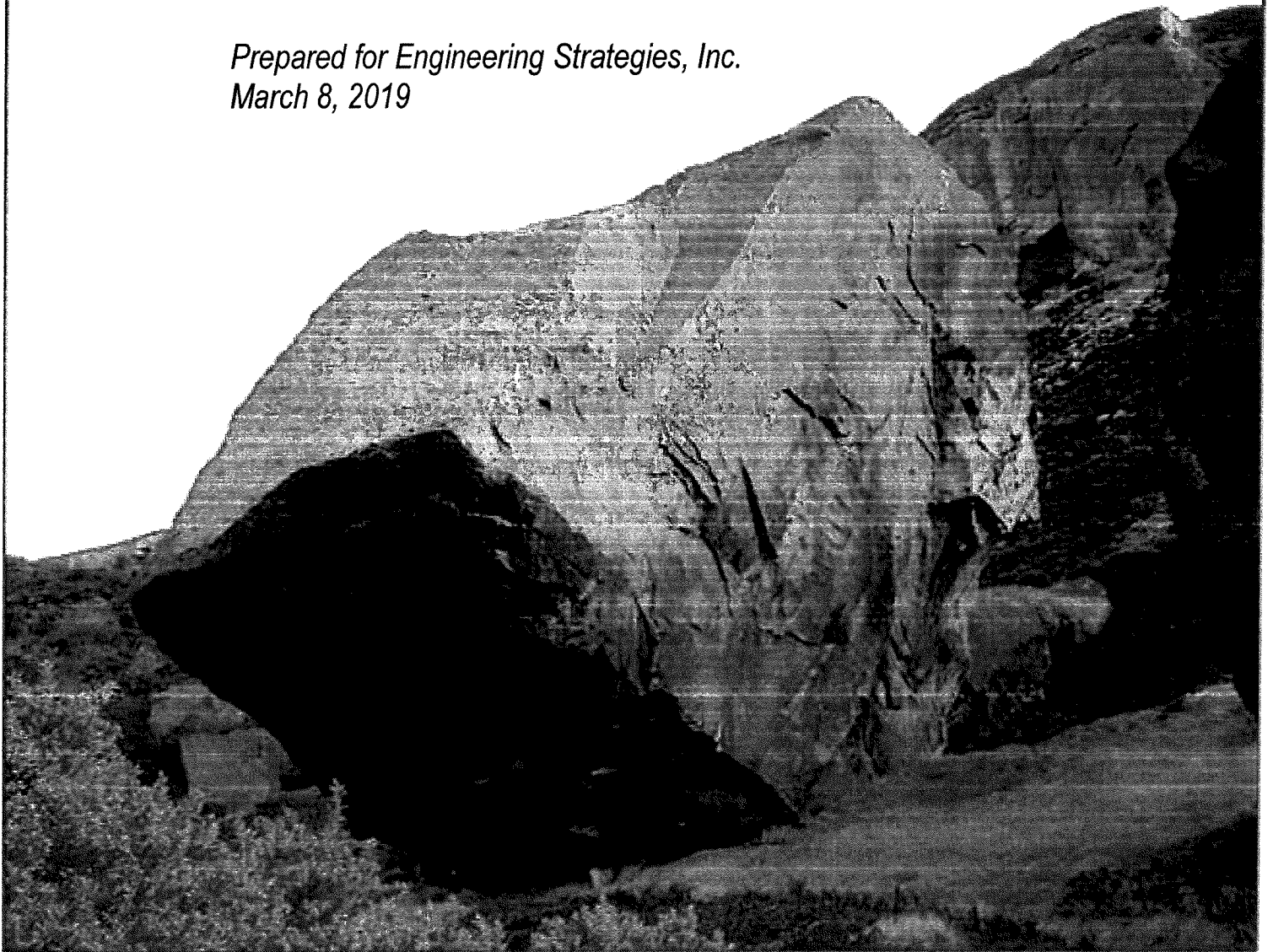


GEOHYDRO **ENGINEERS**

Report of Subsurface Exploration and Geotechnical Engineering Evaluation

**New 6 Million-Gallon Clearwell
Hugh A. Wyckoff Water Treatment Plant
Acworth, Georgia
Geo-Hydro Project Number 181244.20**

*Prepared for Engineering Strategies, Inc.
March 8, 2019*



Mr. Pedro Rossello, P.E.
Engineering Strategies, Inc. (ESI)
3855 Shallowford Road, Suite 525
Marietta, Georgia 30062

March 8, 2019

**Report of Subsurface Exploration
and Geotechnical Engineering Evaluation
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Dear Mr. Rossello:

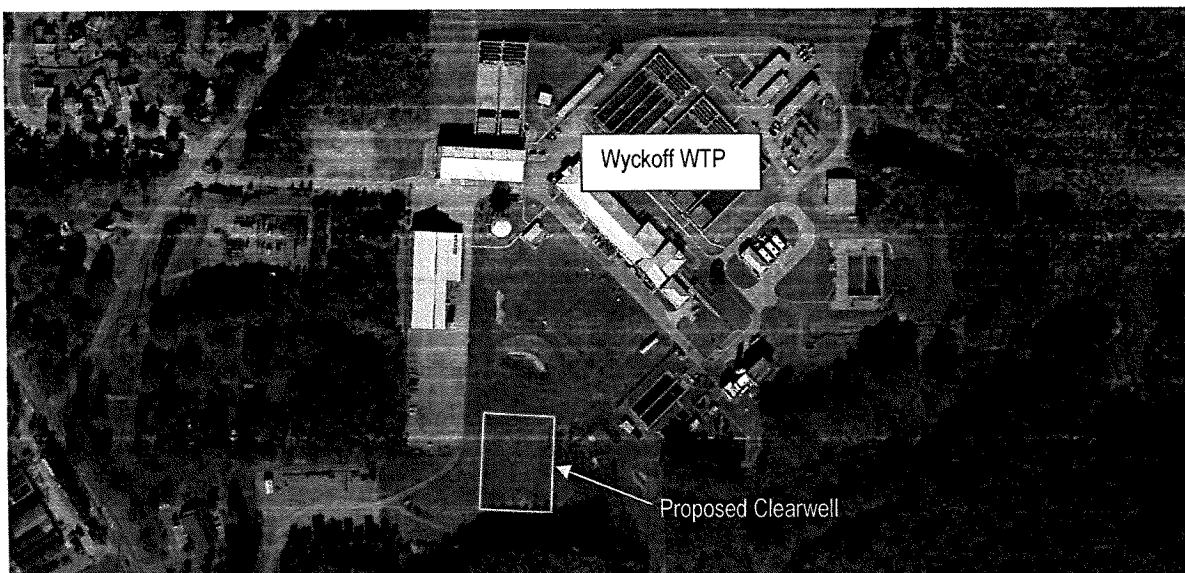
Geo-Hydro Engineers, Inc. has completed the authorized subsurface exploration for the above referenced project. The scope of services for this project was outlined in our proposal number 22054.2 dated July 2, 2018.

PROJECT INFORMATION

The project is located at the existing Hugh A. Wyckoff Water Treatment Plant at 3728 Mars Hill Road in Acworth, Georgia. Figure 1 in the Appendix shows the approximate plant location.

The project includes construction of a new 6 million-gallon clearwell to be located east of the existing gravel parking and laydown area south of the GAC Building. The annotated aerial photograph below shows the planned clearwell location relative to the existing plant.

At the time of this report, design for the clearwell has not been completed. We understand that the clearwell will have approximate plan dimensions of 240 feet by 180 feet with approximately 19 feet of side water depth. The project will also include piping necessary to integrate the new clearwell into the existing plant.



EXPLORATORY PROCEDURES

The subsurface exploration consisted of 13 machine-drilled borings performed at the approximate locations shown on Figure 2 included in the Appendix. The borings were located in the field by Geo-Hydro using a handheld GPS unit with pre-loaded coordinates. In general, the locations of the borings should be considered approximate.

Standard penetration testing, as provided for in ASTM D1586, was performed at select depth intervals in the borings. Soil samples obtained from the drilling operation were examined and classified in general accordance with ASTM D2488 (Visual-Manual Procedure for Description of Soils). Soil classifications include the use of the Unified Soil Classification System described in ASTM D2487 (Classification of Soils for Engineering Purposes). The soil classifications also include our evaluation of the geologic origin of the soils. Evaluations of geologic origin are based on our experience and may be subject to some degree of interpretation.

Rock coring was performed at four soil test boring locations. Coring was performed in general accordance with ASTM D2113 and rock quality designation (RQD) was determined in accordance with ASTM D6032.

REGIONAL GEOLOGY

The project site is located within the Northern Piedmont geologic province of Georgia. Soils in this area have been formed by the in-place weathering of the underlying crystalline rock, which accounts for their classification as "residual" soils. Residual soils near the ground surface, which have experienced advanced weathering, frequently consist of red brown clayey silt (ML) or silty clay (CL). The thickness of this surficial clayey zone may range up to roughly 6 feet. For various reasons, such as erosion or local variation of mineralization, the upper clayey zone is not always present.

With increased depth, the soil becomes less weathered, coarser grained, and the structural character of the underlying parent rock becomes more evident. These residual soils are typically classified as sandy micaceous silt (ML) or silty micaceous sand (SM). With a further increase in depth, the soils eventually become quite hard and take on an increasing resemblance to the underlying parent rock. When these materials have a standard penetration resistance of 100 blows per foot or greater, they are referred to as partially weathered rock. The transition from soil to partially weathered rock is usually a gradual one, and may occur at a wide range of depths. Lenses or layers of partially weathered rock are not unusual in the soil profile.

Partially weathered rock represents the zone of transition between the soil and the indurated metamorphic rocks from which the soils are derived. The subsurface profile is, in fact, a history of the weathering process which the crystalline rock has undergone. The degree of weathering is most advanced at the ground surface, where fine grained soil may be present. And, the weathering process is in its early stages immediately above the surface of relatively sound rock, where partially weathered rock may be found.

The thickness of the zone of partially weathered rock and the depth to the rock surface have both been found to vary considerably over relatively short distances. The depth to the rock surface may frequently range from the ground surface to 80 feet or more. The thickness of partially weathered rock, which overlies the rock surface, may vary from only a few inches to as much as 40 feet or more.

Stream valleys in the Piedmont Region may contain alluvial (water deposited) soils, depending on ground surface topography, stream flow characteristics, and other factors. By nature, alluvial soils can be highly variable depending upon the energy regime at the time of deposition. Coarse materials such as sand or gravel are deposited in higher energy environments, while fine grained materials such as silt and clay are deposited in low energy environments. Alluvial soils may also contain significant organic materials, and are frequently in a loose, saturated condition. In many cases, fine grained alluvial soils will be highly compressible and have relatively low shear strength.

TEST BORING SUMMARY

Detailed measurements or surface materials necessary for quantity estimation were not performed for this exploration, and the thickness of surface materials should be expected to vary. For planning purposes, we recommend an arbitrary thickness of 9 inches for surface materials across the project area.

Starting at the ground surface, all of the borings encountered fill materials extending to depths ranging from about 3 to 27 feet. The fill was classified as clayey silt, sandy silt, and silty sand with varying amounts of mica, rock fragments, and topsoil. Standard penetration resistances recorded in the fill ranged from 3 to 37 blows per foot.

Beneath fill materials, all of the borings encountered residual soils typical of the Piedmont Region. The residual soils were classified as silty sand with some silty clay and clayey silt and varying mica content. Standard penetration resistances recorded in the residual soils ranged from 5 to 63 blows per foot.

Borings C-1 through C-9 encountered partially weathered rock at depths ranging from about 27 to 48 feet. Partially weathered rock is locally defined as residual material having a standard penetration resistance of 100 blows per foot or greater.

Conditions causing auger refusal were encountered in borings C-1 through C-8 at depths ranging from 30 to 56 feet. Auger refusal is the condition that prevents advancement of the boring using conventional soil drilling techniques. The material causing auger refusal may consist of a boulder, a lens or layer of rock, the upper surface of relatively massive rock, or other hard material.

Starting at the depth of auger refusal, rock coring was performed in borings C-1, C-3, C-5, and C-7 to sample the refusal materials. Beneath the depth of auger refusal, the borings recovered slightly fractured to very intensely fractured biotite gneiss with rock quality designations ranging from 7 to 88 percent.

At the time of drilling or twenty-four hours after drilling completion, groundwater was encountered in all of the borings except C-13 at depths ranging from 6 to 33 feet. It is important to note that groundwater levels will fluctuate depending on seasonal variations of precipitation and other factors, and may occur at higher elevations in the future.

For more detailed descriptions of subsurface conditions, please refer to the summary table on the following page and the test boring records included in the Appendix.

Summary of Subsurface Conditions

Boring	Bottom of Fill (feet)	Depth to PWR (feet)	Depth to Auger Refusal (feet)	Boring Termination Depth	Depth to Groundwater (feet)
C-1	23	NE	39	59	8*
C-2	27	37	42	42	13*
C-3	18	27	32	42	6*
C-4	12	27	30	30	25†
C-5	18	37	45	55	28†
C-6	8	53	56	56	26†
C-7	6	28	45	55	29*
C-8	12	38	46	46	33†
C-9	18	48	NE	60	22†
C-10	12	NE	NE	25	16†
C-11	6	NE	NE	25	21†
C-12	6	NE	NE	25	19†
C-13	3	NE	NE	25	NE

All Depths in this Summary Table are Approximate

NE: Not Encountered

PWR: Partially Weathered Rock

*: Groundwater level recorded at least twenty-four hours after drilling completion

†: Groundwater level recorded at time of drilling

EVALUATIONS AND RECOMMENDATIONS

The following evaluations are based on the information available on the proposed clearwell and associated piping, the data obtained from the exploratory borings, and our experience with soils and subsurface conditions similar to those encountered at the explored locations. Because the subsurface exploration represents a statistically small sampling of subsurface conditions, it is possible that conditions between the test borings may be substantially different from those indicated by the borings.

Geotechnical Considerations

The following geotechnical characteristics of the site should be considered for planning and design:

- Partially weathered rock was encountered in all of the borings performed within the clearwell except C-1 at depths ranging from about 27 to 53 feet. Excavation of partially weathered rock typically requires large equipment capable of ripping. Due to the leverage involved, excavation of partially weathered rock is often impractical in trench excavations or on sloping terrain. Conditions causing auger refusal were encountered in borings C-1 through C-8 at depths ranging from 30 to 56 feet. For planning purposes, we recommend assuming that material below the depth of auger refusal will require blasting to remove. The amount of ripping and blasting necessary to construct the clearwell will depend on the bottom elevation of the structure.
- Either at the time of drilling or at least twenty-four hours after drilling completion, groundwater was encountered in all of the borings except B-13 at depths ranging from 6 to 33 feet. Based on the results of the borings, temporary dewatering will be necessary to facilitate construction of the clearwell. It is important to note that the borings were performed during a seasonally wet period, and groundwater levels measured in the borings may be indicative of perched water trapped within the fill mass.

If groundwater above the bottom of the clearwell presents a concern of groundwater migration into the finished water supply, a permanent dewatering system should be installed beneath the clearwell. The permanent dewatering system should consist of a layer of open-graded stone beneath the clearwell. The stone should be at least 12 inches thick and fully wrapped with a non-woven, needle-punched geofabric such as Mirafi 180N or similar. The dewatering system should daylight into the plant's stormwater system.

If groundwater adjacent to the clearwell does not present a concern for groundwater migration into the finished water supply, the clearwell should be designed to resist buoyant uplift forces during periods of seasonally high groundwater levels when the clearwell may be empty or the water level may be depressed in the clearwell.

- Based on our understanding of the project, we expect the foundation bearing surface to experience a net decrease in applied pressure after construction of the clearwell. Assuming a properly prepared

subgrade, we recommend designing the bottom slab of the clearwell based on an allowable bearing pressure of 2,500 psf or a modulus of subgrade reaction of 80 pci.

- Based on the results of the test borings and following the calculation procedure in the 2012 International Building Code (Chapter 20, ASCE 7-10), the *Site Class* for the site is *D*. The mapped and design spectral response accelerations are as follows: $S_s=0.231$, $S_1=0.098$, $S_{DS}=0.247$, $S_{D1}=0.157$.

The following sections provide recommendations regarding these issues and other geotechnical aspects of the project.

Excavation Characteristics

Partially weathered rock was encountered in all of the borings performed within the clearwell footprint except C-1 at depths ranging from about 27 to 53 feet. Excavation of partially weathered rock typically requires large equipment capable of ripping. The amount of ripping necessary to construct the clearwell will depend on the bottom elevation of the structure.

Borings C-1 through C-8 encountered conditions causing auger refusal at depths ranging from 30 to 56 feet. For planning purposes, we recommend assuming that blasting will be necessary to remove material below the depth of auger refusal. The amount of blasting necessary will depend on the bottom elevation of the clearwell.

Based on the results of the borings, difficult excavation conditions are not expected during installation of piping associated with the clearwell. Borings C-10 through C-13 did not encounter partially weathered rock or conditions causing auger refusal within the depths explored.

It is important to note that the geology of the Piedmont is characterized by variable subsurface conditions. Due to the widely-spaced nature of the borings, it is likely that subsurface conditions intermediate of the borings will be different. Weathered rock, mass rock, boulders, and rock seams may all be encountered at locations intermediate of the borings along the alignment. Additionally, boulders are visible at the ground surface within the existing Wyckoff WTP campus southwest of the clearwell footprint. Boulders may be encountered during excavation for the clearwell. Depending on the size of the boulder, blasting may be required to facilitate removal from trench excavations.

For construction bidding and field verification purposes it is common to provide a verifiable definition of rock in the project specifications. The following is a typical definition of trench rock:

- **Mass Rock:** Material which cannot be excavated with a single-tooth ripper drawn by a crawler tractor having a minimum draw bar pull rated at 56,000 pounds (Caterpillar D-8K or equivalent), and occupying an original volume of at least one cubic yard.
- **Trench Rock:** Material occupying an original volume of at least one-half cubic yard which cannot be excavated with a hydraulic excavator having a minimum flywheel power rating of 123 kW (165 hp);

such as a Caterpillar 322C L, John Deere 230C LC, or a Komatsu PC220LC-7; equipped with a short tip radius bucket not wider than 42 inches.

Earth Slopes

Temporary construction slopes should be designed in strict compliance with OSHA regulations. The exploratory borings indicate that most soils are Type C as defined in 29 CFR 1926 Subpart P. In general, we recommend that temporary construction slopes be no steeper than 1.5H:1V for excavation depths of 20 feet or less. However, temporary excavation slopes in firm residual soils above the groundwater level can have a gradient of 1H:1V. Temporary construction slopes should be closely observed on a daily basis by the contractor's "competent person" for signs of mass movement: tension cracks near the crest, bulging at the toe of the slope, etc. The responsibility for excavation safety and stability of temporary slopes should lie solely with the contractor.

We recommend that extreme caution be observed in trench excavations. Several cases of loss of life due to trench collapses in Georgia point out the lack of attention given to excavation safety on some projects. We recommend that applicable local and federal regulations regarding temporary slopes, and shoring and bracing of trench excavations be closely followed.

Temporary Excavation Bracing

If at a given location a sloped excavation is not feasible, trench boxes or other temporary excavation bracing will be required. The most appropriate type of excavation bracing will be dictated by subsurface conditions at the specific excavation or pit location. Typically, the contractor will design and implement temporary excavation bracing as part of means and methods of construction.

Earth Pressure (Cast-in-Place Walls)

Three earth pressure conditions are generally considered for retaining wall design: "at rest", "active", and "passive" stress conditions. Retaining walls which are rigidly restrained at the top and will be essentially unable to rotate under the action of earth pressure (such loading dock walls) should be designed for "at rest" conditions. Retaining walls which can move outward at the top as much as 0.5 percent of the wall height (such as free-standing walls) should be designed for "active" conditions. For the evaluation of the resistance of soil to lateral loads the "passive" earth pressure must be calculated. It should be noted that full development of passive pressure requires deflections toward the soil mass on the order of 1.0 percent to 4.0 percent of total wall height.

Earth pressure may be evaluated using the following equation:

$$p_h = K (D_w Z + q_s) + W_w(Z-d)$$

where: p_h = horizontal earth pressure at any depth below the ground surface (Z).

W_w = unit weight of water

Z = depth to any point below the ground surface

d = depth to groundwater surface

D_w = wet unit weight of the soil backfill (depending on borrow sources). The wet unit weight of most residual soils may be expected to range from approximately 115 to 125 pcf. Below the groundwater level, D_w must be the buoyant weight.

q_s = uniform surcharge load (add equivalent uniform surcharge to account for construction equipment loads)

K = earth pressure coefficient as follows:

<u>Earth Pressure Condition</u>	<u>Coefficient</u>
At Rest (K_o)	0.50
Active (K_a)	0.33
Passive (K_p)	3.0

The groundwater term, $W_w(Z-d)$, should be used if no drainage system is incorporated behind retaining walls. If a drainage system is included which will not allow the development of any water pressure behind the wall, then the groundwater term may be omitted. The development of excessive water pressure is a common cause of retaining wall failures. Drainage systems should be carefully designed to ensure that long term permanent drainage is accomplished.

The above design recommendations are based on the following assumptions:

- Horizontal backfill
- 95 percent standard Proctor compactive effort on backfill (ASTM D698)
- No safety factor is included

For convenience, equivalent fluid densities are frequently used for the calculation of lateral earth pressures. For "at rest" stress conditions, an equivalent fluid density of 63 pcf may be used. For the "active" state of stress an equivalent fluid density of 42 pcf may be used. These equivalent fluid densities are based on the assumptions that drainage behind the retaining wall will allow *no* development of hydrostatic pressure; that native sandy silts or silty sands will be used as backfill; that the backfill soils will be compacted to 95 percent of standard Proctor maximum dry density; that backfill will be horizontal; and that no surcharge loads will be applied.

For analysis of sliding resistance of the base of a cast-in-place concrete retaining wall, the coefficient of friction may be taken as 0.4 for the soils at the project site. This is an ultimate value, and an adequate factor of safety should be used in design. The force which resists base sliding is calculated by multiplying the normal force on the base by the coefficient of friction. Full development of the frictional force could require deflection of the base of roughly 0.1 to 0.3 inches.

Construction Dewatering

Based on the results of the test borings, groundwater will be encountered during excavation for the clearwell. Perched groundwater will be highly variable as it is a function of recent rainfall. Temporary dewatering should be performed to maintain the groundwater level approximately 2 to 3 feet below the lowest prevailing excavation depth. In most cases we expect that direct pumping from the excavation will provide satisfactory temporary construction dewatering. However, the actual dewatering approach will be dictated by conditions at the time of excavation. Sand layers or other more permeable soil layers may significantly increase the amount of water inflow into open excavations. If shoring is required to construct the clearwell, we recommend that the same contractor be responsible for dewatering due to the interaction between shoring and dewatering activities.

The amount of temporary dewatering actually required during construction is related not only to the prevailing weather conditions, but also the contractor's sequencing of construction activities. Construction specifications should include performance guidelines for temporary dewatering. Performance guidelines allow the contractor to select the actual means and methods of construction dewatering. The following sample specification¹ could be used as a guide for development of actual specifications.

Control of groundwater shall be accomplished in a manner that will preserve the strength of the foundation soils, will not cause instability of the excavation slopes, and will not result in damage to existing structures. Where necessary to these purposes, the water level shall be lowered in advance of excavation, utilizing trenches, sumps, wells, well points, or similar methods. The water level, as measured in piezometers, shall be maintained a minimum of 3 feet below the prevailing excavation level. Open pumping from sumps and ditches, if it results in boils, loss of soil fines, softening of the ground, or instability of slopes, will not be permitted. Wells and well points shall be installed with suitable screens and filters so that continuous pumping of soil fines does not occur. The discharge shall be arranged to facilitate collection of samples by the Engineer.

We recommend that pipe bedding be used where groundwater is encountered. This will provide a level, stable base for pipe installation. We recommend #57 or #78 crushed stone meeting Georgia DOT specifications as pipe bedding. The bedding stone should be wrapped in non-woven, needle-punched geotextile fabric meeting the requirements of AASHTO M288 for Class 2 Geotextiles.

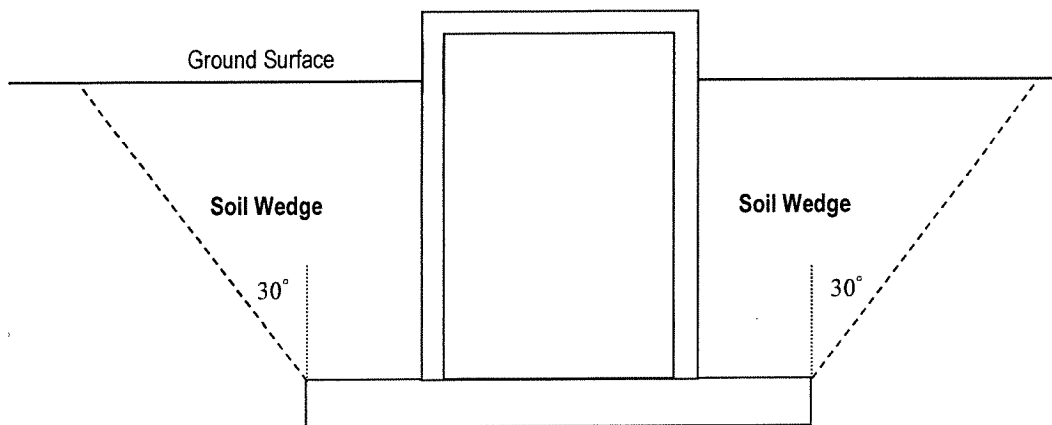
Long-Term Dewatering

Based on the results of the test borings, groundwater will be present above the bottom of the clearwell during periods of seasonally high groundwater levels. This may present concerns that groundwater will migrate into the finished water supply held in the clearwell. If this is a concern, we recommend installing a permanent dewatering system to prevent the groundwater level from rising above the bottom of the clearwell. The dewatering system should consist of a layer of open-graded stone fully wrapped with a

¹ The sample specification was adapted from Construction Dewatering - A Guide to Theory and Practice, John Wiley and Sons, and is not intended for direct use as a construction specification without modifications to reflect specific project conditions.

non-woven, needle-punched filter fabric such as Mirafi 180N or similar. The system can resemble a series of trench drains, a blanket drain throughout the bottom of the clearwell, or a ring drain surrounding the clearwell at an elevation near the bottom of the clearwell. The dewatering system should daylight into the plant's stormwater management system or daylight at an appropriate location which affords gravity drainage.

If groundwater migration into the clearwell is not a concern, the clearwell should be designed to resist potential buoyant uplift forces. In some instances, uplift forces may be resisted by the dead weight of the structure itself. Where necessary, the dead weight of the structure can be effectively increased by extending the reinforced concrete mat foundation beyond the walls of the structure. This mobilizes additional weight of soil to increase the effective dead weight of the structure. The effective weight of a "wedge" of soil backfill as depicted in the following sketch can be used to calculate additional uplift resistance from soil backfill.



To facilitate the evaluation of whether a permanent dewatering system is necessary or whether anchors will be required to resist buoyant forces, we recommend installing 3 or 4 piezometers within the clearwell footprint to develop a better understanding of the groundwater regime. The groundwater levels recorded over time would guide the decision regarding the most appropriate approach to manage groundwater at the site.

Structural Fill Placement

Materials selected for use as structural fill should be free of organic matter, waste construction debris, and other deleterious materials. In general, the material should not contain rocks having diameters over 4 inches. It is our opinion that the following soils represented by their USCS group symbols will typically be suitable for use as structural fill and are commonly found in abundance in the Piedmont region: (CL), (SM), and (ML). The following soil types are typically suitable but are not abundant in the Piedmont region: (SW), (SP), (SC), (SP-SM), and (SP-SC). The following soil types are considered unsuitable: (MH), (CH), (OL), (OH), and (Pt).

Laboratory Proctor compaction tests should be performed on representative samples of proposed fill materials to provide data necessary to determine acceptability and for quality control. The moisture content of suitable borrow soils should generally be no more than 3 percentage points above or below their optimum moisture contents at the time of compaction. Tighter moisture limits may be necessary with certain soils.

Suitable fill material should be placed in thin lifts. Lift thickness depends on type of compaction equipment; but in general lifts of 8 inches loose measurement are recommended. The soil should be compacted by heavy compaction equipment such as a self-propelled sheepsfoot roller. Within confined areas, such as around the pipe or manhole structures, we recommend the use of “wacker packers” or “Rammax” compactors to achieve the specified compaction. Loose lift thicknesses of 4 to 6 inches are recommended in small area fills.

In general, we recommend that structural fill be compacted to at least 95 percent of the standard Proctor maximum dry density (ASTM D698). Following Georgia DOT guidelines, the upper 12 inches of pavement subgrade soils should be compacted to at least 100 percent of the standard Proctor maximum dry density. Geo-Hydro should perform density tests during fill placement.

Soils excavated from elevations approaching and extending below the groundwater level will have moisture contents that will be too high to allow proper compaction. In portions of the water main alignment that will be outside the travel lanes, the compaction criteria can possibly be adjusted to allow the reuse of soils with higher moisture contents than those typically required for structural fill. However, proper compaction must be achieved beneath any roadways and other areas where pavements or other hardscapes will be supported by the fill.

It is important to establish as part of the construction contract whether soils having elevated moisture content will be considered suitable for reuse. We often find this issue to be a point of contention and a source of delays and change orders. From a technical standpoint, soils with moisture contents wet of optimum as determined by the standard Proctor test (ASTM D698) can be reused provided that the moisture is properly adjusted to within the workable range. From a practical standpoint, wet soils can be very difficult to dry in small or congested sites and such difficulties should be considered during planning and budgeting. A clear understanding by the general contractor and grading subcontractor regarding the reuse of excavated soils will be important to avoid delays and unexpected cost overruns.

Foundation Design

After general site preparation and site grading have been completed in accordance with the recommendations of this report, it is our opinion that the clearwell can be supported using a conventional reinforced concrete mat foundation. We recommend that the mat be designed for an allowable soil bearing pressure of 2,500 psf. The concrete slab-on-grade can be designed using a modulus of subgrade reaction of 80 pci.

The recommended allowable soil bearing pressure and modulus of subgrade reaction are based on an estimated maximum settlement no greater than approximately ½-inch, with anticipated differential settlement across the clearwell footprint not exceeding about ½ inch. If the structural engineer determine that the estimated total or differential settlement cannot be accommodated by the proposed structure, please contact us.

We recommend that a layer of crushed stone be placed at the bearing elevation to provide uniform near-surface support conditions and a stable working surface on which to construct the clear well. We recommend a 6-inch layer of graded aggregate base (GAB) compacted to at least 100 percent of the modified Proctor maximum dry density (ASTM D1557). Alternatively, the crushed stone course can consist of 12 inches of fully-wrapped #57 stone to also serve as a blanket drain component of a permanent dewatering system.

The clearwell bearing surface should be evaluated prior to placement of crushed stone. These evaluations should be performed by Geo-Hydro to confirm that the design allowable soil bearing pressure or modulus of subgrade reaction is available. Bearing surface evaluations should be performed using a combination of visual observation, hand augering, and portable dynamic cone penetrometer testing (ASTM STP-399).

Because of natural variation, it is possible that some of the soils at the project site may have an allowable bearing pressure less than the recommended design value. Likewise, existing fill materials are highly variable, and may have an allowable bearing pressure less than the recommended design value. Therefore, foundation bearing surface evaluations will be critical to aid in the identification and remediation of these situations.

Remedial measures should be based on actual field conditions. However, in most cases we expect the use of the stone replacement technique to be the primary remedial measure. Improving subgrade conditions in mat foundation excavations is generally limited to removing soft soils from the foundation area and replacing the soft soils with crushed stone materials. Stone replacement involves the removal of soft or loose soils, and replacement with well-compacted graded aggregate base (GAB) or #57 stone meeting Georgia Department of Transportation specifications for gradation. For budgeting purposes, we suggest considering a contingency to treat approximately 25 percent of the clearwell footprint using stone replacement extending to a depth of 2 feet below planned soil subgrade elevation. The actual quantity of stone replacement will be different and may exceed the suggested estimate.

Seismic Design


Based on the results of the test borings and following the calculation procedure in the 2012 International Building Code (Chapter 20, ASCE 7-10), the *Site Class* for the site is *D*. The mapped and design spectral response accelerations are as follows: $S_S=0.231$, $S_1=0.098$, $S_{DS}=0.247$, $S_{D1}=0.157$.

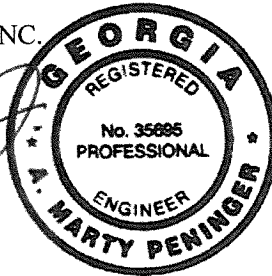
Based on the information obtained from the soil test borings, it is our opinion that the potential for liquefaction of the native soils at the site due to earthquake activity is relatively low.

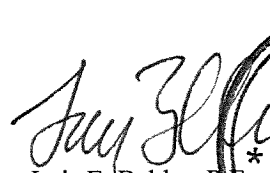
We appreciate the opportunity to serve as your geotechnical consultant for this project. If you have any questions concerning this report or any of our services, please call us.

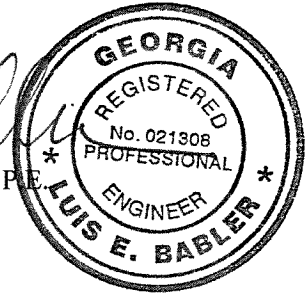
Sincerely,

GEO-HYDRO ENGINEERS, INC.


A. Marty Peninger, P.E.
Senior Geotechnical Engineer
mpeninger@geohydro.com

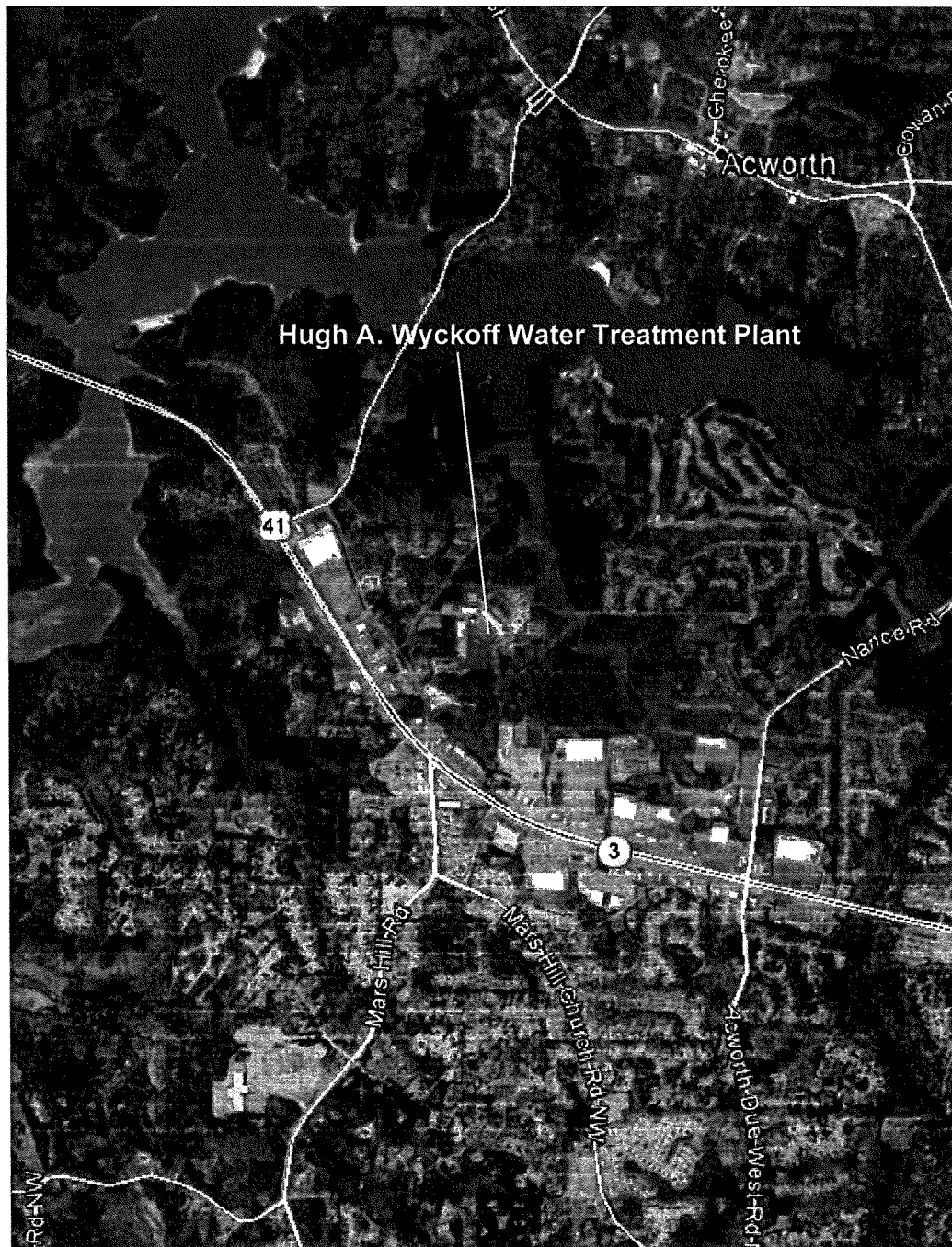



Luis E. Babler, P.E.
Chief Engineer
luis@geohydro.com



AMP/LEB/181244.20 - New 6 MG Clearwell - Wyckoff WTP - Geotechnical Report

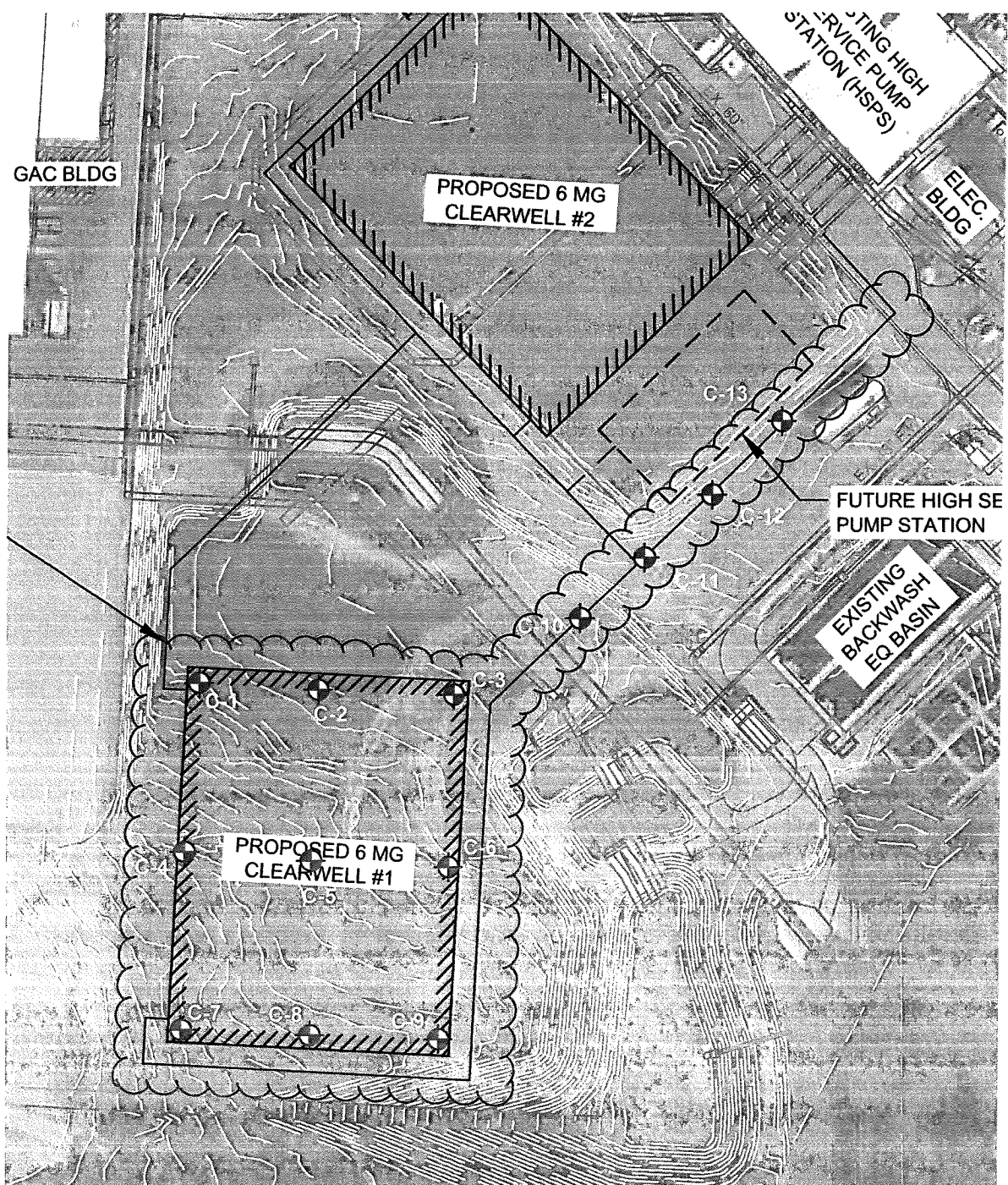
APPENDIX



0 0.25 0.5 1 1.5
Approximate Scale, Miles

Figure 1: Site Location Plan

New 6-Million Gallon Clearwell
Hugh A. Wyckoff Water Treatment Plant
Cobb County Marietta Water Authority (CCMWA)
Acworth, Georgia
Geo-Hydro Project Number 181244.20



LEGEND:  Soil Test Boring



Approximate Scale: 1"=100'

Figure 2: Boring Location Plan

New 6-Million Gallon Clearwell
Hugh A. Wyckoff Water Treatment Plant
Cobb County Marietta Water Authority (CCMWA)
Acworth, Georgia
Geo-Hydro Project Number 181244.20

Symbols and Nomenclature

Symbols

■	Thin-walled tube (TWT) sample recovered
□	Thin-walled tube (TWT) sample not recovered
●	Standard penetration resistance (ASTM D1586)
50/2"	Number of blows (50) to drive the split-spoon a number of inches (2)
65%	Percentage of rock core recovered
RQD	Rock quality designation - % of recovered core sample which is 4 or more inches long
GW	Groundwater
▼	Water level at least 24 hours after drilling
▽	Water level one hour or less after drilling
ALLUV	Alluvium
TOP	Topsoil
PM	Pavement Materials
CONC	Concrete
FILL	Fill Material
RES	Residual Soil
PWR	Partially Weathered Rock
SPT	Standard Penetration Testing

Penetration Resistance Results		Approximate
	Number of Blows, N	Relative Density
Sands	0-4	very loose
	5-10	loose
	11-20	firm
	21-30	very firm
	31-50	dense
	Over 50	very dense
		Approximate
	Number of Blows, N	Consistency
Silts and Clays	0-1	very soft
	2-4	soft
	5-8	firm
	9-15	stiff
	16-30	very stiff
	31-50	hard
	Over 50	very hard

Drilling Procedures

Soil sampling and standard penetration testing performed in accordance with ASTM D 1586. The standard penetration resistance is the number of blows of a 140-pound hammer falling 30 inches to drive a 2-inch O.D., 1.4-inch I.D. split-spoon sampler one foot. Rock coring is performed in accordance with ASTM D 2113. Thin-walled tube sampling is performed in accordance with ASTM D 1587.

C-01

Test Boring Record



Project: New 6-Million Gallon Clearwell Wyckoff WTP						Project No: 181244.20	
Location: Ackworth, Georgia						Date: 2/7/19	
Method: ASTM D2113, ASTM D6151			GWT at Drilling: 27 feet			G.S. Elev:	
Driller: GD (Auto Hammer)			GWT at 24 hrs: 8 feet			Logged By: KDJ	

Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)
				Soft to firm red-brown slightly micaceous fine sandy silt (ML) (FILL)		0 10 20 30 40 50 60 70 80 90 100
	5				7	●
	5			Firm to stiff brown micaceous clayey silt (ML) (FILL)	4	●
	10				9	●
	10				6	●
	15				9	●
	20				9	●
	25			Very firm brown to black micaceous silty fine sand (SM) (RESIDUUM)	26	●
	30				30	●
	35				28	●
	40			Partially weathered rock sampled as brown micaceous silty fine to medium sand (SM)	50/2"	●
	40			Auger Refusal at 39 feet - Begin Rock Coring		
	45			Light gray and dark gray, moderately to highly decomposed, phaneritic, intensely to very intensely fractured, Biotite Gneiss. Fractures extremely narrow to moderately wide, light brown discoloration, dipping between 0-90 degrees TCA.	Core Run 1 39'-0" to 44'-0" REC=31% RQD=7%	

Remarks: Approximate Latitude: 34.0444
 Approximate Longitude: -84.6902
 TCA indicates measured To Core Axis

TEST BORING RECORD ROCK CORING.GPJ GEO HYDRO.GDT 3/8/19

C-01

Test Boring Record



Project: New 6-Million Gallon Clearwell Wyckoff WTP					Project No: 181244.20															
Location: Ackworth, Georgia					Date: 2/7/19															
Method: ASTM D2113, ASTM D6151			GWT at Drilling: 27 feet		G.S. Elev:															
Driller: GD (Auto Hammer)			GWT at 24 hrs: 8 feet		Logged By: KDJ															
Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)														
						0 10 20 30 40 50 60 70 80 90 100														
	50			Light gray and dark gray, moderately to highly decomposed, phaneritic, intensely to very intensely fractured, Biotite Gneiss. Fractures extremely narrow to moderately wide, light brown discoloration, dipping between 0-90 degrees TCA.	Core Run 2 44'-0" to 49'-0" REC=15% RQD=7%															
	55				Core Run 3 49'-0" to 54'-0" REC=38% RQD=27%															
	60				Core Run 4 54'-0" to 59'-0" REC=17% RQD=12%															
	60				Boring Terminated at 59 feet															
	65																			
	70																			
	75																			
	80																			
	85																			
	90																			
Remarks: Approximate Latitude: 34.0444 Approximate Longitude: -84.6902 TCA indicates measured To Core Axis																				

TEST BORING RECORD, ROCK CORING.GPJ GEO HYDRO.GDT 3/8/19

C-02

Test Boring Record



Project: New 6-Million Gallon Clearwell - Wyckoff WTP				Project No: 181244.20	
Location: Acworth, Georgia				Date: 12/13/18	
Method: HSA- ASTM D1586		GWT at Drilling: 30 feet		G.S. Elev:	
Driller: GCD (Rope & Cathead)		GWT at 24 hrs: 13 feet		Logged By: EM	

Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)
				Firm brown slightly micaceous fine sandy silt (ML) (FILL)	7	
	5			Stiff to very stiff brown micaceous clayey silt (ML) (FILL)	16	
	10				17	
	15				19	
	20				23	
	25			Dense gray micaceous silty fine sand (SM) (FILL)	11	
	30				31	
	35			Very firm brown micaceous silty fine sand (SM) (RESIDUUM)	22	
	40				29	
	45			Very dense dark brown highly micaceous silty fine sand (SM)	63	
	50			Auger Refusal at 42 feet		
	55					
	60					
	65					

Remarks: Approximate Latitude: 34.0443
 Approximate Longitude: -84.6900

TEST BORING RECORD TEST BORING RECORD.GPJ GEO HYDRO.GDT 3/6/19

C-03

Test Boring Record

GEOHYDRO
ENGINEERS

Project: New 6-Million Gallon Clearwell Wyckoff WTP						Project No: 181244.20												
Location: Ackworth, Georgia						Date: 1/31/19												
Method: ASTM D2113, ASTM D6151			GWT at Drilling: 25 feet			G.S. Elev:												
Driller: GD (Auto Hammer)			GWT at 24 hrs: 6 feet			Logged By: KDJ												
Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)												
				Loose brown micaceous silty fine sand (SM) (FILL)		0	10	20	30	40	50	60	70	80	90	100		
	5	▼		Very firm to dense brown micaceous silty fine sand (SM) (FILL)	9													
					37													
	10				24													
					23													
	15				24													
	20			Very firm brown to black micaceous silty fine to coarse sand (SM) (RESIDUUM)	29													
	25	▽			27													
	30			Partially weathered rock sampled as gray-brown micaceous silty fine to coarse sand (SM) Auger Refusal at 32 feet - Begin Rock Coring	50/3"													
	35			Light gray and dark gray, fresh to slightly decomposed, phaneritic, slightly to moderately fractured, Biotite Gneiss. Fractures extremely narrow to narrow, light brown discoloration, dipping between 0-90 degrees TCA.	Core Run 1 32'-0" to 37'-0" REC=77% RQD=60%													
	40			37'-0" Fresh, slightly fractured. Fractures extremely narrow to narrow, clean, dipping between 0-90 degrees TCA.	Core Run 2 37'-0" to 42'-0" REC=82% RQD=82%													
	42			39'-8" Unfractured														
	45			Boring Terminated at 42 feet														
Remarks: Approximate Latitude: 34.0443 Approximate Longitude: -84.6897 TCA indicates measured To Core Axis																		

C-04

Test Boring Record



Project: New 6-Million Gallon Clearwell - Wyckoff WTP						Project No: 181244.20	
Location: Acworth, Georgia						Date: 12/13/18	
Method: HSA- ASTM D1586			GWT at Drilling: Not Encountered			G.S. Elev:	
Driller: GCD (Rope & Cathead)			GWT at 24 hrs: 25 feet			Logged By: EM	

Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)
				Firm brown slightly micaceous clayey silt (ML) (FILL)	8	
	5			Very stiff brown slightly micaceous clayey silt (ML) (FILL)	20	
					23	
	10				26	
				Very firm to dense red-brown to gray-brown highly micaceous silty fine sand (SM)	23	
	15					
	20				27	
	25				40	
				Partially weathered rock - no sample recovered at 30 feet		
	30			Auger Refusal at 30 feet	50/1"	
	35					
	40					
	45					
	50					
	55					
	60					
	65					

Remarks: Approximate Latitude: 34.0440
 Approximate Longitude: -84.6902

TEST BORING RECORD TEST BORING RECORD.GPJ GEO HYDRO.GDT 3/8/19

C-05

Test Boring Record



Project: New 6-Million Gallon Clearwell Wyckoff WTP						Project No: 181244.20	
Location: Ackworth, Georgia						Date: 2/6/19	
Method: ASTM D2113, ASTM D6151			GWT at Drilling: Not Encountered			G.S. Elev:	
Driller: GD (Auto Hammer)			GWT at 24 hrs: 28 feet			Logged By: KDJ	

Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)
				Firm brown micaceous fine sandy silt (ML) (FILL)		0 10 20 30 40 50 60 70 80 90 100
	5			Very stiff brown micaceous fine sandy silt (ML) (FILL)	8	
	10				18	
	15			Stiff brown clayey silt (ML) with topsoil (FILL)	22	
	20			Firm to very firm tan-brown to gray-brown highly micaceous silty fine sand (SM) (RESIDUUM)	26	
	25				15	
	30				16	
	35				22	
	40			Partially weathered rock sampled as gray-brown micaceous silty fine to medium sand (SM)	30	
	45			Auger Refusal at 45 feet - Begin Rock Coring	29	
					50/6"	

Remarks: Approximate Latitude: 34.0440
 Approximate Longitude: -84.6900
 TCA indicates measured To Core Axis

TEST BORING RECORD, ROCK CORING, GPJ, GEO HYDRO, GDT 3/8/19

C-05

Test Boring Record



Project: New 6-Million Gallon Clearwell Wyckoff WTP						Project No: 181244.20												
Location: Ackworth, Georgia						Date: 2/6/19												
Method: ASTM D2113, ASTM D6151			GWT at Drilling: Not Encountered			G.S. Elev:												
Driller: GD (Auto Hammer)			GWT at 24 hrs: 28 feet			Logged By: KDJ												
Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)												
						0	10	20	30	40	50	60	70	80	90	100		
	50			Light gray and dark gray, highly decomposed, phaneritic, intensely to very intensely fractured, Biotite Gneiss. Fractures extremely narrow to wide, non cohesive sediment, dipping between 0-90 degrees TCA. 48'-11" Fresh, slightly fractured. Fractures healed to narrow, clean, dipping between 0-45 degrees TCA.	Core Run 1 45'-0" to 50'-0" REC=57% RQD=38%													
	55			Boring Terminated at 55 feet	Core Run 2 50'-0" to 55'-0" REC=88% RQD=88%													
	60																	
	65																	
	70																	
	75																	
	80																	
	85																	
	90																	
Remarks: Approximate Latitude: 34.0440 Approximate Longitude: -84.6900 TCA indicates measured To Core Axis																		

TEST BORING RECORD ROCK CORING.GPJ GEO HYDRO.GDT 3/8/19

C-06

Test Boring Record


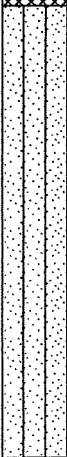



TEST BORING RECORD TEST BORING RECORD.GPJ GEO HYDRO.GDT 3/8/19

C-07

Test Boring Record



Project: New 6-Million Gallon Clearwell Wyckoff WTP						Project No: 181244.20												
Location: Ackworth, Georgia						Date: 2/5/19												
Method: ASTM D2113, ASTM D6151			GWT at Drilling: 33 feet			G.S. Elev:												
Driller: GD (Auto Hammer)			GWT at 24 hrs: 29 feet			Logged By: KDJ												
Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)												
						0	10	20	30	40	50	60	70	80	90	100		
	5			Stiff to very stiff brown fine sandy silt (ML) (FILL)	10		10											
	10			Very firm to dense red-brown to gray-brown micaceous silty fine sand (SM) (RESIDUUM)	19			20										
	15				26				30									
	20				34					40								
	25				36						40							
	30			Very dense gray-brown micaceous silty fine sand (SM)	42							50						
	35				63								60					
	40				50/6"											100		
	45				50/4"											100		
	50				50/3"											100		
	55			Auger Refusal at 45 feet - Begin Rock Coring														

Remarks:

Approximate Latitude: 34.0437

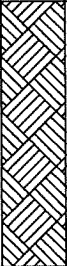
Approximate Longitude: -84.6902

TCA indicates measured To Core Axis

C-07

Test Boring Record



Project: New 6-Million Gallon Clearwell Wyckoff WTP						Project No: 181244.20												
Location: Ackworth, Georgia						Date: 2/5/19												
Method: ASTM D2113, ASTM D6151				GWT at Drilling: 33 feet		G.S. Elev:												
Driller: GD (Auto Hammer)				GWT at 24 hrs: 29 feet		Logged By: KDJ												
Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)												
						0	10	20	30	40	50	60	70	80	90	100		
	50			Light gray and dark gray, moderately to highly decomposed, phaneritic, intensely to very intensely fractured, Biotite Gneiss. Fractures narrow to moderately wide, non cohesive sediment, dipping between 0-90 degrees TCA.	Core Run 1 45'-0" to 50'-0" REC=77% RQD=12%													
	55			50'-0" Slightly to moderately decomposed, intensely to moderately fractured. Fractures extremely narrow to very narrow, non cohesive sediment, dipping between 0-90 degrees TCA.	Core Run 2 50'-0" to 55'-0" REC=97% RQD=58%													
				Boring Terminated at 55 feet														
	60																	
	65																	
	70																	
	75																	
	80																	
	85																	
	90																	
Remarks: Approximate Latitude: 34.0437 Approximate Longitude: -84.6902 TCA indicates measured To Core Axis																		

C-08

Test Boring Record



Project: New 6-Million Gallon Clearwell - Wyckoff WTP				Project No: 181244.20	
Location: Acworth, Georgia				Date: 1/30/19	
Method: HSA- ASTM D1586		GWT at Drilling: 33 feet		G.S. Elev:	
Driller: GD (Auto Hammer)		GWT at 24 hrs: NE (Caved at 27 feet)		Logged By: EM	

Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)
				Very loose to loose tan-brown slightly micaceous silty fine to medium sand (SM) (FILL)	6	
	5			Firm tan-brown slightly micaceous silty fine to medium sand (SM) (FILL)	3	
	10				15	
	15			Loose to firm tan-brown silty fine to coarse sand (SM) (RESIDUUM)	20	
	20				13	
	25				11	
	30				9	
	35			Dense tan-gray silty fine to coarse sand (SM)	11	
	40			Partially weathered rock sampled as tan-gray silty fine to coarse sand (SM)	32	
	45				50/5"	
	46			Auger Refusal at 46 feet	50/2"	
	50					
	55					
	60					
	65					

Remarks: Approximate Latitude: 34.0437
 Approximate Longitude: -84.6900

TEST BORING RECORD TEST BORING RECORD.GPJ GEO HYDRO.GDT 3/8/19

C-09**Test Boring Record****GEOHYDRO**
ENGINEERS

Project: New 6-Million Gallon Clearwell - Wyckoff WTP					Project No: 181244.20	
Location: Acworth, Georgia					Date: 2/4/19	
Method: HSA- ASTM D1586			GWT at Drilling: 22 feet		G.S. Elev:	
Driller: GD (Auto Hammer)			GWT at 24 hrs: 29 feet		Logged By: EM	

Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)
						0 10 20 30 40 50 60 70 80 90 100
	5			Loose to firm brown slightly micaceous silty fine to medium sand (SM) with rock fragments (FILL)	6	●
		9			●	
	10	11			●	
		12			●	
	15			Loose to firm red-tan to tan slightly micaceous silty fine to coarse sand (SM) (RESIDUUM)	9	●
	20	8			●	
	25	8			●	
	30	8			●	
	35	11			●	
	40	10			●	
	45	19			●	
	50	50/5"			●	
	55	50/3"	●			
	60	50/1"	●			
	65			Boring Terminated at 60 feet		

Remarks: Approximate Latitude: 34.0437
Approximate Longitude: -84.6897

TEST BORING RECORD TEST BORING RECORD.GPJ GEO HYDRO.GDT 3/8/19

C-10

Test Boring Record



Project: New 6-Million Gallon Clearwell - Wyckoff WTP				Project No: 181244.20	
Location: Acworth, Georgia				Date: 1/31/19	
Method: HSA- ASTM D1586		GWT at Drilling: 16 feet		G.S. Elev:	
Driller: GD (Auto Hammer)		GWT at 24 hrs: N/A (Boring Backfilled)		Logged By: EM	

Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)
						0 10 20 30 40 50 60 70 80 90 100
	5			Loose to firm tan-brown slightly micaceous silty fine to medium sand (SM) (FILL)	7	●
	10				13	●
	15				10	●
	15	▽		Firm tan-gray silty clay (CL) (RESIDUUM)	8	●
	20			Loose tan-brown slightly micaceous silty fine to medium sand (SM)	6	●
	25				5	●
	25			Boring Terminated at 25 feet	8	●
	30					
	35					
	40					
	45					
	50					
	55					
	60					
	65					

Remarks: Approximate Latitude: 34.0444
 Approximate Longitude: -84.6894

TEST BORING RECORD TEST BORING RECORD.GPJ GEO HYDRO.GDT 3/8/19

C-11

Test Boring Record



Project: New 6-Million Gallon Clearwell - Wyckoff WTP						Project No: 181244.20	
Location: Acworth, Georgia						Date: 12/17/18	
Method: HSA- ASTM D1586			GWT at Drilling: 21 feet			G.S. Elev:	
Driller: GCD (Rope & Cathead)			GWT at 24 hrs: N/A (Boring Backfilled)			Logged By: EM	

Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)
						0 10 20 30 40 50 60 70 80 90 100
	5			Stiff brown micaceous fine sandy silt (ML) (FILL)	9	
	10			Very stiff red-brown slightly micaceous clayey silt (ML) (RESIDUUM)	15 19 21	
	15			Firm red-brown to gray-brown highly micaceous silty fine sand (SM)	11	
	20				17	
	25			Boring Terminated at 25 feet	19	
	30					
	35					
	40					
	45					
	50					
	55					
	60					
	65					

Remarks: Approximate Latitude: 34.0445
Approximate Longitude: -84.6892

C-12

Test Boring Record



Project: New 6-Million Gallon Clearwell - Wyckoff WTP						Project No: 181244.20	
Location: Acworth, Georgia						Date: 12/17/18	
Method: HSA- ASTM D1586				GWT at Drilling: 19 feet		G.S. Elev:	
Driller: GCD (Rope & Cathead)				GWT at 24 hrs: N/A (Boring Backfilled)		Logged By: EM	

Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)
				Stiff brown slightly micaceous fine sandy silt (ML) (FILL)	11	
	5			Firm to very firm red-brown to gray-brown micaceous silty fine sand (SM)	15	
	10				20	
	15				23	
	20				15	
	25				19	
	30				20	
	35					
	40					
	45					
	50					
	55					
	60					
	65					

Remarks: Approximate Latitude: 34.0447
Approximate Longitude: -84.6891

TEST BORING RECORD TEST BORING RECORD.GPJ GEO HYDRO.GDT 3/8/19

C-13

Test Boring Record



Project: New 6-Million Gallon Clearwell - Wyckoff WTP						Project No: 181244.20										
Location: Acworth, Georgia						Date: 12/17/18										
Method: HSA- ASTM D1586			GWT at Drilling: Not Encountered			G.S. Elev:										
Driller: GCD (Rope & Cathead)			GWT at 24 hrs: N/A (Boring Backfilled)			Logged By: EM										
Elev. (Ft)	Depth (Ft)	GWT	Symbol	Description	N Value & RQD	Standard Penetration Test (Blows/Foot)										
				Firm brown silty fine to medium sand (SM) with rock fragments (FILL)	13	0	10	20	30	40	50	60	70	80	90	100
	5			Firm to very firm red-brown to brown highly micaceous silty fine sand (SM) (RESIDUUM)	24											
	10				15											
	15				14											
	20				13											
	25			Boring Terminated at 25 feet	22											
	30				20											
	35															
	40															
	45															
	50															
	55															
	60															
	65															
Remarks: Approximate Latitude: 34.0448 Approximate Longitude: -84.6889																