service Authority - 12 mgd Improvements			**Location:**	Abingdon, VA
Type of Boring:	Soil Boring - Intermittent Sampling			**Drilling Contractor:**	S & ME
Elevation, ft:	1793	**Date Started:**	4 14 10	**Date Completed:**	4 14 10
Weather:					

Stratum Description	Depth, ft	BLOWS* REC./RQD**	Sample Description
	0		
FILL - brown & tan silty clay		8-7-8	FILL - brown & tan silty clay
	5	2-2-2	FILL - brown clay (0.2' rec)
		1-2-2	FILL - ditto & gray organic clay, soft
	10	50/0.5	FILL - gray weathered shale fragments
Brown slightly organic SILT (ALLUVIUM)			
	15	5-21-50/0.1	Gray decomposed SHALE
Gray decomposed SHALE			
	20	50/0.2	Auger refusal @ 19.0 ft
Auger refusal @ 19.0 ft			
	25		
	30		
	35		

Groundwater Data			
Depth, ft	**Time, hr**	**Depth, ft**	**Time, hr**

NOTES:

* No. of Blows Required to Drive 2" O.D., 1.375" I.D., Sampler 6" Using 140-lb Hammer, 30" Fall

** Core Recovery as Percent of Length of Drill Run. RQD is Rock Quality Designation

See NOTES TO BORING LOG which are a part of this log.