

Bad Creek Revised Study Plan Appendices **Part III** Appendix I This page intentionally left blank.

APPENDIX I

SUPPLEMENTAL INFORMATION – GEOLOGY AND PROJECT FEASIBILITY

Bad Creek Pumped Storage Project FERC Project No. 2740

Oconee County, South Carolina

December 2022

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GEOLOGY AND PROJECT FEASIBILITY BAD CREEK PUMPED STORAGE PROJECT FERC PROJECT NO. 2740 TABLE OF CONTENTS

| Section | Title | Page No. |
|----------------|--|----------|
| | | |
| 1 Stu | dy Requests and Formal Comments | |
| 2 Goa | als and Objectives | |
| 3 Geo | ology and Geotechnical Studies | |
| 3.1 | Background | |
| 3.1 | .1 Regional Geology | |
| 3.1 | .2 Site Geology | |
| 3.2 | Previous Geologic Mapping | 7 |
| 3.2 | .1 Lithology | 7 |
| 3.2 | .2 Structural Geology | |
| 3.2 | .3 In-Situ Stress Measurements | |
| 3.3 | Seismicity | |
| 3.4 | Evaluation of Geologic Characteristics | |
| 3.5 | Slope Stability | |
| 3.5 | .1 Historic Landslides | |
| 3.5 | .2 Ongoing Monitoring | |
| 3.6 | Geotechnical Study | |
| 3.7 | Summary | |
| 4 Lov | wer Reservoir CFD Modeling | |
| 4.1 | Background | |
| 4.2 | Methods | |
| 4.3 | Study Results | |
| 4.4 | Summary | |
| 4.5 | Future Studies to Support Relicensing | |
| 5 Co | nclusion. | |
| 6 Ref | ferences | |
| 5 1101 | | 20 |

ATTACHMENTS

| Attachment 1 | – Geology | and Seismo | logy St | udies R | eport |
|---------------|-----------|------------|---------|---------|-------|
| Attachinent I | - Ocology | and Seismo | iogy Si | uuius R | epon |

- Attachment 2 Geotechnical Studies Report
- Attachment 3 Lower Reservoir CFD Flow Modeling Report

TABLE OF CONTENTS

CONTINUED

Section

Title

TABLES

| Table 3-1. Summary of Geologic Characteristics | 16 |
|--|----|
| Table 3-2. Active Instrumentation at the Project | 20 |
| Table 3-3. Boring Summary | 21 |

FIGURES

| Figure 3-1. Tectonic Map of the Southern and Central Appalachians and Location of the Bad |
|--|
| Creek Pumped Storage Project (from Hatcher et al. 2007) (Td = Toxaway Gneiss) |
| Figure 3-2. Geologic Map of Bad Creek Pumped Storage Project and Proposed Project |
| Figure 3-3. Cross-section of Existing Bad Creek Underground from the Upper Intake to the |
| Discharge/Intake Structure on Lake Jocassee showing Location of Shear Zones A, B, C, and D10 |
| Figure 3-4. Southeastern U.S. Seismicity (1774 to 1987), Physiographic Provinces and Seismic |
| Zones |
| Figure 3-5. Central and Eastern United States Seismotectonic Zones and Location of the Bad |
| Creek Pumped Storage Project |
| Figure 3-6. Seismic Hazard and Historic Earthquake Centers near the Bad Creek Pumped |
| Storage Project |
| Figure 3-7. Hazard Curve and Uniform Hazard Response Spectrum (2475-year return period; 5% |
| Damping) for a) $V_{s30} = 760$ m/sec and b) $V_{s30} = 2000$ m/sec |
| Figure 3-8. Bad Creek II Power Complex – Proposed Alignment – Projection of Shear Zones 18 |

ACRONYMS AND ABBREVIATIONS

| Bad Creek II ComplexBad Creek II Power ComplexCFDComputational Fluid DynamicscmcentimeterCVSZCentral Virginia Seismic ZoneDuke Energy or LicenseeDuke Energy Carolinas, LLCETSZEast Tennessee Seismic ZoneFERC or CommissionFederal Energy Regulatory Commissionftfeet/footkmkilometersI/O structureinlet/outlet structureKT ProjectKeowee-Toxaway Hydroelectric ProjectMamillion years agoMASWmultichannel analysis of surface wavesmslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | Bad Creek or Project | Bad Creek Pumped Storage Project |
|---|-------------------------|---|
| CFDComputational Fluid DynamicscmcentimeterCVSZCentral Virginia Seismic ZoneDuke Energy or LicenseeDuke Energy Carolinas, LLCETSZEast Tennessee Seismic ZoneFERC or CommissionFederal Energy Regulatory Commissionftfeet/footkmkilometersI/O structureinlet/outlet structureKT ProjectKeowee-Toxaway Hydroelectric ProjectMamillion years agoMASWmultichannel analysis of surface wavesmslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | Bad Creek II Complex | Bad Creek II Power Complex |
| cmcentimeterCVSZCentral Virginia Seismic ZoneDuke Energy or LicenseeDuke Energy Carolinas, LLCETSZEast Tennessee Seismic ZoneFERC or CommissionFederal Energy Regulatory Commissionftfeet/footkmkilometersI/O structureinlet/outlet structureKT ProjectKeowee-Toxaway Hydroelectric ProjectMamillion years agoMASWmultichannel analysis of surface wavesmslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | CFD | Computational Fluid Dynamics |
| CVSZCentral Virginia Seismic ZoneDuke Energy or LicenseeDuke Energy Carolinas, LLCETSZEast Tennessee Seismic ZoneFERC or CommissionFederal Energy Regulatory Commissionftfeet/footkmkilometersI/O structureinlet/outlet structureKT ProjectKeowee-Toxaway Hydroelectric ProjectMamultichannel analysis of surface wavesmslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | cm | centimeter |
| Duke Energy or LicenseeDuke Energy Carolinas, LLCETSZEast Tennessee Seismic ZoneFERC or CommissionFederal Energy Regulatory Commissionftfeet/footkmkilometersI/O structureinlet/outlet structureKT ProjectKeowee-Toxaway Hydroelectric ProjectMamillion years agoMASWmultichannel analysis of surface wavesmslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | CVSZ | Central Virginia Seismic Zone |
| ETSZEast Tennessee Seismic ZoneFERC or CommissionFederal Energy Regulatory Commissionftfeet/footkmkilometersI/O structureinlet/outlet structureKT ProjectKeowee-Toxaway Hydroelectric ProjectMamillion years agoMASWmultichannel analysis of surface wavesmslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | Duke Energy or Licensee | Duke Energy Carolinas, LLC |
| FERC or CommissionFederal Energy Regulatory Commissionftfeet/footkmkilometersI/O structureinlet/outlet structureKT ProjectKeowee-Toxaway Hydroelectric ProjectMamillion years agoMASWmultichannel analysis of surface wavesmslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | ETSZ | East Tennessee Seismic Zone |
| ftfeet/footkmkilometersI/O structureinlet/outlet structureKT ProjectKeowee-Toxaway Hydroelectric ProjectMamillion years agoMASWmultichannel analysis of surface wavesmslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | FERC or Commission | Federal Energy Regulatory Commission |
| kmkilometersI/O structureinlet/outlet structureKT ProjectKeowee-Toxaway Hydroelectric ProjectMamillion years agoMASWmultichannel analysis of surface wavesmslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPScoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | ft | feet/foot |
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| KT ProjectKeowee-Toxaway Hydroelectric ProjectMamillion years agoMASWmultichannel analysis of surface wavesmslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | I/O structure | inlet/outlet structure |
| Mamillion years agoMASWmultichannel analysis of surface wavesmslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | KT Project | Keowee-Toxaway Hydroelectric Project |
| MASWmultichannel analysis of surface wavesmslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | Ma | million years ago |
| mslmean sea levelNEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | MASW | multichannel analysis of surface waves |
| NEPANational Environmental Policy ActPM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | msl | mean sea level |
| PM&EProtection, Mitigation, and EnhancementPADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | NEPA | National Environmental Policy Act |
| PADPre-application DocumentPSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | PM&E | Protection, Mitigation, and Enhancement |
| PSPProposed Study PlanRSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | PAD | Pre-application Document |
| RSPRevised Study PlanSD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | PSP | Proposed Study Plan |
| SD2Scoping Document 2TGnToxaway GneissTFFTallulah Falls Formation | RSP | Revised Study Plan |
| TGnToxaway GneissTFFTallulah Falls Formation | SD2 | Scoping Document 2 |
| TFF Tallulah Falls Formation | TGn | Toxaway Gneiss |
| | TFF | Tallulah Falls Formation |

1 Study Requests and Formal Comments

The Federal Energy Regulatory Commission's (FERC or the Commission) August 5, 2022 Scoping Document 2 (SD2) identified the following environmental resource issues to be analyzed in the National Environmental Policy Act (NEPA) document for the Bad Creek Pumped Storage Project (Project) relicensing related to geology and soil resources. These resource issues address the effects of continued Project operations under the Existing License as well as potential construction and operation of a second powerhouse during the New License term for the Bad Creek II Power Complex (Bad Creek II Bad Creek II Complex]):

- Effects of seismic activity in the Project area on construction of the Bad Creek II Complex, and vice versa.
- Effects of (expanded) Project operation on shoreline erosion along the lower reservoir (*will be analyzed for both cumulative and site-specific effects*)
- Effects of (expanded) Project construction on slope instability in the Project area.
- Effects of (expanded) Project construction and spoil disposal on soil erosion and sedimentation.

As stated in Section 1.3 of the Pre-application Document (PAD) (Duke Energy 2022) and reiterated in the Proposed Study Plan (PSP) submitted to the FERC on August 5, 2022, a full engineering feasibility study in support of the proposed Bad Creek II Complex was completed in Summer 2022, and some follow-on activities will continue into 2023. Relevant components of the feasibility study report are summarized herein to address specific environmental resource issues identified the Commission's Scoping Documents. Three individual volumes of the Bad Creek II Power Complex Feasibility Study (submitted to Duke Energy under Confidential Client Privilege on September 1, 2022; HDR 2022) along with select relevant appendices are included as Attachment 1 (Geology and Seismology Studies Report), Attachment 2 (Geotechnical Studies Report) and Attachment 3 (Lower Reservoir Computational Fluid Dynamics [CFD] Flow Modeling Report).

No formal study requests related to geology and soil resources were received during the scoping process and as stated in the PAD and PSP, Duke Energy does not propose to conduct a separate relicensing study focused on geology and soils. Stakeholder and FERC comments relevant to geology and soils were considered in the development of the PSP and this Revised Study Plan (RSP). All comments on the PAD and Scoping Document 1 relevant to geology and soils were included in Appendix A of the PSP and are included in this RSP in the formal correspondence documentation provided in Appendix B.

2 Goals and Objectives

While there are no anticipated additional adverse effects to geology and soils resources due to the continued operation of the Project, potential adverse effects resulting from the construction and operation of the Bad Creek II Complex should be evaluated. The goal of the Geology and Feasibility report is to summarize key methods and results from the feasibility study related to geology and seismology of the Project area as well as findings from the lower reservoir CFD modeling effort, which provides relevant information on shoreline erosion in Whitewater River cove. The full reports and select report appendices are included in Attachments 1, 2, and 3. The information in the following sections addresses the first three resource issues identified by FERC in SD2 listed above. The fourth item in the list of resource issues (i.e., effects of Project construction and spoil disposal on soil erosion and sedimentation) will be addressed through the Water Resources Study carried out for the relicensing as well as during environmental permitting efforts related to construction and spoil disposal.

3 Geology and Geotechnical Studies

Extensive geologic and geotechnical field and laboratory investigations were carried out to support the feasibility design of the Bad Creek II Complex. As part of the overall feasibility study effort, HDR performed a geological/geotechnical field investigation with the following objectives:

- To provide a well-structured study plan, utilizing the geologic mapping data and special geologic studies during the construction of the existing Project, additional geologic assessments conducted to date, topographic data, and preliminary layout studies to function as a bridge between the site feasibility study and potential future site studies.
- 2. To assess, to the extent possible, site geological/geotechnical conditions in support of site layouts, conceptual designs, basic construction methods, and construction materials. Results of the geological/geotechnical studies will be used to develop recommendations regarding project structures, locations, and layout; provide input for Project cost opinions and schedule; and plan future geological/geotechnical investigations for the Project.

The study involved 1) a review of existing geological information from the investigations for and during construction of the Bad Creek Project and 2) incorporation of geotechnical and geophysical data from HDR's geotechnical exploration program, which included geophysical field testing and drilling five exploration boreholes. The study included a field review of rock core from the five boreholes drilled for the feasibility study, review of seismic refraction and multichannel analysis of surface waves (MASW)

lines and other geophysical data (downhole geophysical measurements), review of geotechnical testing data, and a field reconnaissance to assess geologic features and site conditions as related to the construction and operation of the proposed Bad Creek II Complex. Results from the geology and geotechnical studies are summarized in the sections that follow and details are provided in Attachment 1 (Geology and Seismology Studies Report) and Attachment 2 (Geotechnical Studies Report), along with site and regional geology, lithology, structural geology and shear zones, in-situ stress measurements, and regional and local seismology.

Geologic characteristics that could impact the proposed Project are identified and further evaluation of these characteristics will be performed during the next study phase if the Bad Creek II Complex is pursued.

3.1 Background

3.1.1 Regional Geology

The Project is located in the Blue Ridge physiographic province, a mountainous zone that extends northeast-southwest from southern Pennsylvania to central Alabama, varying in width from less than 15 miles to 70 miles maximum. It is characterized by rugged terrain with valleys ranging in elevation from 1,000 feet (ft) in the south to greater than 1,500 ft in the north. In North Carolina, massive and resistant gneissic and metasedimentary rocks underlie most of the province, with the valleys tending to follow weaker-rock outcrops (e.g., schist or minor carbonate rocks) and fractures or fault/shear zones. The underlying geologic structure has a strong influence on local topography.

The crystalline rocks of the southern Appalachians occur in northeast-trending parallel geologic terranes. The Bad Creek Project is within the Tugaloo terrane, which includes rocks of the eastern Blue Ridge northwest of the Brevard zone (Figure 3-1; Hatcher et al. 2007; Hatcher 2002). The Blue Ridge is a complex crystalline terrane consisting of Precambrian gneissic basement rocks structurally overlain by a vast thickness of metasedimentary and metavolcanic rocks of Precambrian to lower Paleozoic age (Hatcher 1978a, 1978b). The structure of the Blue Ridge is controlled by major thrust faults, associated complex polyphase folding, and subsequent brittle faulting (Hatcher 1978a; Clendenin and Garihan 2007a, 2007b). The principal rock unit of the western Tugaloo terrane (eastern Blue Ridge belt) is the Tallulah Falls Formation (TFF). The TFF generally consists of biotite gneiss (metagraywacke), pelitic

schist, mafic volcanic rocks, and quartzite; in places the rocks of the TFF are migmatitic¹. These rocks are intruded by Paleozoic granitoid rocks and overlie 1,150 to 1,200 million years ago (Ma) Precambrian Grenville basement rocks in the Toxaway Dome. Dominant metamorphic fabric and peak metamorphism in the eastern Blue Ridge is circa 450 Ma, based on metamorphic ages of detrital monazite and zircon grains from TFF rocks (Miller et al. 1997, 2000; Moecher et al. 2011; Cattanach et al. 2012).

The Toxaway Gneiss (TGn), part of the Precambrian Grenville basement of the eastern Blue Ridge, is exposed in the core of the Toxaway Dome. It is typically a medium- to coarse-grained banded biotite-plagioclase-microcline-quartz gneiss with some massive and augen varieties, which do not appear to be significantly different in chemical/mineralogical composition (Schaeffer 1987, 2016; Merschat et al. 2003). The TGn has an Rb/Sr whole-rock isochron age of 1203+54 Ma (Fullagar et al. 1979). A derived zircon age for the TGn is 1,150 Ma (Carrigan et al. 2003 in Hatcher et al. 2007). More detail is included in the complete Geology and Seismology Studies Report in Attachment 1.

3.1.2 Site Geology

The Project is located immediately northwest of the Brevard zone in the Tugaloo terrane within the Toxaway Dome (Figure 3-1) and most of the site is underlain by TGn (see Figure 9 in Attachment 1). All tunnels, shafts, and the powerhouse cavern for the existing Project were excavated in TGn and based on geologic information available, the underground structures for the proposed Bad Creek II will be excavated in the same rock (Figure 3-2). The Main Dam and East Dike are founded on TGn; the West Dam and a portion of the reservoir are underlain by a sequence of schistose rocks belonging to the TFF. The TFF rocks are predominantly the garnet-aluminous schist member; however, in places portions of the upper graywacke-schist member is present. This belt of TFF rocks is isolated from similar rocks on northwest and southeast of the Toxaway Dome by the refolding of earlier folds (Hatcher 1978a; Schaeffer 1987, 2016).

Layers of biotite-hornblende schist (sills or dikes, possibly feeders for the mafic volcanic rocks of the TFF) are present with thicknesses up to 20 ft. Their orientation is parallel to the dominant foliation/banding in the TGn. At least two generations of quartz-feldspar-mica pegmatites occur within the TGn. They are distinguished by the fact that the later generation is undeformed except by fracturing, whereas the earlier generation is folded. Most of the early pegmatites parallel the dominant foliation, the

¹ Migmatite – Rock consisting of alternating layers or lenses of granitic material in gneisses and schists; related to partial melting of the rock during deformation and metamorphism and then re-crystallization of the melt during the waning stages of metamorphism.

later generation cuts across foliation. Small cross-cutting quartz veins are also present. For more details on the TFF in the site vicinity, see Attachment 1.



Figure 3-1. Tectonic Map of the Southern and Central Appalachians and Location of the Bad Creek Pumped Storage Project (from Hatcher et al. 2007) (Td = Toxaway Gneiss)



Figure 3-2. Geologic Map of Bad Creek Pumped Storage Project and Proposed Project

3.2 Previous Geologic Mapping

During the original design studies for the Project (pre-1985), the subsurface exploration program had the following primary objectives related to the underground excavations and structures: 1) examine the rock characteristics and geologic structure of the proposed powerhouse location, 2) determine the most feasible powerhouse orientation and location with respect to the geologic structure and in-situ stresses, 3) provide the data and experience necessary to facilitate an efficient design of the underground portions of the project, and 4) serve as a model for the instrumentation and monitoring to be incorporated into the permanent underground structures.

Along with a pilot tunnel excavation and testing from October 1976 through September 1977, the geologic program conducted during construction of the Project (from 1985 to 1991) provided geologic information for construction and design. Components of the original geologic study included observation, measurement, sampling, photographs, mapping, and evaluation of the exposed rock and foundation surfaces. The geologic conditions encountered in the underground works were documented by geologic mapping of at least one rib of all tunnels; the walls of the two vertical shafts; and the walls, crown, and floor of the powerhouse cavern at a scale of 1 inch = 6.56 ft. The aboveground structures including dam foundations, intake excavation, and discharge excavation were mapped at a scale of 1 inch = 20 ft. The upper reservoir area was mapped at a scale of 1 inch = 200 ft after all excavation and borrow work was completed. The mapping was the primary input into construction and design considerations as work progressed and was supplemented by additional studies as needed. The geologic work during construction, including additional studies beyond the geologic mapping (for documentation), are described and discussed in Duke Power Company (1991) and Schaeffer (2016 [included as Attachment 1, Appendix B]). Note that an alternate interpretation of the geology along Lake Jocassee at the inlet/outlet (I/O) structure area is presented by Clendenin and Garihan (2007a); details are included in the full report in Attachment 1.

3.2.1 Lithology

Detailed geologic mapping of the Bad Creek Project underground excavations resulted in a detailed subdivision of rock types within the TGn. The following units were recognized and mapped during the original construction:

- Granitic Gneiss, medium light gray to light gray, medium- to coarse-grained gneiss consisting of alternating layers of light-colored quartz-feldspar bands and darker biotite-quartz-feldspar bands, well-foliated;
- Banded Augen Granitic Gneiss, medium light gray to light gray, medium- to coarse-grained gneiss consisting of a foliated (banded) quartz-feldspar-biotite gneiss containing feldspar augen up to 1 centimeter (cm) long;

- Augen Granitic Gneiss, medium light gray, coarse-grained gneiss consisting of a coherent, massive, poorly foliated feldspar-quartz-biotite gneiss with feldspar and locally hornblende augen up to 3 cm long;
- Biotite Schist, medium dark gray to dark gray, coarse-grained biotite-hornblende schist;
- Biotite Gneiss, medium dark gray to dark gray, medium- to coarse-grained biotite-hornblende gneiss;
- Biotite Augen Gneiss, medium gray to medium dark gray, medium- to coarse-grained, foliated biotite-feldspar-quartz gneiss with feldspar augen up to 1 cm long, biotite content generally greater than 30 percent;
- Quartz-Feldspar Gneiss, very light gray to white, very coarse-grained, distinctly foliated quartz-feldspar gneiss with minor biotite (less than 10 percent);
- Very Coarse-Grained Granitic Gneiss, light gray, very coarse-grained, distinctly foliated quartzfeldspar-biotite gneiss, biotite content greater than 10 percent;
- Weathered Sheared Rock, moderate to moderately severe weathering, light gray to yellowish gray to greenish gray, original rock type granitic or augen granitic gneiss; and
- Hard Sheared Rock, medium light gray to light gray, medium- to coarse-grained rock, original rock type granitic or augen granitic gneiss.

3.2.2 Structural Geology

The foliation in the TGn and TFF rocks is defined by the parallel orientation of platy minerals and by compositional layering. The average orientation of foliation in the Bad Creek reservoir area is N37E; 38SE and varies from N35-50E; 28-41SE in the underground works. Minor folds are present; some lie within foliation whereas others fold the dominant foliation. The earliest set of folds are isolated "z-", "s-", and crescent-shaped fragments, which are axial planar to the dominant foliation. The presence of these isolated fold fragments indicates that transposition of an older foliation has occurred. The second set of folds are isoclinal to open with variable development of a secondary foliation. In areas where this folding is isoclinal, an axial planar foliation (defined by secondary biotite) is present. Later open folding was recognized in several tunnels of the existing Project.

Shear zones with thicknesses up to 200 ft occur throughout the TGn and generally parallel the dominant foliation. Four major shear zones are present in the reservoir and dam areas (Shear Zones C, D, E, and F on Figure 3-2) and two additional major shear zones (Shear Zones A and B on Figure 3-2) were mapped in the underground tunnels (Figure 3-3; projections to the ground surface are shown on Figure 3-2).

Shear Zone A is in the vertical access shaft and in the excavation along Lake Jocassee for the I/O structure. Shear Zone B is present in the vertical access shaft, the main access, Tailrace 1 and 2, and Tailrace 3 and 4 tunnels. Shear Zone C is present in the main access, penstock bypass, tailrace bypass, draft tube gate, Tailrace 1 and 2, and Tailrace 3 and 4 tunnels and the vertical access shaft. Shear Zone D is present in the manifold, Penstock 1, Penstock 2, Penstock 3, and Draft Tube 1 tunnels and in the west, north, and east wall and along the floor of the powerhouse cavern. The zones consist of hard sheared rock with layers of weathered sheared rock present. The zones are mineralized with chlorite, epidote, calcite,

and quartz in various combinations. Along some of the shear planes, breccia is present with thicknesses of less than 1 inch to approximately 12 inches. The breccia consists of granitic gneiss, coarse quartz/feldspar (pegmatites), and vein quartz fragments in a matrix of fine-grained chlorite and epidote. Several of the shear zones have associated weathered zones up to 12 inches thick. Within the weathered zone there is up to 2 inches of gouge-breccia composed of granitic gneiss, coarse quartz/feldspar, and vein quartz fragments in a clay matrix. The hard sheared rock exhibits tight, complex isoclinal folding with sheared out limbs and a secondary axial planar foliation defined by biotite.

Fault and fault zones in the underground portion of the Project are present and are generally associated with the northeast-striking joint sets. Single fault planes with few associated fractures have offsets up to 6 inches (vertical separation). The fault zones have complex fracturing with several planes and offsets ranging from less than 1 inch to greater than 12 ft. Breccias up to 6 inches thick are developed along some of the fault planes and consist of rock, quartz/feldspar, and vein quartz fragments in a fine-grained matrix of chlorite-epidote. In some fault zones the rock is shattered between fault planes with chlorite-quartz mineralization throughout the fracture zone. The brecciation and mineralization of the fault zones occurred at the same time as the brecciation along the shear zones. The faults and shear zones are similar to others within the southern Appalachians that have been healed under greenschist metamorphic conditions, suggesting the last movement occurred at least 300 Ma (Gilbert et al. 1982).

All site structural data from mapping in areas of the west dam, main dam, reservoir area, and underground areas are included in Attachment 1.



Source: Talwani et al. 1999

Figure 3-3. Cross-section of Existing Bad Creek Underground from the Upper Intake to the Discharge/Intake Structure on Lake Jocassee showing Location of Shear Zones A, B, C, and D

3.2.3 In-Situ Stress Measurements

Two methods of in-situ stress measurement were employed for the design of the existing Bad Creek Project tunnels, caverns, and shafts: hydrofracturing and overcoring. Hydrofracturing tests were performed in a deep borehole (B-52) from the ground surface and the overcoring technique was employed in the proposed powerhouse location in the pilot tunnel. Overcoring stress values were among the input parameters for finite element modeling performed for the design of the existing Bad Creek Project powerhouse and tunnels. Results of the finite element modeling analysis were used to determine the shape of the powerhouse and tunnels; other factors such as geologic structure, support methods, and other functional requirements played a major role. The most useful information from the finite element modeling results was an estimate of the how much rock movement should be expected during and after powerhouse excavation. These estimates became the basis for evaluating the data from installed instruments during and after construction of the existing powerhouse.

3.3 Seismicity

The East Tennessee Seismic Zone (ETSZ), closest to the Bad Creek Project, is one of the most active seismic zones in eastern North America (Bollinger et al. 1985) and is located primarily in the Valley and Ridge physiographic province of Tennessee with a portion in the Valley and Ridge and Blue Ridge physiographic province of western North Carolina (Figure 3-4). The zone is approximately 300 kilometers (km) long and 50 km wide and has not produced a damaging earthquake in historical time (Powell et al. 1994). The earthquakes occur at depths of to 5 to 25 km within Precambrian crystalline basement rocks beneath the thrust sheets of Paleozoic sedimentary rocks of the Valley and Ridge (Bollinger et al. 1976; Bollinger et al. 1991). The structures likely responsible for the seismicity in the

zone are reactivated Precambrian to Cambrian normal faults formed during the rifting (extension) that formed the Iapetus Ocean and are located beneath the later accreted Appalachian thrust sheets (like the Giles County Seismic Zone in Virginia; Wheeler 1995). In the recent EPRI (2012) Central and Eastern United States seismic source characterization, the site is in the Paleozoic extended crust zone (Figure 3-5) as described in the previous two sentences. Despite its relatively high rate of activity, the largest known earthquake in the ETSZ is $M_w 4.7^2$ (1973 Alcoa-Marysville earthquake; Bollinger et al. 1991).



Note: BCPSP = Bad Creek Pumped Storage Project; A = Valley and Ridge and Blue Ridge; B = Piedmont; C= Coastal Plain. GCSZ = Giles County Seismic Zone (not discussed in text); ETSZ = East Tennessee Seismic Zone; CVSZ = Central Virginia Seismic Zone; CSZ = Charleston Seismic Zone (not discussed in text); NMSZ = New Madrid Seismic Zone (not discussed in text). Figure modified from Bollinger et al. 1991).

Figure 3-4. Southeastern U.S. Seismicity (1774 to 1987), Physiographic Provinces and Seismic Zones

² M_w = Moment Magnitude.



Source: EPRI 2012

Figure 3-5. Central and Eastern United States Seismotectonic Zones and Location of the Bad Creek Pumped Storage Project

Recent work between Vonore and Maryville, Tennessee, centered on the Tellico Reservoir and the Little Tennessee River, has yielded evidence of paleoseismic features within a narrow northeast-trending zone (Hatcher et al. 2015; Glasbrenner et al. 2015; Warrell et al. 2017). The evidence includes faulted Quaternary river sediments and folded terrace deposits with faults that have offsets of up to 2 meters that involve bedrock (Hatcher et al. 2015; Warrell et al. 2017). Warrell et al. (2017) dated features within the zone and determined that at least three large earthquakes occurred in the ETSZ during the late Pleistocene (1.0 (?) to 0.012 Ma) with at least one or more exceeding $M_w 6$.

The Central Virginia Earthquake of September 1, 2011 (M_w 5.7 - 5.8) was the largest and most damaging in the central and eastern United States since the 1886 Charleston, South Carolina earthquake (estimated M_w 6.8 - 7.0). The earthquake occurred on a north or northeast-striking plane with reverse faulting within a previously recognized seismic zone, the "Central Virginia Seismic Zone." The Central Virginia Seismic Zone (CVSZ) has produced small and moderate earthquakes since at least the 18th century. The previous largest historical shock from the Central Virginia Seismic Zone occurred in 1875. The CVSZ is in the Appalachian Piedmont Province between Richmond and Charlottesville, Virginia. The zone has an elliptical area, with a north-south dimension of 100 km and an east-west dimension of 120 km, as defined by historical earthquake activity (Bollinger and Sibol 1985; Coruh et al. 1988). The depth of the earthquakes ranges from near surface to 12 km, placing them above the Appalachian detachment (Chapman 2015) in contrast to the ETSZ where earthquakes occur below the detachment.

On August 9, 2020, a 5.1 M_w magnitude earthquake occurred on August 9, 2020, with an epicenter approximately 2.5 miles southeast of Sparta, just south of the Virginia-North Carolina border (Figure 3-4). The earthquake caused damage to over 500 buildings and other infrastructure (Hill 2020; Figueiredo et al. 2022). Surface ruptures were attributed to a south-southwest-dipping reverse fault (Little River Fault) and were traced for ~2.5 km along the northwest trend (Hill 2020; Figueiredo et al. 2022). The Little River Fault produced a maximum vertical displacement of 25.2 cm, with similar vertical displacements along much of the fault trace (Hill 2020; Figueiredo et al. 2022). The hanging wall was to the south (northeast side up; reverse fault as shown by the initial USGS focal mechanisms [USGS 2020a]). There is no recorded historical seismicity in and around Sparta, but Hill (2020) speculated that the Little River Fault may be associated with the Giles County Seismic Zone, which is centered in Virginia approximately 100 km to the north. The depth of the main shock, 4.1 km (USGS 2020b), suggests that it occurred above the master decollement (depths of 5 to 12 km) and is not related to the Giles County Seismic Zone or ETSZ where the earthquakes typically occur below the decollement in the Paleozoic extended crust. The estimated magnitude of the Skyland 1916 earthquake is M_w 5.1 (Figure 3-5) similar to the magnitude of the Sparta 2020 earthquake.

Prior to filling Lake Keowee in 1968, none of the historical seismic activity occurred in the vicinity of the Bad Creek Project. Because seismic activity appeared to have increased after impoundment of the Keowee Hydro Project (as evidenced by a swarm of seismic events associated with Lake Keowee in 1978 and other recorded events), the potential of reservoir-induced seismicity was studied by Duke Power Company (Schaeffer 1991). Both Lake Keowee and then later Lake Jocassee were associated with reservoir-induced seismicity (sometimes referred to as reservoir-triggered seismicity). Most of the events have been small, with the largest having a Local Magnitude of 3.8. Activity at Lake Jocassee has decreased significantly since first filling in 1976 while activity at Keowee has also decreased (Schaeffer

2000). During the study of the reservoir-induced seismicity, seismic activity was closely recorded by the stations of the seismic network operated by Duke Power Company and that of the South Carolina Seismic Network. Only a minor increase in seismicity was reportedly related to initial filling of the Bad Creek upper reservoir – from about 5 events per month to about 10 per month. However, no correlation could be made with the observed increase with Bad Creek reservoir filling and operation of the plant (up to 160 ft of potential change in the reservoir level). Of the minor earthquakes in the area, none were located under or very near to the Bad Creek reservoir. Seismic activity clearly related to Lakes Keowee and Jocassee decreased to near background levels by 2000 (Schaeffer 2000). The cluster of earthquakes on Figure 3-6 near the site are primarily related to the induced seismicity at Lakes Jocassee and Keowee.

Earthquakes with $M_w \ge 3$ and contours of Peak Ground Acceleration (PGA) for V_{s30}^3 equals 760 m/sec with 2 percent probability of exceedance in 50 years (2475-year return period) from the 2018 National Seismic Hazard Maps developed by the U.S. Geological Survey (USGS 2018) are shown on Figure 3-6. The PGA at the Bad Creek Project site is 0.24g for V_{s30} of 760 m/sec (Site Class B/C⁴ Boundary) and 0.21g for V_{s30} of 2000 m/sec (Site Class A⁴) as shown in Figure 3-7 as are the hazard curves for spectral acceleration at selected periods and a Uniform Hazard Spectrum (UHS at 5% Damping) for both values of V_{s30} (USGS 2014b).

 $^{^3}$ $V_{\rm s30}$ is the shear wave velocity of the upper 30 meters of earth materials.

⁴ Site Class A = Hard Rock (V_s > 1524 m/sec); Class B = Rock (762 m/sec < V_s \leq 1524 m/sec); Class C = Very Dense Soil and Soft Rock (366 m/sec < V_s \leq 762 m/sec).



Figure 3-6. Seismic Hazard and Historic Earthquake Centers near the Bad Creek Pumped Storage Project



Note: This figure is not intended to be used for design or any type of analyses. Source: USGS 2014a

Figure 3-7. Hazard Curve and Uniform Hazard Response Spectrum (2475-year return period; 5% Damping) for a) V_{s30} = 760 m/sec and b) V_{s30} = 2000 m/sec

3.4 Evaluation of Geologic Characteristics

The geologic characteristics of the bedrock in which the underground structures are to be excavated and constructed for Bad Creek II are summarized in Table 1. This information is based on the geological and geotechnical studies performed for the design of and geologic mapping and studies performed during construction of the existing Bad Creek Project underground structure.

| Geologic Characteristic | Relation to Project Area | | | |
|-----------------------------------|--|--|--|--|
| High seismic risk/active faulting | The Project area is considered to have low to moderate seismic risk. No known | | | |
| within the project area | Quaternary/active faults in the site vicinity (USGS 2014a, 2014b, 2018). | | | |
| | There is an old landslide at the intake/discharge of the Bad Creek Project on | | | |
| | Lake Jocassee (see Appendix B in Attachment 1; Schaeffer 2016). The slide | | | |
| Active landslides in project area | material was removed during construction of the existing plant and a retaining | | | |
| Active fandshides in project area | wall was installed on the slope that stabilized part of the original landslide | | | |
| | above the retaining wall and below the present control room//switchyard | | | |
| | complex. Figure 3-2 and Figure 3-8 show the extent of a landslide/rockslide at | | | |

 Table 3-1. Summary of Geologic Characteristics



| Geologic Characteristic | Relation to Project Area | | | | |
|------------------------------------|--|--|--|--|--|
| | the proposed Bad Creek II I/O structure on Lake Jocassee. The | | | | |
| | landslides/rockslides at the proposed Lower Reservoir I/O works will be an | | | | |
| | issue during excavation in this area to construct the works. The landslide may | | | | |
| | possibly be in the crown of the tailrace tunnels as it approaches the I/O works | | | | |
| | and may be present around the main access tunnel portal (Figure 3-2 and Figure | | | | |
| | 3-8; see Attachment 1) | | | | |
| | Total soil thickness and the depth of overburden (soil/saprolite) and weathered | | | | |
| | bedrock at the Upper Reservoir I/O works, low pressure headrace gates area, | | | | |
| | and vertical headrace shafts area varies from 10 ft to greater than 90 ft. At the | | | | |
| Deep weathering profile | Lower Reservoir I/O on Lake Jocassee, the overburden is primarily landslide | | | | |
| | deposits that are up to 100+ ft thick based on the interpretation of the one | | | | |
| | borehole (B-21-4) in the area and the seismic refraction and MASW lines (see | | | | |
| | Attachment 1.) The landslide deposits are not deeply weathered. | | | | |
| | Most of the water encountered in the Bad Creek Project underground | | | | |
| | excavations, past the initial ~200 ft of the main access and tailrace tunnels from | | | | |
| Highly permeable rock | their portals on Lake Jocassee, were associated with specific geologic features - | | | | |
| | the foliation parallel shear zones and some of the high-angle fault zones (Figure | | | | |
| | 3-2 and Figure 3-8; Schaeffer 1987, 2016; Duke Power Company 1991). | | | | |
| Soluble rock material | Not present in the TGn. | | | | |
| Low strength, vibration-sensitive, | Weathered rock associated with shear zones and biotite schist and biotite- | | | | |
| friable, highly abrasive, slaking, | hornblande schist will have lower shear strengths than the unweathered TGn | | | | |
| or unlithified rock material | normolende schist will nave lower snear strengths than the unweathered TGN. | | | | |
| | Most of the faults/fractures in the TGn have secondary mineralization and are | | | | |
| Highly faulted, folded, or | not highly fractured/faulted. The shear zones mapped in the reservoir and in the | | | | |
| fractured rock material | existing Bad Creek Project underground structures have weathered sheared rock | | | | |
| | and later brittle faulting associated with them. | | | | |
| Thinly laminated, structurally | Phyllonitic material present along some of the foliation-parallel shear zones in | | | | |
| deformed, fine-grained rock | the underground excavations and thin, foliation parallel biotite-hornblende | | | | |
| masses | schist layers. | | | | |
| | High in-situ stresses that can result in rock burst and stress-related issues in the | | | | |
| | larger underground opening including the powerhouse, voltage bus/excitation | | | | |
| Rock Mass In-Situ Stress Field | galleries, draft tube gate and access gallery tunnel, draft tube gate annexes, and | | | | |
| | draft tube gate vertical shafts and at intersections of tunnels and shafts | | | | |
| | (Schaeffer 2016; Attachment 1, Appendix B). | | | | |



Figure 3-8. Bad Creek II Power Complex – Proposed Alignment – Projection of Shear Zones

3.5 Slope Stability

There is minor active slope movement in the Project area and evidence of previous mass wasting events, as described below. These areas are routinely monitored (monthly) and the Project vicinity is considered to have low to moderate seismic risk (there are no known Quaternary/active faults in the site vicinity), therefore, no further Protection, Mitigation, and Enhancement (PM&E) measures are proposed for the existing Project. Slope monitoring at the upper and lower tie-back walls, tunnel portal slope, west abutment, and reservoir rim are monitored routinely as described in Dam Safety Surveillance and Monitoring Plan (in compliance with FERC's *Engineering Guidelines for the Evaluation of Hydropower Projects*); monitoring will continue during the New License term.

3.5.1 Historic Landslides

In 1980, a geologic survey of the alignment of the main access road was performed to identify geologic features that could influence the stability of cuts and fills. Potential stability problems related to rock cuts and the presence of old landslides consisting of colluvial materials (boulders in a finer-grained matrix) were identified during the survey. The results of this study are summarized in this section and details are included in Schaeffer (2016) (Attachment 1, Appendix B).

Four old landslides were identified on the last mile of the access road (see Figures 32 and 33 in Attachment 1, Appendix B). The depth to sound rock under Slides 1 and 2 was shallow enough to allow excavation of all the colluvium under the access road (within 1 meter of grade). Cuts above the road in these slide areas were laid back at 3:1. The depth of the colluvial material in Slide 3 was up to 8 meters below road grade. Because of stability concerns, all of the colluvial material down to sound rock were removed; however, there would not be enough area from the access road to Lake Jocassee to build a structural fill with the nominal 2:1 slopes when finished, therefore, a retaining wall was constructed across the Slide 3 area. The depth of colluvial material in Slide 4 is up to 25 meters. Because of the volume of material that would have to be excavated and the height and length of the required retaining wall that would be needed across the area, an alternate approach for stabilization was considered. Seven slope indicators were installed in the slide area in 1980 (Figure 35; Attachment 1, Appendix B). Very small movements at the colluvium-sound rock contact were noted in three of the slope indicators located above the access road. The movements were less than one millimeter per month and discontinuous along the contact. Boring data indicated that the water table was generally within one meter of the contact between the colluvium and sound rock. Because access road construction in the area did not start until 1983, subhorizontal drains were installed in an attempt to drain the slide above the contact to stop the discontinuous slope movement. The drains did stop the movement of the slope (in the 3 slope indicators

that showed movement before the installation of the drains). Therefore, the access road was constructed across the colluvial material of Slide 4. No movement of the area has been noted since the completion of the access road.

There is also an area indicating a previous landslide above the I/O structure that was reactivated during the initial portal preparation at Bad Creek before Lake Jocassee was filled in 1974. In 1984, the slide progressed up the slope towards the switchyard. The area was mapped in 1986 to provide geologic input for stabilization efforts to prevent localized slides during construction and permanent plant operation. The final design for the stabilization of the area called for the removal of all older colluvium and more recent slide material from the slope, laying back the saprolite/soil area south of the east-west fault zone on 2:1 slopes, and construction of a retaining wall along the general alignment of the ditch (Figures 39 and 40, Attachment 1, Appendix B). An insert wall was constructed to stabilize the soil-saprolite below the existing wall consisting of anchor bars, anchor plates, and a toe buttress wall tied to underlying rock with grouted rock anchors.

Initial work in the main dam area (west abutment) began in the spring of 1986 and tension cracks indicative of slide movement were noted. Because of continued deterioration of the abutment slope, an exploration program was undertaken in July of the same year which included soil borings, installation of crack monitors, shear tubes, and inclinometers, which are measured monthly under the current monitoring program.

3.5.2 Ongoing Monitoring

The Project contains an extensive collection of monitoring instrumentation. Table 3-2 provides an overview of the current active instrumentation.

| Instrument Type | Main Dam* | West Dam | East Dike | Tunnels/Penstocks/ Draft tubes | Powerhouse | I/O Area |
|---------------------------|--------------|-------------|--------------|-----------------------------------|------------|-------------|
| Observation well | 15 | 1 | 2 | | | |
| Piezometers | 32 | 13 | 4 | 18 | | |
| Seepage Monitoring Points | 2 | 3 | 1 | 1 | 6 | |
| Inclinometers | 6 | | | | | 7 |
| Extensometers | | | | | 31 | |
| Surface monuments | 49 | 11 | 8 | | | |
| Strong motion instruments | 2 | | | | | |

Table 3-2. Active Instrumentation at the Project

*Includes west abutment buttress; Information based on 2016 Dam Safety Surveillance and Monitoring Plan Report

3.6 Geotechnical Study

In addition to the geologic investigation, a limited geotechnical field exploration program was carried out to support the feasibility study (HDR 2022) of the Bad Creek II Complex water conveyance I/O structures, tunnels and shafts, access tunnels and shafts, underground powerhouse, and appurtenant structures. An evaluation of boreholes and seismic line data collected at the upper and lower reservoir I/O works is provided in Attachment 1, Appendix D. The complete Geotechnical Studies Report (with select appendices) is provided in Attachment 2.

A total of five borings were drilled at the Bad Creek II site; these locations are shown on Figure 3-2. Borings B-21-1 and B-21-5 are located at the upper reservoir I/O, Boring B-21-2 is in the area of the lowpressure headrace tunnels just downstream of the low-pressure headrace gates, Boring B-21-3 is downstream of the vertical intake shaft, and Boring B-21-4 is at the lower reservoir I/O structure. The borings were drilled to obtain geotechnical data including soil properties, depth to top of weathered rock, depth to top of competent rock, lithology and rock hardness, rock recovery, and rock quality designation, depth and thickness of shear zones, and rock permeability data water pressure (i.e., packer tests). Downhole geophysical logging of the borings was performed to assess rock mass fractures, foliation/banding, and other rock mass discontinuities. The borings were drilled vertically to depths ranging from 120.3 to 500.3 ft below existing grade. Sampling methods included Standard Penetration Test sampling and HQ coring methods. Boring logs and photos are included in Attachment 2, Appendix B while soil sample laboratory testing reports are included in Attachment 2, Appendix G.

A boring summary is provided in Table 3-3.

| Boring | Total Depth (ft) | Inclination | Azimuth | Soil Depth (ft) | Number of Water Pressure Tests | Well screen depths (ft) ¹ | Acoustic and Optical Televiewer |
|--------|---------------------|-------------|---------|--------------------|--------------------------------------|---|---------------------------------------|
| B-21-1 | 250.8 | 90 | NA | 4.0 | 5 | NA | Yes |
| B-21-2 | 300.8 | 90 | NA | 4.0 | 11 | 50-70 | Yes |
| B-21-3 | 500.4 | 90 | NA | 6.4 | 7 | 70-90 | Yes |
| B-21-4 | 150.4 | 90 | NA | 29.9 | - | NA | Yes |
| B-21-5 | 120.3 | 90 | NA | 46.6 | 2 | NA | Acoustic only |

 Table 3-3. Boring Summary

¹ Well screens are 2-inch diameter PVC

In addition to drilling and testing, surface geophysics including seismic refraction and MASW line surveys were completed by GEL Solutions. Geophysical surface investigations were carried out to better

understand the subsurface conditions at the proposed locations of the upper reservoir I/O structure, the low-pressure gate shafts and tunnels and the vertical water intake shafts. Approximately 6,000 ft (linear) of surface geophysical investigation was performed including seismic refraction surveys to establish compressional wave velocities (Vp) and MASW to establish shear wave velocities (Vs) of subsurface materials that are utilized in the interpretation of subsurface materials (overburden, weathered rock, firm/sound rock). A complete evaluation of seismic line data is included in Attachment 1, Appendix D.

3.7 Summary

Detailed summaries of the relationship between geology and constructability at individual areas (i.e., upper reservoir, lower reservoir, tunnels, vertical shafts, powerhouse cavern) assessed for Bad Creek II are included in Attachment 1 (Geology and Seismology Studies Report). There are no geological fatal flaws associated with the construction and operation of a second powerhouse. After 30+ years, the underground excavations at the existing Bad Creek Project have stabilized and the support installed in them during construction has and is serving its function well. Several recommendations have been made, including adding more borings to verify certain components where assumptions were made, as well the installation of inclinometers above the location of the retaining wall planned for the lower reservoir I/O works excavations to provide a baseline or potential movement before and after excavation/construction and during plant operations.

4 Lower Reservoir CFD Modeling

4.1 Background

A three-dimensional CFD model was developed by HDR to support the feasibility design of the Bad Creek II Complex. The goal of the desktop study was to quantify and evaluate potential hydraulic impacts within the Whitewater River cove of Lake Jocassee to establish velocity and flow patterns along the channel and near the east bank of the cove opposite of the discharge structure under existing conditions and under proposed conditions (i.e., two I/O structures). Results aid in identifying potential operational impacts of the Bad Creek II Complex during turbine mode and effects on shoreline erosion potential of the east bank of the Whitewater River arm of Lake Jocassee.

Note that additional CFD modeling will be carried out as a licensing study activity (Water Resources Study Plan) to determine vertical mixing and flow patterns in the Whitewater River cove under a two-discharge scenario.

4.2 Methods

Model simulations were carried out assuming both existing and proposed powerhouses were operating both simultaneously and independently under several scenarios. The modeling utilized Lake Jocassee bathymetry and the existing and proposed Bad Creek II Complex I/O structures to evaluate velocities and flow patterns within the Whitewater River cove to assess operational impacts. Simulations were run at elevations of 1,110 ft above mean sea level (msl) (i.e., normal full pool elevation) and 1,080 ft msl (minimum normal elevation) to calibrate the CFD model velocities and flow patterns to the 1986 physical model results reported by Alden Research Laboratory (ARL) (Larsen and White 1986) assuming the same discharge flows modeled.

Bad Creek is currently undergoing upgrades to the pump-turbine units. Upgraded operations at Bad Creek as well as proposed Bad Creek II operations (and I/O structure operations) were subsequently added to the model. Unit operations in both the turbine and pump mode were simulated with the existing and proposed structures at reservoir levels 1,110 ft msl, 1,096 ft msl, and 1,080 ft msl. The elevation of 1,096 ft msl was selected as an intermediate lake elevation operating scenario for the following reasons:

- 1. The surface water elevation threshold for implementation of protective operational measures to minimize fish entrainment is 1,099 ft msl.
- 2. The surface water elevation below which fish entrainment becomes elevated at Bad Creek and historically occurs less than 22 percent of the time is 1,096 ft msl.

4.3 Study Results

The hydraulics for both the existing and proposed inlet/outlet structures were simulated to target outflow convergence to establish flow and velocity patterns along the east bank of the discharge area to assess potential for erosion. While the generation flow predicted by the physical model had higher velocities than that predicted by the CFD model, the overall flow patterns (including major recirculation patterns) were accurately captured in the CFD model. These observations are seen in both the full pond and maximum drawdown elevation scenarios for Lake Jocassee under existing conditions (16,000 cubic ft per second discharge). East bank velocities along the existing inlet/outlet structure centerline predicted by the physical model range between about 0.5 fps and 2.25 fps at reservoir level 1,110 ft msl. At the maximum drawdown reservoir elevation of 1,080 ft msl, the velocities are slightly lower ranging from 0.5 fps to 1.3 fps.

The proposed Bad Creek II powerhouse inlet/outlet structure configuration was then added to the CFD model, assuming full generation at both inlet/outlet structures (a combined 39,560 cubic ft per second) to determine impacts on flow velocity along the east bank of Lake Jocassee in the Whitewater River cove,

opposite from the structures. Under full pond reservoir elevation, modeling showed that flow from the proposed structure forces flow from the existing structure to the center of the Whitewater River cove, lowering the velocities along the east bank. Four designated elevations within the water column were assessed, including surface elevations, and results indicated that the higher velocity region along the east bank moved approximately 600 ft to the north with peak velocities at 2.5 fps (along tunnel centerlines).

4.4 Summary

Under maximum drawdown reservoir elevation, flow patterns were similar to the full reservoir configuration, with increased velocities throughout, as expected. Lower elevations in Lake Jocassee increased the effect of the concentrated flow from the inlet/outlet structures and surface velocities have the potential to exceed 5.0 fps, while flow along the east bank generally peaked at approximately 3.5 fps along the tunnel centerlines.

The peak velocities for the proposed Bad Creek II Complex I/O configuration along the east bank do not exceed the modeled velocities shown in the existing Bad Creek configuration at Lake Jocassee elevation 1,110 ft msl. The proposed Bad Creek II Complex I/O configuration predicted minor increases to peak velocities along the east bank when compared to the existing Bad Creek modeled velocities. The location of the peak velocities is spatially closer to the proposed Bad Creek II Complex I/O structure and similar in magnitude to the physical model simulation results (Larsen and White 1986).

The results of this study indicate that the additional generation flows resulting from Bad Creek II (in combination with the Bad Creek Station) do not appear to increase the potential for erosion along the east/opposite bank of the Whitewater River cove in Lake Jocassee, assuming the geology is consistent along the bank (i.e., predominantly bedrock). The modeled velocities were approximately equivalent to the physical model study velocities, which are representative of the existing conditions. To HDR's knowledge, flow from the existing configuration and operations have not resulted in erosion along the east bank and velocities are within the general range from the proposed configuration.

For complete details, please refer to the full study report in Attachment 3.

4.5 Future Studies to Support Relicensing

Expansion of the existing submerged weir downstream of the I/O structure is planned during the construction of the Bad Creek II Complex; during initial CFD modeling studies described above, velocities in the water column above the submerged weir increased as the flow depth decreased. Velocities along the eastern bank near the expanded weir were higher when compared to the simulations using existing weir. The CFD model will be used to provide information on flows and mixing in the



vicinity and above the weir as a task under the Water Resources Study for the Bad Creek relicensing. In addition, the CFD model results will be used to support the Recreational Resources study in determining maximum surface velocities for public/boater safety.

5 Conclusion

There are no known additional adverse effects to geology or soils in the upper or lower reservoir areas due to the continued operation of the Project or construction of the expanded Project, therefore, no additional PM&E measures beyond the existing Shoreline Management Plan for Lake Jocassee (pursuant to the Keowee-Toxaway [KT] Project No. 2503 Operating License) to limit/prevent/mitigate potential erosion are warranted. Duke Energy plans to continue operating the KT Project with the existing restrictions on land and shoreline development in the vicinity of the Bad Creek Project Boundary as defined in the KT Project Shoreline Management Plan. Further, Duke Energy believes the results of the geology/geotechnical studies and lower reservoir CFD modeling study for the Bad Creek II Complex is sufficient to inform the relevant geological requirements of the draft and final license applications, including preparation of a preliminary Supporting Design Report for the Bad Creek II Complex.

The effects of construction of the Bad Creek II Complex and potential spoil disposal on soil erosion and sedimentation will be assessed as part of (1) the future Water Quality Monitoring Plan, (2) the environmental permitting process, and (3) development of an erosion and sedimentation control plan that will be integral to the construction and monitoring of the expanded Project.

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Attachment 1

Attachment 1 – Geology and Seismology Studies Report

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Bad Creek II Power Complex Feasibility Study

Volume 7: Geology and Seismology Studies

Salem, South Carolina September 1, 2022





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Contents

| 1 | Introc | ntroduction | | |
|---|------------------------------|--|---------------------------------------|----|
| 2 | Desc | ription o | f Project | 2 |
| | 2.1 | Existing | g Bad Creek Pumped Storage Project | 2 |
| | 2.2 | Propos | ed Bad Creek II Power Complex | 2 |
| 3 | Geote | echnical | Exploration Summary | 2 |
| 4 | Geolo | ogy and | Seismicity | 11 |
| | 4.1 | Region | nal Physiography | 11 |
| | 4.2 | Region | nal Geology | 11 |
| | 4.3 | Site Ge | eology | 13 |
| | | 4.3.1 | Introduction | 13 |
| | | 4.3.2 | Lithology | 20 |
| | | 4.3.3 | In-Situ Stress Measurements | 20 |
| | 4.4 | Seismi | city | 26 |
| 5 | Evalu | ation of | Geologic Characteristics | 32 |
| 6 | Geology and Constructability | | | |
| | 6.1 | Intake/ | Discharge Structure – Upper Reservoir | 35 |
| | 6.2 | Intake/Discharge Structure – Lower Reservoir | | |
| | 6.3 | Tunnels, Vertical Shafts, Powerhouse Cavern | | |
| | 6.4 | Construction Materials3 | | |
| | 6.5 | Summa | ary | 38 |
| 7 | Recommendations | | | 38 |
| 8 | References | | | 39 |

Tables

| Table 1. Structural Data from Bad Creek 1 Geologic Mapping | 22 |
|--|----|
| Table 2. Hydrofracturing Results in Borehole B-52 | 24 |
| Table 3. Summary of Geologic Characteristics | 32 |

Figures

| Figure 1. Bad Creek II Geotechnical Investigation General Site Features | 4 |
|--|----|
| Figure 2. Legend for Graphic Logs in Figures 3 to 7 | 5 |
| Figure 3. Graphic Log for Borehole B-21-1 | 6 |
| Figure 4. Graphic Log for Borehole B-21-2 | 7 |
| Figure 5. Graphic Log for Borehole B-21-3 | 8 |
| Figure 6. Graphic Log for Borehole B-21-4 | 9 |
| Figure 7. Graphic Log for Borehole B-21-5 | 10 |
| Figure 8. Tectonic Map of the Southern and Central Appalachians and Location of the Bad Creek Pumped Storage Project(from Hatcher et al. 2007). Td = Toxaway Gneiss | 12 |
| Figure 9. Geologic Map of the Bad Creek Pumped Storage Project Site | 15 |
| Figure 10. Geologic Map | 16 |
| Figure 11. MS-28 – Geologic Map of a Portion of the Salem and Reid Quadrangles | 19 |
| Figure 12. Cross-section of Existing Bad Creek Underground from the Upper Intake to the Discharge/Intake Structure on Lake Jocassee showing Location of Shear Zones A, B, C, and D | 21 |
| Figure 13. Result of Overcoring In-situ Stress Measurements in the Pilot Tunnel | 25 |
| Figure 14. Southeastern U.S. Seismicity (1774 to 1987), Physiographic Provinces and Seismic Zones | 27 |
| Figure 15. Central and Eastern United States Seismotectonic Zones and Location of the Bad Creek Pumped Storage Project | 28 |
| Figure 16. Seismic Hazard and Historic Earthquake Centers near the Bad Creek Pumped Storage Project | 31 |
| Figure 17. Hazard Curve and Uniform Hazard Response Spectrum (2475-year return period; 5% Damping) for a) $V_{s30} = 760$ m/sec and b) $V_{s30} = 2000$ m/sec | 32 |
| Figure 18. Bad Creek II Power Complex – Proposed Alignment – Projection of Shear Zones | 34 |

Appendices

Appendix A - Stereonet Data

- Appendix B Engineering Geology of the Bad Creek Pumped Storage Project, Northwestern South Carolina (Schaeffer 2016)
- Appendix C Kinematic Analysis of Proposed Sinking Cuts at the Upper Reservoir Inlet/Outlet Works and Associated Channel (Schaeffer 2021)
- Appendix D Evaluation of Boreholes and Seismic Line Data Collected at the Upper and Lower Reservoir Inlet/Outlet Works (Schaeffer 2021)

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Acronyms and Abbreviations

| Bad Creek II or Project | Bad Creek II Power Complex | | |
|-------------------------|---|--|--|
| Bad Creek Project | Bad Creek Pumped Storage Project | | |
| CVSZ | Central Virginia Seismic Zone | | |
| cm | centimeters | | |
| Duke Energy | Duke Energy Carolinas, LLC | | |
| EPRI | Electric Power Research Institute | | |
| ETSZ | East Tennessee Seismic Zone | | |
| FEM | finite element modeling | | |
| FERC | Federal Energy Regulatory Commission | | |
| HDR | HDR Engineering, Inc. | | |
| I/O | inlet/outlet | | |
| km | kilometers | | |
| LRF | Little River Fault | | |
| MASW | multi-channel assessment of surface waves | | |
| PGA | Peak Ground Acceleration | | |
| psi | pounds per square inch | | |
| RQD | rock quality designation | | |
| SR | seismic refraction | | |
| TFF | Tallulah Falls Formation | | |
| TGn | Toxaway Gneiss | | |
| UHS | Uniform Hazard Spectrum | | |
| USGS | United States Geological Survey | | |
| Vs | shear wave velocity | | |
| Vp | compressional wave velocity | | |

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1 Introduction

Duke Energy Carolinas is interested in the potential to develop a pumped storage hydroelectric project utilizing the existing Bad Creek Pumped Storage Project (Bad Creek Project) upper reservoir and building an additional underground powerhouse and associated infrastructure. Pumped storage is an efficient means to store energy when the demand for power is low and to generate power with the stored energy when the demand for power is high. Pumped storage is also recognized as one of the most useful methods for regulating intermittent renewable generation resources, such as wind and solar.

The proposed Bad Creek II Power Complex (Bad Creek II or Project) will be constructed and operated by Duke Energy. During peak energy demand periods, water from the upper reservoir will be released to the lower reservoir through turbines to generate power. During periods of low power demand, water will be pumped back from the lower reservoir to the upper reservoir. The power grid benefits of such operations include, but are not limited to, the integration of intermittent power generation sources, enhancement of grid stability, and supply of other ancillary services.

As part of the overall feasibility study effort, HDR performed a geological/geotechnical field investigation with the following objectives:

- Provide a well-structured study plan, utilizing the geologic mapping data and special geologic studies during the construction of the Bad Creek Project, additional geologic assessments conducted to date, topographic data, and preliminary layout studies to function as a bridge between the site feasibility study and potential future site studies.
- Assess, to the extent possible, site geological/geotechnical conditions in support of site layouts, conceptual designs, basic construction methods, and construction materials. Results of the geological/geotechnical studies will be used to develop recommendations regarding project structures, locations, and layout; provide input for Project cost opinions and schedule; and plan future geological/geotechnical investigations for the Project.

HDR's geologic study involved 1) a review of existing geological information from the investigations for and during construction of the Bad Creek Project and 2) incorporation of geotechnical and geophysical data from HDR's geotechnical exploration program, which included geophysical field testing and the drilling of five exploration boreholes, as documented in Volume 8 (Geotechnical Studies) of this feasibility study report. The study documented in this volume included a field review of rock core from the five boreholes drilled for this study, review of seismic refraction (SR) and multichannel analysis of surface waves (MASW) lines and other geophysical data (downhole geophysical measurements), review of geotechnical testing data, and a field reconnaissance to assess geologic features and site conditions as related to the construction and operation of the proposed Project.

Geologic characteristics that could impact the proposed Project were identified and it is recommended that further evaluation of these characteristics be performed during the next study phase. The findings, inferences, conclusions, and recommendations drawn from HDR's desktop review of existing geologic information, field investigations, and data collection efforts performed by HDR and its subcontractors are provided in the following sections.

2 Description of Project

2.1 Existing Bad Creek Pumped Storage Project

The existing Bad Creek Project (Federal Energy Regulatory Commission [FERC] Project No. 2740) is located in Oconee County, South Carolina, approximately eight miles north of Salem. The Bad Creek Reservoir was formed from the damming of Bad Creek and West Bad Creek, and serves as the Bad Creek Project's upper reservoir. Lake Jocassee, licensed as part of Duke Energy's Keowee-Toxaway Hydroelectric Project (FERC Project No. 2503), serves as the Bad Creek Project's lower reservoir.

The Bad Creek Project is operated by Duke Energy under the terms of an Original License issued by the FERC on August 1, 1977, as subsequently amended. Construction of the Bad Creek Project took approximately 10 years, and operations commenced in 1991. The structures and features included in the Bad Creek Project license include the upper reservoir and dams, inlet/outlet (I/O) structures in the upper and lower reservoirs, water conveyance system, underground powerhouse, tailrace tunnels, transmission facilities, and an approximately 9.25-mile-long transmission line corridor extending from the Bad Creek Project to the Keowee-Toxaway Project's Jocassee switchyard.

2.2 Proposed Bad Creek II Power Complex

Bad Creek II would utilize the existing Bad Creek Project's upper and lower reservoirs (Bad Creek Reservoir and Lake Jocassee, respectively) and would consist of a new Upper Reservoir I/O (within the existing upper reservoir), water conveyance system, underground powerhouse, and Lower Reservoir I/O (along the shoreline of Lake Jocassee). No modifications to the existing upper and lower reservoirs would be required for Bad Creek II other than construction of an Upper Reservoir I/O structure within the Bad Creek Reservoir and a Lower Reservoir I/O structure within Lake Jocassee. Duke Energy currently owns all property that would be required for construction of Bad Creek II.

3 Geotechnical Exploration Summary

As part of the Bad Creek II feasibility study, a geotechnical field exploration program was performed at the existing Bad Creek Project site from February 2021 through June 2021. Geotechnical site investigation efforts were organized and implemented by HDR and various subcontractors with logistical and site access support provided by Duke Energy. The Bad Creek II Geotechnical Investigation was performed to support a feasibility study of the Bad Creek II water conveyance tunnels and shafts, access tunnels and shafts, underground powerhouse, and appurtenant structures including the proposed Upper Reservoir I/O works and Lower Reservoir I/O works.

Five borings were drilled vertically at the Project site to depths ranging from 120.3 to 500.3 feet below existing grade and included downhole logging, packer testing, and water level monitoring wells in two of the borings (see Figure 1 and Figure 10). Four of the five borings (B-21-1, B-21-2, B-21-3, and B-21-4) were drilled at locations along the proposed water conveyance alignment. Boring B-21-1 is located at the Upper Reservoir I/O, Boring B-21-2 is located in the area of the low-pressure headrace tunnels just downstream of the low-pressure headrace gates, Boring B-21-3 is located downstream of the vertical intake shaft, and Boring B-21-4 is located at the Lower Reservoir I/O.

Boring B-21-5 was completed to investigate the Upper Reservoir I/O area, verify subsurface geophysical profiles, and to determine the location in the subsurface of a previously mapped shear zone in the Bad Creek Project upper reservoir. The borings were drilled to obtain geotechnical data including soil properties, depth to top of weathered rock, depth to top of competent rock, lithology and rock hardness, rock recovery and Rock Quality Designation (RQD), depth and thickness of shear zones, and rock permeability data using water pressure tests(i.e., packer tests). Sampling methods included Standard Penetration Test sampling and HQ coring methods.

Downhole geophysical logging of the borings was performed to assess rock mass fractures, foliation/banding, and other rock mass discontinuities. Stereonets of the downhole structural data are included in Appendix A, Figures A-1 through A-9.

Surface geophysical investigations were performed including seismic refraction surveys to establish compressional wave velocities (Vp) and multi-channel assessment of surface waves (MASW) to establish shear wave velocities (Vs) of subsurface materials that are utilized in their interpretation.

Graphic logs of Borings B-21-1 and B-21-5 are shown on Figure 2 through Figure 7 and will be referenced in later report sections. The geotechnical field exploration program is discussed in detail in Volume 8 (Geotechnical Studies) of this feasibility study report.



Note: Location of Boreholes B-21-1 to B-21-5 also shown on Figure 3. Figure 1. Bad Creek II Geotechnical Investigation General Site Features



Figure 2. Legend for Graphic Logs in Figures 3 to 7



Figure 3. Graphic Log for Borehole B-21-1



Figure 4. Graphic Log for Borehole B-21-2



Figure 5. Graphic Log for Borehole B-21-3



Figure 6. Graphic Log for Borehole B-21-4



Figure 7. Graphic Log for Borehole B-21-5

4 Geology and Seismicity

4.1 Regional Physiography

The Bad Creek Project is located in the Blue Ridge physiographic province (Blue Ridge), a mountainous zone that extends northeast-southwest from southern Pennsylvania to central Alabama, varying in width from less than 15 miles to 70 miles maximum. It is characterized by rugged terrain with valleys ranging in elevation from 1,000 feet in the south to greater than 1,500 feet in the north. Several mountain peaks have elevations greater than 6,000 feet with relief of up to 3,500 feet. In North Carolina, massive and resistant gneissic and metasedimentary rocks underlie most of the province, with the valleys tending to follow weaker-rock outcrops (e.g., schist or minor carbonate rocks) and fractures or fault/shear zones. The underlying geologic structure has a strong influence on local topography.

Drainage is generally to the west; however, the slopes separating the Blue Ridge from the Piedmont physiographic province are typically steep and provide the initial run-off (headwaters) for some of the largest streams of the Piedmont, which drain to the east and southeast. The Bad Creek Project site is located just northwest of the steep slope (Blue Ridge Scarp) separating the two physiographic provinces.

4.2 Regional Geology

The crystalline rocks of the southern Appalachians occur in northeast-trending parallel geologic terranes. The Bad Creek Project is within the Tugaloo terrane, which includes rocks of the eastern Blue Ridge northwest of the Brevard zone (Figure 8; Hatcher et al. 2007; Hatcher 2002). The Blue Ridge is a complex crystalline terrane consisting of Precambrian gneissic basement rocks structurally overlain by a vast thickness of metasedimentary and metavolcanic rocks of Precambrian to lower Paleozoic age (Hatcher 1978a, 1978b). Numerous igneous bodies of mafic to felsic composition intrude into the basement core and into the overlying metasedimentary and metavolcanic sequences. The structure of the Blue Ridge is controlled by major thrust faults, associated complex polyphase folding, and subsequent brittle faulting (Hatcher 1978a; Clendenin and Garihan 2007a, 2007b).

The southern Blue Ridge is divided into three belts: 1) a western belt of imbricate thrust sheets involving upper Precambrian and lower Paleozoic rock and some basement rocks, 2) a central belt containing most of the basement rocks exposed in the Blue Ridge terrane along with higher grade upper Precambrian and possible lower Paleozoic metasedimentary rocks, and 3) an eastern belt of high-grade early Paleozoic metasedimentary and metavolcanic rocks (Hatcher 1978a, 1978b; Hatcher et al. 2007). The eastern belt of the southern Blue Ridge comprises those portions of the Tugaloo terrane that occur northwest of the Brevard zone (Figure 8).



Source: Hatcher et al. 2007

Figure 8. Tectonic Map of the Southern and Central Appalachians and Location of the Bad Creek Pumped Storage Project(from Hatcher et al. 2007). Td = Toxaway Gneiss.

The principal rock unit of the western Tugaloo terrane (eastern Blue Ridge belt) is the Tallulah Falls Formation (TFF). The TFF generally consists of biotite gneiss (metagraywacke), pelitic schist, mafic volcanic rocks, and quartzite; in places the rocks of the TFF are migmatitic¹. These rocks are intruded by Paleozoic granitoid rocks and overlie 1,150 to 1,200 million years ago (Ma) Precambrian Grenville basement rocks in the Toxaway Dome (see Section 4.3.1). More specifically, the TFF consists of four members described in ascending order: 1) the quartzite-schist member, 2) the lower graywacke-schist-amphibolite member, 3) the garnet-aluminous schist member, and 4) the upper graywacke-schist member (Hatcher 1977). The lowest member contains quartzite with interlayered schist. The lower graywacke-schist-amphibolite schist. Layers of granitic gneiss and pegmatites also occur in this member. Overlying the lower member is the garnet-aluminous schist member. It consists of muscovite-garnet-kyanite schist with interlayered amphibolite, muscovite schist, biotite gneiss, granitic gneiss, and pegmatites. It is generally easily recognizable by abundant garnet and kyanite. The upper graywacke-schist member contains biotite gneiss, mica schist, garnet mica schist, with minor amounts of amphibolite, granitic gneiss, quartzite, calc-silicate rocks, and pegmatites.

The Toxaway Gneiss (TGn), part of the Precambrian Grenville basement of the eastern Blue Ridge, is exposed in the core of the Toxaway Dome. It is typically a medium- to coarse-grained banded biotite-plagioclase-microcline-quartz gneiss with some massive and augen varieties, which do not appear to be significantly different in chemical/mineralogical composition (Schaeffer 1987, 2016; Merschat et al. 2003). The TGn has an Rb/Sr whole-rock isochron age of 1203<u>+</u>54 Ma (Fullagar et al. 1979). A derived zircon age for the TGn is 1,150 Ma (Carrigan et al. 2003 in Hatcher et al. 2007).

The TFF rocks are metamorphosed to the upper amphibolite facies (kyanite-sillimanite zone; Hatcher 1977; Butler 1991; Schaeffer 2016). Dominant metamorphic fabric and peak metamorphism in the eastern Blue Ridge is circa 450 Ma, based on metamorphic ages of detrital monazite and zircon grains from TFF rocks (Miller et al. 1997, 2000; Moecher et al. 2011; Cattanach et al. 2012). The Grenvillian basement rocks of the Blue Ridge, including the TGn, were subjected to granulite facies² metamorphism approximately 1000 Ma (Hatcher and Butler 1979).

4.3 Site Geology

4.3.1 Introduction

The Bad Creek Project is located immediately northwest of the Brevard zone in the Tugaloo terrane within the Toxaway Dome (Figure 8). The Toxaway Dome consists of a core of TGn and a sliver of TFF. It is an elongate feature that has a steeply dipping to overturned northwest limb and a more moderately inclined southeast limb. At the ends, the structure plunges gently northeast and southwest, resulting in a structural dome defined by the upward arching of the dominant foliation in the TGn. Detailed mapping performed during the construction of the Bad Creek Project indicates that the basement (TGn)/cover (TFF) contact is repeated several times due to isoclinal folding and transposition. Textural evidence (grain size reduction and truncated foliation and fold axis in the TGn at the contact) suggests that the original basement/cover contact was a pre-metamorphic fault (before Taconic age [~450 Ma] and after Grenville age [~1000 Ma] metamorphisms).

¹ Migmatite – Rock consisting of alternating layers or lenses of granitic material in gneisses and schists; related to partial melting of the rock during deformation and metamorphism and then re-crystallization of the melt during the waning stages of metamorphism.

² Granulite facies – Rocks that have been subjected to high temperature and moderate pressure metamorphism and the rocks generally represent, as is the case of the Toxaway Gneiss, deep continental crust.

Most of the site is underlain by TGn (Figure 9 and Figure 10). All the tunnels, shafts, and the powerhouse cavern for the existing Bad Creek Project were excavated in the TGn and based on the geologic information available and obtained from the geotechnical investigation program for this study phase, so will the underground structures for the proposed Bad Creek II (Figure 9 and Figure 10). The Main Dam and East Dike are founded on the TGn. The West Dam and a portion of the reservoir are underlain by a sequence of schistose rocks belonging to the TFF (Figure 9). The TFF rocks are predominantly the garnet-aluminous schist member; however, in places portions of the upper graywacke-schist member is present. This belt of TFF rocks is isolated from similar rocks on northwest and southeast of the Toxaway Dome by the refolding of earlier folds (Figure 9; Hatcher 1978a; Schaeffer 1987, 2016).

The TGn, part of the Precambrian basement of the eastern Blue Ridge, is a medium- to coarsegrained gneiss of granitic to quartz monzonitic composition. It is composed of microcline, plagioclase, quartz, and biotite with minor amounts of epidote, garnet, allanite, muscovite, zircon, sphene, apatite, and opaques. The TGn can be divided into two major types: 1) a banded, mediumto coarse-grained granitic gneiss composed of alternating light-colored quartz-feldspar rich bands and dark biotite-quartz-feldspar bands and 2) a coarse-grained augen granitic gneiss consisting of a poorly foliated feldspar-quartz-biotite gneiss with feldspar and locally hornblende augen up to 3 centimeters (cm) in length and a medium- to coarse-grained quartz-feldspar-biotite gneiss with a more distinct foliation and feldspar augen up to 1 cm. Layers of biotite-hornblende schist (sills or dikes, possibly feeders for the mafic volcanic rocks of the TFF) are present with thicknesses up to 20 feet. Their orientation is parallel to the dominant foliation/banding in the TGn. At least two generations of quartz-feldspar-mica pegmatites occur within the TGn. They are distinguished by the fact that the later generation is undeformed except by fracturing, whereas the earlier generation is folded. Most of the early pegmatites parallel the dominant foliation, the later generation cuts across foliation. Small cross-cutting quartz veins are also present.



Source: Duke Power Company 1991; Schaeffer 1987, 2016

Figure 9. Geologic Map of the Bad Creek Pumped Storage Project Site





The TFF consists of three members in the site vicinity (Hatcher 1977; Schaeffer 1987, 2016; Figure 9). The lower graywacke-schist-amphibolite unit consists of meta-graywacke (biotite gneiss), amphibolite, muscovite schist, biotite schist, pegmatites, and minor granitic gneiss. The garnet-aluminous schist member includes muscovite-garnet-kyanite schist with minor interlayered amphibolite, muscovite schist, and meta-graywacke. The upper graywacke-schist member consists of metagraywacke (biotite gneiss), muscovite schist, and muscovite biotite schist with minor amounts of interlayered amphibolite, granitic gneiss, and pegmatite. The units have undergone regional metamorphism to the kyanite zone of the amphibolite facies.

During the original design studies for the Bad Creek Project (pre-1985), the subsurface exploration program had the following primary objectives related to the underground excavations and structures: 1) examine the rock characteristics and geologic structure of the proposed powerhouse location, 2) determine the most feasible powerhouse orientation and location with respect to the geologic structure and in-situ stresses, 3) provide the data and experience necessary to facilitate an efficient design of the underground portions of the project, and 4) serve as a model for the instrumentation and monitoring to be incorporated into the permanent underground structures.

Early in the project it was decided that a pilot tunnel into the proposed powerhouse location would be the primary activity of the underground exploration program. Preliminary core drilling, laboratory testing of core samples, and deep borehole hydrofracturing stress measurements (see Section 4.3.4) had been conducted before the design of the pilot tunnel program (Duke Power Company 1978; Schaeffer and Steffens 1979). Data from these tests showed generally good rock conditions, but with high horizontal in-situ stresses present. However, due to the magnitude of the project, the pilot tunnel program was considered a prudent investment. The pilot tunnel excavation and testing lasted from October 1976 through September 1977. The work was divided into three main components: 1) excavation monitoring, 2) rock testing including the measurement of the in-situ rock mass stress orientation and magnitude utilizing the overcoring methodology (see Section 4.3.4), and 3) geologic mapping and investigations (Duke Power Company 1978; Schaeffer and Steffens 1979).

The geologic program conducted during construction of the Bad Creek Project (from 1985 to 1991) provided additional geologic information for construction and design personnel to make necessary changes to the design and construction techniques due to geologic conditions and to document the conditions encountered. The geologic studies included observation, measurement, sampling, photographs, mapping, and evaluation of the exposed rock and foundation surfaces. The geologic conditions encountered in the underground works were documented by geologic mapping of at least one rib of all tunnels; the walls of the two vertical shafts; and the walls, crown, and floor of the powerhouse cavern at a scale of 1 inch = 6.56 feet. The aboveground structures including dam foundations, intake excavation, and discharge excavation were mapped at a scale of 1 inch = 20 feet. The upper reservoir area was mapped at a scale of 1 inch = 200 feet after all excavation and borrow work was completed. The mapping was the primary input into construction and design considerations as work progressed and was supplemented by additional studies as needed. The geologic work during construction, including additional studies beyond the geologic mapping (for documentation), are described and discussed in Duke Power Company (1991) and Schaeffer (2016; included in Appendix B). The drawings documenting the underground geologic mapping and specific geologic studies are part of the as-built Bad Creek Project documentation (Drawing Series BK-1011-09 to -15).

The intake, underground structures (tunnels, powerhouse, vertical shafts), and intake/discharge structure of Bad Creek II will be excavated in the TGn based on the geotechnical investigation and the previously collected geologic data (Figure 9 and Figure 10).

An alternate interpretation of the geology along Lake Jocassee at the intake/discharge area is shown in Figure 11 (Clendenin and Garihan 2007a). It shows TGn in the Bad Creek II underground structure area, but a more complex relationship between the TGn and TFF rock units than shown in Figure 9 as well as two northwest-trending faults that are discussed later in Section 4.3.3 of this report.



Source: Excerpt from the S.C. Geological Survey Map Series 28 (Clendenin and Garihan, 2007a)

Map Description

Inclined metamorphic or tectonic foliation, showing strike and dip

Contact - Identity and existence certain, location approximate; short dash where concealed.



Oblique-slip fault – Identity and existence certain, location approximate; short dash where concealed. Arrows show relative motion. Where recognizable, upthrown block (U) and downthrown block (D) are identified.



Quaternary alluvium – Gravel, sand, silt, and clay deposits of Quaternary age occur beneath the flood plains and discontinuously along the stream channels of major and minor drainages in the area.



Tallulah Falls Formation – Rocks of the Tallulah Falls Formation crop out immediately to the northwest of the Rosman Fault that marks the boundary of the Brevard zone in Salem and Reid quadrangles. White clays mark zones of hydrothermal alteration throughout the formation. The contact between the underlying Toxaway Gneiss and the Tallulah Falls Formation is marked by golden-brown micaceous schist and, locally along strike, by boudins of dark-green ultramafic rock.



Toxaway Gneiss – The Toxaway Gneiss crops out in the southwest corner of Reid quadrangle and is the oldest rock in South Carolina (Grenvillian). Toxaway Gneiss is hard when hit with a hammer, stands competently in vertical roadside cuts, forms hillside balds in the Whitewater River valley, and restricts that river near the state line to form lower Whitewater Falls.



BAD CREEK II POWER COMPLEX MS-28 - GEOLOGIC MAP OF SALEM AND REID QUADRANGLES FIGURE 4-4

FEASIBILITY REPORT

Figure 11. MS-28 – Geologic Map of a Portion of the Salem and Reid Quadrangles

4.3.2 Lithology

Detailed geologic mapping of the Bad Creek Project underground excavations resulted in a detailed subdivision of rock types within the TGn. The following units were recognized and mapped during the construction:

- 1. Granitic Gneiss, medium light gray to light gray, medium- to coarse-grained gneiss consisting of alternating layers of light-colored quartz-feldspar bands and darker biotite-quartz-feldspar bands, well-foliated;
- 2. Banded Augen Granitic Gneiss, medium light gray to light gray, medium- to coarse-grained gneiss consisting of a foliated (banded) quartz-feldspar-biotite gneiss containing feldspar augen up to 1 cm long;
- 3. Augen Granitic Gneiss, medium light gray, coarse-grained gneiss consisting of a coherent, massive, poorly foliated feldspar-quartz-biotite gneiss with feldspar and locally hornblende augen up to 3 cm long;
- 4. Biotite Schist, medium dark gray to dark gray, coarse-grained biotite-hornblende schist;
- 5. Biotite Gneiss, medium dark gray to dark gray, medium- to coarse-grained biotite-hornblende gneiss;
- Biotite Augen Gneiss, medium gray to medium dark gray, medium- to coarse-grained, foliated biotite-feldspar-quartz gneiss with feldspar augen up to 1 cm long, biotite content generally greater than 30%;
- 7. Quartz-Feldspar Gneiss, very light gray to white, very coarse-grained, distinctly foliated quartz-feldspar gneiss with minor biotite (less than 10%);
- 8. Very Coarse-Grained Granitic Gneiss, light gray, very coarse-grained, distinctly foliated quartz-feldspar-biotite gneiss, biotite content greater than 10%;
- 9. Weathered Sheared Rock, moderate to moderately severe weathering, light gray to yellowish gray to greenish gray, original rock type granitic or augen granitic gneiss; and
- 10. Hard Sheared Rock, medium light gray to light gray, medium- to coarse-grained rock, original rock type granitic or augen granitic gneiss.

4.3.3 Structural Geology

The foliation in the TGn and TFF rocks is defined by the parallel orientation of platy minerals and by compositional layering. The average orientation of foliation in the Bad Creek reservoir area is N37E; 38SE and varies from N35-50E; 28-41SE in the underground works. Minor folds are present; some lie within foliation whereas others fold the dominant foliation. The earliest set of folds are isolated "z-", "s-", and crescent-shaped fragments, which are axial planar to the dominant foliation. The presence of these isolated fold fragments indicates that transposition of an older foliation has occurred. The second set of folds are isoclinal to open with variable development of a secondary foliation. In areas where this folding is isoclinal, an axial planar foliation (defined by secondary biotite) is present. Later open folding was recognized in several tunnels of the existing Bad Creek Project.

Shear zones with thicknesses up to 200 feet occur throughout the TGn and generally parallel the dominant foliation. Four major shear zones are present in the reservoir and dam areas (Shear Zones C, D, E, and F on Figure 10) and two additional major shear zones (Shear Zones A and B on Figure

10) were mapped in the underground tunnels (Figure 12; projections to the ground surface are shown on Figure 10).



Source: Talwani et al. 1999

Figure 12. Cross-section of Existing Bad Creek Underground from the Upper Intake to the Discharge/Intake Structure on Lake Jocassee showing Location of Shear Zones A, B, C, and D

Shear Zone A is in the vertical access shaft and in the excavation along Lake Jocassee for the intake/discharge structure. Shear Zone B is present in the vertical access shaft, the main access, Tailrace 1 & 2, and Tailrace 3 & 4 tunnels. Shear Zone C is present in the main access, penstock bypass, tailrace bypass, draft tube gate, Tailrace 1 & 2, and Tailrace 3 & 4 tunnels and the vertical access shaft. Shear Zone D is present in the manifold, Penstock 1, Penstock 2, Penstock 3, and Draft Tube 1 tunnels and in the west, north, and east wall and along the floor of the powerhouse cavern. The zones consist of hard sheared rock with layers of weathered sheared rock present. The zones are mineralized with chlorite, epidote, calcite, and quartz in various combinations. Originally white feldspars have been discolored to a pink or light orange-pink color within and adjacent to the shear zones. Along some of the shear planes, breccia is present with thicknesses of less than 1 inch to approximately 12 inches. The breccia consists of granitic gneiss, coarse guartz/feldspar (pegmatites), and vein quartz fragments in a matrix of fine-grained chlorite and epidote. Several of the shear zones have associated weathered zones up to 12 inches thick. Within the weathered zone there is up to 2 inches of gouge-breccia composed of granitic gneiss, coarse guartz/feldspar, and vein quartz fragments in a clay matrix. The hard sheared rock exhibits tight, complex isoclinal folding with sheared out limbs and a secondary axial planar foliation defined by biotite. This relationship indicates that the major shearing is related to the second fold event, although some of the shear zones may have been reactivated from the first fold event. The brecciation and mineralization of the zones is a later faulting event.

In the intake excavation, Shear Zone C (referred to as the D6/East Dike shear zone in the Bad Creek Design Report [Duke Power Company 1991]) was first mapped during the intake structure excavation. In the east dike foundation, the shear zone consists of a weathered zone 2 to 3 feet thick with alternating layers of hard material (quartz-feldspar pegmatites and breccia with an epidote-chlorite matrix) and soft material (weathered granitic gneiss, weathered sheared rock, discontinuous layers of biotite schist, and discontinuous layers of phyllonite ½ to 12 inches thick). Within portions of the shear, there is up to 8 inches of gouge-breccia composed of rock, quartz/feldspar fragments, and vein quartz fragments in a clay matrix. A relatively pure clay layer, 1 to 2 inches thick, is present along the hard layer of breccia. The harder layers within the zone are highly fractured with Mn and Fe staining along the fractures indicating water percolation.

For this phase of study, a representative sample of structural data collected during the geologic mapping of the Bad Creek 1 above- and underground structures that were still available in various files were analyzed. This included structural data from the following:

- 1. West dam foundation (only data collected from granitic gneiss (primarily TGn) and biotite gneiss (TFF);
- 2. Main dam foundation (all from TGn); and
- 3. All underground tunnels (main access, draft tube gate, penstock bypass, tailrace bypass, powerhouse bypass, manifold, penstocks [4], draft tubes [4], and tailrace tunnels [2]) and vertical shafts (intake and access shafts). The data were extracted from the as-built geologic maps of these structures. Structural data from the powerhouse mapping are not included in the underground data sets.

The compiled data is included on four Excel spreadsheets (including the GEL Solutions televiewer data) and the DIPS Version 8.008 files used for the stereonets of the structural data included in Appendix A (files are provided electronically including scans of the original field data compilation for the main and west dams).

The data from the main dam and reservoir mapping was utilized in the kinematic analysis of the proposed Upper Reservoir I/O rock cuts (the analysis is provided in Appendix C and discussed later in Section 6.1 of this report). The compiled data from the underground geologic mapping was used in the projection of the shear zones into the vicinity of the proposed Bad Creek II water conveyance alignment and is discussed in Section 6.3. The site structural data is summarized in Table 1.

| West Dam Mapping (1987-1990) - Granitic and Biotite Gneiss; Foliation from Reservoir Mapping - Joints, N = 1152; Foliation, N = 116 | Main Dam Mapping (1986-1990) Sampled Data. Joints N = 2689 of 6687 Measurements; Foliation = 1188 of 3619 Measurements | |
|---|---|--|
| N33E; 33SE (S) ¹ | N34E; 34SE (S) | |
| N62W; 83SW (Jt) ² | N51W; 80SW (Jt) | |
| N37E; 77NW (Jt) | N37E; 70 NW (Jt) | |
| N89W; 76NE (Jt) | N85E; 78NW (Jt) | |
| Reservoir Area - (1983-85 Mapping) | Main Dam Mapping (1986-1990); Faults, N = 676; Shear Planes, N = 402 | |
| N37E; 38SE (S) | N36E; 77SE (Flt) ³ | |
| N47W; 88SW (Jt) | N49W; 82SW (Flt) | |
| N77E; 82NW (Jt) | N35E; 33SE (Sh) ⁴ | |
| N42E; 74NW (Jt) | | |
| Underground Mapping (1985 to 1989) | Underground Mapping (1985 to 1989) ⁵ . Joints, N = 764; Foliation, N = 1131; Faults, N = 193; Shear Planes, N = 72 | |
| N35E; 30SE (S) | N84E; 67NW (Jt) | |
| N70E-N70W; <50N & S (Jt) | N44E; 30SE (S) | |
| N60E; 60NW (Jt) | N63E; 55NW (Flt) | |
| N65E; 30SE (Jt) | N49E; 31SE (Sh) | |
| N45W; 70-90SW or NE(Jt) | | |

Table 1. Structural Data from Bad Creek 1 Geologic Mapping

¹S - Foliation; ²Jt - Joint; ³Flt - Fault; ⁴Sh - Shear Plane

⁵Underground data compiled (2021-2022); powerhouse structural data not included.

There are three dominant joint sets in the Bad Creek reservoir area based on the pre-construction mapping: 1) N77E; 82 NW, 2) N42E; 74NW (strike joints), and 3) N47W; 88SW (dip joints). The predominant joint set varies between N70W and N70E with steep north and south dips (>50°) in the underground works. Another set strikes N60E with moderate to steep northwest dips and a weakly developed set oriented N45W with steep southwest dips is present. All joint sets have some degree of mineralization, but the northeast and particularly the east-west set (N77E in the reservoir area) contain a greater percentage of mineralized joints. The dominant mineral fillings are quartz, chlorite, epidote, biotite, and calcite in various combinations. Iron oxide and manganese staining is present along weathered joint surfaces. Spacing within the joint sets varies from less than 1 inch to greater than 50 feet.

In the underground portion of the Bad Creek Project, the dominant joint set is oriented N70E to N70W (~N87E; see Table 1) with dips >50° north and south. Other sets are oriented N60E; 60NW, N65E; 30SE (foliation joints), and N45W; 70-90SW or NE. The joints are tight at depth with similar mineral fillings as noted in the reservoir area. Near the ground surface some joints are open and with weathering resulted in blocky conditions at the main access tunnel portal for approximately 200 feet into the tunnel that was supported by steel sets and a concrete lining.

Fault and fault zones in the underground portion of the Project are present and are generally associated with the northeast-striking joint sets. Single fault planes with few associated fractures have offsets up to 6 inches (vertical separation). The fault zones have complex fracturing with several planes and offsets ranging from less than 1 inch to greater than 12 feet. Breccias up to 6 inches thick are developed along some of the fault planes and consist of rock, quartz/feldspar, and vein guartz fragments in a fine-grained matrix of chlorite-epidote. Discoloration of feldspars to pink occurs along some of the fault planes. All fractures within the zones are mineralized by combinations of epidote, chlorite, guartz, and calcite. Along some of the fault planes, chlorite up to 2 inches thick is present. Subhorizontal slickensides on the chlorite indicate the primary movement was strike-slip. The thicker chlorite mineralization has a secondary shear foliation, indicating minor movement after the primary mineralization. In some fault zones the rock is shattered between fault planes with chlorite-quartz mineralization throughout the fracture zone. The brecciation and mineralization of the fault zones occurred at the same time as the brecciation along the shear zones. The faults and shear zones are similar to others within the southern Appalachians that have been healed under greenschist metamorphic conditions, suggesting the last movement occurred at least 300 Ma (Gilbert et al. 1982).

Clendenin and Garihan (2007a) mapped two northwest-trending oblique-slip faults northeast and southeast of the existing and proposed underground works. Northwest-trending faults were not encountered in any of the underground excavations for the Bad Creek Project and only minor northwest-trending faults were mapped in the Bad Creek reservoir and in the main dam, west dam, east dike, and intake channel/structure (see Appendix A, Figures A-13 [aboveground data] and A-18 [underground data]; in Appendix A; Duke Power Company 1991; Schaeffer 1987, 2016; Table 1). These northwest-trending faults mapped in the reservoir and dam/intake areas were short splays with minor offsets of the primarily northeast-trending faults as discussed in the previous paragraph. The previous mapping (Figure 9) and mapping during the feasibility study (Figure 10) did not identify these two faults along the present access road along Lake Jocassee to the location of the existing and the proposed Lower Reservoir I/O works. At both locations on the access road to the existing powerhouse complex, landslides (previously mapped in the early 1980s; Schaeffer 2016) are present and there is no indication of faulting on either side of the two landslides, although the landslides could be concealing the faults. However, the geologic sequence along the access road

was checked during the field reconnaissance and confirmed that the earlier mapping shown in Figure 9 is correct regarding the location of the TGn/TFF contact indicating faulting shown in Figure 11 is not supported by geologic interpretations presented in this report. Along Musterground Road (see Figure 11), the rock identified by Clendenin and Garihan (2007a) is a coarser phase of the TGn and not migmatitic lithologies of the TFF. The northwest-fault in that vicinity was not identified or observed during the field reconnaissance and the determination of the lithologies northeast of the fault along Musterground Road as phases of the TGn makes the through-going northwest-striking fault shown on Clendenin and Garihan's map (Figure 11; 2007a) unlikely.

4.3.4 In-Situ Stress Measurements

Two methods of in-situ stress measurement were employed for the design of the existing Bad Creek Project tunnels, caverns, and shafts: hydrofracturing and overcoring. Hydrofracturing tests were performed in a deep borehole (B-52) from the ground surface and the overcoring technique was employed in the proposed powerhouse location in the pilot tunnel. Table 2 provides the in-situ stress values obtained from the hydrofracturing tests and Figure 13 depicts values from the overcoring tests. Preliminary calculations and the hydrofracturing measurements assumed a vertical stress (lithostatic) component equal to that due to overburden. At the overcoring test depth this would be approximately 690 psi. The vertical stress determined from overcoring was 1476 psi and was oriented 10° south of east at an angle of 14° from vertical (Figure 13). If this higher stress magnitude had been assumed in the hydrofracturing stress calculations, there would have been good agreement with the overcoring results. The direction of the horizontal stresses is in excellent agreement between the overcoring and hydrofracturing tests.

| Stress | Pore Pressure | Stress Magnitude | Orientation of Principal Stress |
|--|------------------|------------------------------------|------------------------------------|
| Vertical Stress, $\sigma_{\scriptscriptstyle 3}$ | | 800 – 1000 psi | Vertical |
| Maximum Horizontal, σ_{i} | 0 psi 300 psi | 2500 – 4100 psi 2200 – 3800 psi | N60E N60E |
| Minimum Horizontal, σ_2 | | 1950 – 2650 psi | N30W |

Table 2. Hydrofracturing Results in Borehole B-52

Note: Several tests were performed at different depths in the vicinity of the proposed Bad Creek II powerhouse.



Source: Duke Power Company 1991

Figure 13. Result of Overcoring In-situ Stress Measurements in the Pilot Tunnel

Overcoring stress values were among the input parameters for finite element modeling (FEM) performed for the design of the existing Bad Creek Project powerhouse and tunnels. Results of the FEM analysis were used to determine the shape of the powerhouse and tunnels; other factors such as geologic structure, support methods, and other functional requirements played a major role. The most useful information from the FEM results was an estimate of the how much rock movement should be expected during and after powerhouse excavation. These estimates became the basis for evaluating the data from installed instruments during and after construction of the existing powerhouse.

4.4 Seismicity

The East Tennessee Seismic Zone (ETSZ), closest to the Bad Creek Project, is one of the most active seismic zones in eastern North America (Bollinger et al. 1991) and is located primarily in the Valley and Ridge physiographic province of Tennessee with a portion in the Valley and Ridge and Blue Ridge physiographic province of western North Carolina (Figure 14). The zone is approximately 300 kilometers (km) long and 50 km wide and has not produced a damaging earthquake in historical time (Powell et al. 1994). The earthquakes occur at depths of to 5 to 25 km within Precambrian crystalline basement rocks beneath the thrust sheets of Paleozoic sedimentary rocks of the Valley and Ridge (Bollinger et al. 1976; Bollinger et al. 1991). The structures likely responsible for the seismicity in the zone are reactivated Precambrian to Cambrian normal faults formed during the rifting (extension) that formed the lapetus Ocean and are located beneath the later accreted Appalachian thrust sheets (like the Giles County Seismic Zone in Virginia; Wheeler 1995). In the recent EPRI (2012) Central and Eastern United States seismic source characterization, the site is in the Paleozoic extended crust zone (Figure 15) as described in the previous two sentences. Despite its relatively high rate of activity, the largest known earthquake in the ETSZ is M_w 4.7³ (1973 Alcoa-Marysville earthquake; Bollinger et al. 1991).

³ M_w = Moment Magnitude.



Note: BCPSP = Bad Creek Pumped Storage Project; A = Valley and Ridge and Blue Ridge; B = Piedmont; C= Coastal Plain. GCSZ = Giles County Seismic Zone (not discussed in text); ETSZ = East Tennessee Seismic Zone; CVSZ = Central Virginia Seismic Zone; CSZ = Charleston Seismic Zone (not discussed in text); NMSZ = New Madrid Seismic Zone (not discussed in text). Figure modified from Bollinger et al. 1991).

Figure 14. Southeastern U.S. Seismicity (1774 to 1987), Physiographic Provinces and Seismic Zones



Source: EPRI 2012

Figure 15. Central and Eastern United States Seismotectonic Zones and Location of the Bad Creek Pumped Storage Project

Recent work between Vonore and Maryville, Tennessee, centered on the Tellico Reservoir and the Little Tennessee River, has yielded evidence of paleoseismic features within a narrow northeast-trending zone (Hatcher et al. 2015; Glasbrenner et al. 2015; Warrell et al. 2017). The evidence includes faulted Quaternary river sediments and folded terrace deposits with faults that have offsets of up to 2 meters that involve bedrock (Hatcher et al. 2015; Warrell et al. 2017). Warrell et al. (2017) dated features within the zone and determined that at least three large earthquakes occurred in the ETSZ during the late Pleistocene (1.0 (?) to 0.012 Ma) with at least one or more exceeding M_w 6.

The Central Virginia Earthquake of September 1, 2011 (M_w 5.7 - 5.8) was the largest and most damaging in the central and eastern United States since the 1886 Charleston, South Carolina
earthquake (estimated M_w 6.8 - 7.0). The earthquake occurred on a north or northeast-striking plane with reverse faulting within a previously recognized seismic zone, the "Central Virginia Seismic Zone." The Central Virginia Seismic Zone (CVSZ) has produced small and moderate earthquakes since at least the 18th century. The previous largest historical shock from the Central Virginia Seismic Zone occurred in 1875. The CVSZ is in the Appalachian Piedmont Province between Richmond and Charlottesville, Virginia (Figure 14). The zone has an elliptical area, with a northsouth dimension of 100 km and an east-west dimension of 120 km, as defined by historical earthquake activity (Bollinger and Sibol 1985; Coruh et al. 1988). The depth of the earthquakes ranges from near surface to 12 km, placing them above the Appalachian detachment (Chapman 2015) in contrast to the ETSZ where earthquakes occur below the detachment.

On August 9, 2020, a 5.1 M_W magnitude earthquake occurred on August 9, 2020, with an epicenter approximately 2.5 miles southeast of Sparta, just south of the Virginia-North Carolina border (Figure 16). The earthquake caused damage to over 500 buildings and other infrastructure (Hill 2020; Figueiredo et al. 2022). Surface ruptures were attributed to a south-southwest-dipping reverse fault (Little River fault [LRF]) and were traced for ~2.5 km along the northwest trend (Hill 2020; Figueiredo et al. 2022). The LRF produced a maximum vertical displacement of 25.2 cm, with similar vertical displacements along much of the fault trace (Hill 2020; Figueiredo et al. 2022). The hanging wall was to the south (northeast side up; reverse fault as shown by the initial USGS focal mechanisms [USGS 2020a]). There is no recorded historical seismicity in and around Sparta, but Hill (2020) speculated that the LRF may be associated with the Giles County Seismic Zone, which is centered in Virginia approximately 100 km to the north. The depth of the main shock, 4.1 km (USGS 2020b), suggests that it occurred above the master decollement (depths of 5 to 12 km) and is not related to the Giles County Seismic Zone or ETSZ where the earthquakes typically occur below the decollement in the Paleozoic extended crust. The estimated magnitude of the Skyland 1916 earthquake is M_W 5.1 (Figure 16) similar to the magnitude of the Sparta 2020 earthquake.

Prior to filling Lake Keowee in 1968, none of the historical seismic activity occurred in the vicinity of the Bad Creek Project. Because seismic activity appeared to have increased after impoundment of the Keowee Hydro Project (as evidenced by a swarm of seismic events associated with Lake Keowee in 1978 and other recorded events), the potential of reservoir-induced seismicity was studied by Duke Power Company (Schaeffer 1991). Both Lake Keowee and then later Lake Jocassee were associated with reservoir-induced seismicity (sometimes referred to as reservoirtriggered seismicity). Most of the events have been small, with the largest having a local Magnitude (M_I) of 3.8. Activity at Lake Jocassee has decreased significantly since first filling in 1976 while activity at Keowee has also decreased (Schaeffer 2000). During the study of the reservoir-induced seismicity, seismic activity was closely recorded by the stations of the seismic network operated by Duke Power Company and that of the South Carolina Seismic Network. Only a minor increase in seismicity was reportedly related to initial filling of the Bad Creek upper reservoir - from about 5 events per month to about 10 per month. However, no correlation could be made with the observed increase with Bad Creek reservoir filling and operation of the plant (up to 160 feet of potential change in the reservoir level). Of the minor earthquakes in the area, none were located under or very near to the Bad Creek reservoir. Seismic activity clearly related to Lakes Keowee and Jocassee decreased to near background levels by 2000 (Schaeffer 2000). The cluster of earthquakes on Figure 16 near the site are primarily related to the induced seismicity at Lakes Jocassee and Keowee.

Earthquakes with $M_w \ge 3$ and contours of Peak Ground Acceleration (PGA) for V_{s30}^4 equals 760 m/sec with 2 percent probability of exceedance in 50 years (2475-year return period) from the 2018 National Seismic Hazard Maps developed by the U.S. Geological Survey (USGS 2018) are shown in Figure 16. The PGA at the Bad Creek Project site is 0.24g for V_{s30} of 760 m/sec (Site Class B/C⁵ Boundary) and 0.21g for V_{s30} of 2000 m/sec (Site Class A⁴) as shown in Figure 17 as are the hazard curves for spectral acceleration at selected periods and a Uniform Hazard Spectrum (UHS at 5% Damping) for both values of V_{s30} (USGS 2014b).

 $^{^4}$ V_{s30} is the shear wave velocity of the upper 30 meters of earth materials.

⁵ Site Class A = Hard Rock (V_s > 1524 m/sec); Class B = Rock (762 m/sec < V_s < 1524 m/sec); Class C = Very Dense Soil and Soft Rock (366 m/sec < V_s < 762 m/sec).</p>



Figure 16. Seismic Hazard and Historic Earthquake Centers near the Bad Creek Pumped Storage Project



Note: This figure is not intended to be used for design or any type of analyses. Source: USGS 2014a

Figure 17. Hazard Curve and Uniform Hazard Response Spectrum (2475-year return period; 5% Damping) for a) V_{s30} = 760 m/sec and b) V_{s30} = 2000 m/sec

5 Evaluation of Geologic Characteristics

The geologic characteristics of the bedrock in which the underground structures are to be excavated and constructed for Bad Creek II are summarized in Table 3. This information is based on the geological and geotechnical studies performed for the design of and geologic mapping and studies performed during construction of the existing Bad Creek Project underground structure.

| Geologic Characteristic | Relation to Project Area |
|---|--|
| High seismic risk/active faulting within the project area | The project area is considered to have low to moderate seismic risk. No known Quaternary/active faults in the site vicinity (USGS 2014a, 2014b, 2018). |
| Active landslides in project area | There is an old landslide at the intake/discharge of the Bad Creek Project on Lake Jocassee (see Appendix B; Schaeffer 2016). The slide material was removed during construction of the existing plant and a retaining wall was installed on the slope that stabilized part of the original landslide above the retaining wall and below the present control room//switchyard complex. Figure 10 and Figure 18 show the extent of a landslide/rockslide at the proposed Bad Creek II I/O structure on Lake |

Table 3. Summary of Geologic Characteristics



| Geologic Characteristic | Relation to Project Area |
|--|---|
| | Jocassee. The landslides/rockslides at the proposed Lower Reservoir I/O works will be an issue during excavation in this area to construct the works. The landslide may possibly be in the crown of the tailrace tunnels as it approaches the I/O works and may be present around the main access tunnel portal (Figure 10 and Figure 18; Appendix D, Photographs 1 and 2). |
| Deep weathering profile | Total soil thickness and the depth of overburden (soil/saprolite) and weathered bedrock at the Upper Reservoir I/O works, low pressure headrace gates area, and vertical headrace shafts area varies from 10 feet to greater than 90 feet. At the Lower Reservoir I/O on Lake Jocassee, the overburden is primarily landslide deposits that are up to 100+ feet thick based on the interpretation of the one borehole (B-21-4) in the area and the seismic refraction and MASW lines (Appendix D) The landslide deposits are not deeply weathered. |
| Highly permeable rock | Most of the water encountered in the Bad Creek Project underground excavations, past the initial ~200 feet of the main access and tailrace tunnels from their portals on Lake Jocassee, were associated with specific geologic features - the foliation parallel shear zones and some of the high-angle fault zones (Figure 10 and Figure 18; Schaeffer 1987, 2016 in Appendix B; Duke Power Company 1991). |
| Soluble rock material | Not present in the TGn. |
| Low strength, vibration-sensitive, friable, highly abrasive, slaking, or unlithified rock material | Weathered rock associated with shear zones and biotite schist and biotite-hornblende schist will have lower shear strengths than the unweathered TGn. |
| Highly faulted, folded, or fractured rock material | Most of the faults/fractures in the TGn have secondary mineralization and are not highly fractured/faulted. The shear zones mapped in the reservoir and in the existing Bad Creek Project underground structures have weathered sheared rock and later brittle faulting associated with them. |
| Thinly laminated, structurally deformed, fine-grained rock masses | Phyllonitic material present along some of the foliation-parallel shear zones in the underground excavations and thin, foliation parallel biotite- hornblende schist layers. |
| Rock Mass In-Situ Stress Field | High in-situ stresses that can result in rock burst and stress-related issues in the larger underground opening including the powerhouse, voltage bus/excitation galleries, draft tube gate and access gallery tunnel, draft tube gate annexes, and draft tube gate vertical shafts and at intersections of tunnels and shafts (Schaeffer 2016; see pages 66 to 70 in Appendix B). |



Figure 18. Bad Creek II Power Complex – Proposed Alignment – Projection of Shear Zones

6 Geology and Constructability

6.1 Intake/Discharge Structure – Upper Reservoir

The intake discharge channel will be excavated primarily in weathered rock/sound rock as most of the soil in that area was removed and used in the cores of the upper reservoir's dams and dike. The thickness of overburden (fill/soil/saprolite) and weathered rock overlying firm/sound rock is shown on the figures in Appendix D. Shear Zone E will be present in the upper part of the excavation, but should not be a major stability issue since it dips away from the excavation face. The Upper Reservoir I/O excavation will require sinking cuts to keep a portion of the weathered rock /sound rock as a temporary cofferdam to allow the existing Bad Creek Project to continue to operate during the Upper Reservoir I/O construction.

A kinematic analysis of the sinking rock cuts in the four walls was performed and is documented in Appendix C. The results indicated that a 0.5H/1V cut was the most stable configuration. Cuts in rock up to vertical are feasible based on the experience at the Bad Creek Project intake structure. The rock cuts, regardless of dip angle, will require some degree of stabilization including pattern rock bolts and possibly wire mesh.

The thickness of overburden (fill/soil/saprolite) and weathered rock overlying firm/sound rock underlying along the low-pressure headrace tunnels, the low-pressure gate shafts, and the vertical headrace shaft areas are shown on the figures in Appendix D.

6.2 Intake/Discharge Structure – Lower Reservoir

The Lower Reservoir I/O works on Lake Jocassee will be constructed through landslide deposits that overlie TGn (Figure 1 and Figure 18). The base of the landslide is consistent with the projected location of Shear Zone B (Figure 18; Appendix D). It is approximately 91 feet thick at the location of B-21-4 (Figure 1 and Figure 10) and may be over 100 feet thick in places based on the seismic refraction and MASW lines (see figures in Appendix D). The cuts to the north, west, and east for construction of the works will require support (such as a tie- back wall or series of tie-back walls) through the landslide deposits and rock bolts or other types of support in bedrock. The best interpretation of the data to date suggests that the crown of tailrace tunnels at the I/O works may be landslide deposits. Additional exploration is needed in the area to better understand the geologic conditions. The ground conditions at the proposed location of the main access tunnel portal for Bad Creek II are not yet known, but will be near the southern boundary of the landslide.

6.3 Tunnels, Vertical Shafts, Powerhouse Cavern.

The major factors affecting the design of the underground structures are the structural geology of the site and the orientation and magnitude of the in-situ stresses. The underground structures of the existing Bad Creek Project and likely the new Bad Creek II powerhouse are in the TGn. The rock is of good to excellent quality. The foliation is consistent with an average orientation of N35-44E; 30SE in the existing underground works and may or may not be the same in the underground works for Bad Creek II. The dominant joint set is oriented N70E to N70W (east-west) with dips >50° north and south. Other sets are oriented N60E; 60NW, N65E; 30SE (foliation joints), and N45W; 70-90SW or NE. The joints are tight at depth. Near the surface some joints are open, and weathering resulted in blocky conditions that will require support and/or ground reinforcement measures and minor water

in-flow at the tunnel portals. Shear zones are present with orientations parallel to foliation and faults with minor offsets are present and related to the northeast-striking joint set. Most of the shear zones and some of the faults made small amounts of water and were the only sources of water encountered during the excavation of the existing underground excavations. Zones of closely spaced joints, faults, and the shear zones may cause local zones of instability in the underground works.

The rock that will be encountered in the underground for Bad Creek II should be similar to that in the original underground tunnels where the tunnels and vertical shafts generally stood unsupported after excavation. The high in situ stresses caused some spalling to occur, primarily in the tunnel and powerhouse crowns, but also in the northwest and southeast corners of the powerhouse excavation. The spalling was continuously observed during the pilot tunnel work and was noted in the Pilot Tunnel Geologic Report (Duke Power Company 1978) and in the bid documents. The spalling rock occurred as thin slabs of rock and was most prominent in the more massive gneiss bodies in the underground works. Near the ground surface where stresses had been relieved over time, spalling did not occur. Only after a depth had been reached where the stresses had not been relieved did spalling occur. Other than the blocky rock near the main access portal, no support of the main access tunnel was needed (outside of spot rock bolts in the ribs) until the tunnel had advanced approximately 770 feet, where the overburden was about 500 feet, and spalling occurred. At this point, the spalling was controlled by using 10-foot-long, resin-anchored rock bolts (#9 bars) on a 5foot by 5-foot spacing in the tunnel crown and a 1-inch-thick layer of fiber reinforced shotcrete. The need for rock bolts and shotcrete varied somewhat, depending on the rock type, but pattern rock bolts and shotcrete were used routinely in the tunnel crowns for safety purposes in all the tunnels after the first 770 feet in the main access tunnel. Similar conditions are likely for the Bad Creek II underground works. Similar support measures in the tunnels and vertical shafts will likely be required for Bad Creek II.

The Bad Creek 1 powerhouse cavern was oriented long-axis north-south based on the geologic conditions documented during the Pilot Tunnel studies in 1976-1977 (Duke Power Company 1978; Schaeffer and Steffens 1979; Schaeffer 2016) and the results of hydrofracturing stress measurements in borehole B-52 and overcoring stress measurements in the Pilot Tunnel (Duke Power Company 1978; Schaeffer et al. 1979). The magnitude and direction of the in-situ stresses

determined by the overcoring technique are: $\sigma_{\rm i}$, maximum principal stress, 29.3 MPa (4253 psi) @

N57E, σ_2 , intermediate principal stress, 18.4 MPa (2675 psi) @ N32W, and σ_3 , least principal stress, 10.2 MPa (1476 psi) subvertical. All stresses are compressive. The subvertical stress is approximately two times that expected from overburden, indicating the Toxaway Gneiss at this location is overstressed. The in-situ stresses are high enough that they caused shallow spalling of excavated surfaces. Most of the spalling during the pilot tunnel studies occurred in the enlarged powerhouse test chamber where the shape of the crown arch was such that large tangential stresses were produced. The optimum orientation of the long-axis of the powerhouse cavern with respect to the in-situ stresses would be N57E-S57W; that is, the short wall would be perpendicular to the direction of the intermediate stress. The main set of discontinuities in the powerhouse area are joints of Set #1 (N75E; 86NW – closer to east-west strike in the powerhouse). These combined with the foliation could produce large wedges in the crown. A north-south orientation of the powerhouse minimizes the potential size of the wedges. The north-south orientation was selected as the most stable with respect to both the discontinuities and the in-situ stresses. A north-south orientation for the Bad Creek II powerhouse is also recommended.

For the Bad Creek Project powerhouse, with high horizontal stresses, a flat crown in the powerhouse cavern would be advantageous, but a crown 20 feet high above the springline was deemed necessary to provide frictional support for potential rock blocks delineated by the east-west joint set and the foliation. An analysis of potential rock blocks in the cavern walls and crown was performed using stereographic methods including rock bolt forces. Pattern rock bolts were specified in the walls and crown of the powerhouse based on the analysis and successful experience in similar powerhouses. In the crown and wall of the powerhouse above the structural concrete, 20-foot-long, #9 Grade 60 rock bolts on a 5-foot by 5-foot pattern were specified. In the areas of the structural concrete a 6-foot by 6-foot pattern was specified. The pattern in the end walls varied somewhat and was modified based on rock conditions. All the rock bolts were of the fully polyester resin encapsulated type. The bolts were designed as dowels (no pre-stressing), but to ensure they were "snugged up" in order to mobilize their strength in case of rock movement, a two-part resin system was used with nominal 350 foot-pounds of torgue applied to provide nominal pretension. In addition to the pattern rock bolts, the powerhouse crown received two 2-inch layers of shotcrete with welded wire fabric installed between the layers. The pattern rock bolts have extensions through the shotcrete allowing the false ceiling to be coupled to them for support. Additional rock bolts were installed in rock wedges in the crown and portions of the Powerhouse crown had 12.5-foot by 25-foot wire rope panels overlying #11 galvanized chain link and finer fabric-mesh installed for further crown support.

Similar designed support will be required for the proposed Bad Creek II powerhouse. Potential issues for the Bad Creek II powerhouse include stress relief in the crown resulting in cracking and spalling shotcrete and are like those encountered in the Bad Creek Project powerhouse crown, which required changes in the excavation sequence and size of bench blasts and the wire rope support installed (see Appendix B; Schaeffer 2016, pages 66 to 70 for full description).

The major shear zones mapped in the upper reservoir and in the underground excavations for the existing Bad Creek Project are shown on Figure 10. Shear Zones B, D, and E were identified in Boreholes B-21-3 and B-21-2. A small shear zone was identified in B-21-4 and is presently interpreted as one of the smaller shears of limited thickness encountered both in the reservoir area and in the Bad Creek Project underground. The major mapped shear zones in the reservoir area and underground structures and constrained by the location of the shear zones in the boreholes were projected into the area of the proposed Bad Creek II structures. Their relationship to the underground structures for Bad Creek II are shown in Figure 18. Based on the projection, Shear Zones A, B, C, and D may be encountered in the Vertical Access shaft to the Powerhouse Complex and Shear Zones C and D may be present in the Tailrace Tunnels. Shear Zone E projects into the upper portions of the powerhouse crown and the voltage bus/excitation gallery and draft tube gate and access gallery tunnel (Figure 18). It should be noted that Shear Zone E died out to the southwest in the Bad Creek reservoir area and was not mapped in the foundation of the main dam. Shear Zone F projects into the ~ 90° elbow where the vertical headrace shafts enter the highpressure headrace tunnels, there is the possibility that not all the shear zones projected into the area of the proposed Bad Creek II excavations and structures are present. Mapping in the power tunnel of the Bad Creek Project showed that broad open folds are present in the bedrock (TGn) and possibly folded the shear zones. In this case, the correlation of shear zones between the upper reservoir area and the underground excavations as presented on Figure 18 may not be entirely correct.

6.4 Construction Materials

Rock at the Bad Creek II site is generally not suitable for use in concrete aggregate due to its foliated/banded nature and was not used during the construction of Bad Creek 1. Sources of suitable sand and aggregate will be assessed during the next phase of work.

6.5 Summary

There are no geological fatal flaws associated with the construction and operation of a Bad Creek II powerhouse. After 30+ years, the underground excavations at the existing Bad Creek Project have stabilized and the support installed in them during construction has and is serving its function well.

7 Recommendations

The following are recommendations for the next phase of field geological/geotechnical investigations.

- Additional borings and seismic refraction/MASW lines in the area of the Upper Reservoir I/O
 works to better define the excavation required for its construction and for the design of a
 dewatering system and/or grout curtain to reduce inflow from the existing reservoir into the
 sinking cut required for construction.
- A deep boring in the vicinity of the proposed powerhouse to verify geologic assumptions including the projection of the shear zones into the proposed water conveyance alignment.
- Additional borings and seismic refraction/MASW lines in the area of the Lower Reservoir I/O works to better define the limits (both horizontally and vertically) of the landslide deposits in the area of the excavation required for its construction including the location and extent (length across and depth) of required support (tie-back) for the upslope landslide deposits, whether the landslide deposits may be present in the crown of the tailrace tunnels at the I/O works, and to assess the conditions at the location of the proposed main access tunnel portal.
- Borings with inclinometers should be install above the location of the retaining wall planned for the Lower Reservoir I/O works excavations to provide a baseline or potential movement before and after excavation/construction and during plant operations.

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Appendix A Stereonet Data

Not included - Available upon request

Appendix B

Engineering Geology of the Bad Creek Pumped Storage Project, Northwestern South Carolina (Schaeffer 2016)

Not included - Available upon request

Appendix C

Kinematic Analysis of Proposed Sinking Cuts at the Upper Reservoir Inlet/Outlet Works and Associated Channel (Schaeffer 2021)

Not included - Available upon request

Appendix D

Evaluation of Boreholes and Seismic Line Data Collected at the Upper and Lower Reservoir Inlet/Outlet Works (Schaeffer 2021)

Technical Memorandum

| Date: | Thursday, September 17, 2020 |
|----------|--|
| Project: | Bad Creek Powerhouse 2 Feasibility Study |
| To: | FILE |
| CC | Ed Luttrell, P.E., HDR; Ron Grady, P.E., HDR |
| From: | Malcolm Schaeffer. P.G. |
| Subject: | Evaluation of Boreholes and Seismic Line Data Collected at the Upper and Lower Reservoir Inlet/Outlet Works |

Introduction

As part of the Bad Creek II Power Complex Feasibility Study, three boreholes and approximately 6,000 linear feet of seismic refraction and Multi-Channel Analysis of Surface Waves (MASW) were assessed by GEL Solutions (GEL 2021a, 2021b). The locations of the lines are shown on **Figure 1** for the upper reservoir area (3,500 linear feet; Bad Creek Reservoir) and **Figure 2** for the lower reservoir area (2,500 linear feet; Lake Jocassee). The seismic lines from the draft GEL Solutions report (2021a) were utilized for the interpretations.

The preliminary excavation drawings for the upper reservoir and lower reservoir on which the interpretations were placed were dated 05/20/20021 and 07/12/2021, respectively, and do not represent the final excavation configuration.

Interpretation of this data was used in conjunction with the data/information discussed in the following section to inform the excavation/grading plans for the upper and lower reservoir inlet/outlet works.

This memorandum documents HDR's interpretations of the subsurface conditions with the present data.

Analysis

HDR's analysis of seismic lines relied primarily on the refraction lines (Vp – Compressional Wave Velocity); borehole data (B-21-1, B-21-2, B-21-3, and B-21-4; Figures 1 and 2); previous geologic investigations, including foundation mapping of the dams, dike, and intake structure and upper reservoir; geologic mapping of the landslide and discharge structure at the location of the existing lower reservoir inlet/outlet works; and an understanding of the weathering patterns of the underlying granitic gneisses that underlie most of the Bad Creek site (Schaeffer 2016). The MASW lines provided verification of visual observations of the landslide/rockslide located at the proposed lower reservoir inlet/outlet works (**Figures 2** and **3** and **Photographs 1** and **2**).

Top of Partially Weathered Rock (TPWR) and Top of Firm Rock (TFR) were defined as a V_p (Compressional Wave Velocity) of 5,500 – 6,500 ft/sec and 8,500 – 9,500 ft/sec, respectively. In the boreholes, TPWR was defined as the final refusal of either augers or tri-cone rotary bits. TFR was defined as Rock Recovery (REC) greater than 95% and Rock Quality Designation (RQD) greater than 50%

Results

The analysis seismic lines with boreholes and excavation cross-sections for the upper reservoir and lower reservoir inlet/outlet works are provided in Attachments A and B, respectively. Note that both the inlet/outlet works and tunnel and gate details shown are not the final configurations.

The results of HDR's analysis are summarized below:

- 1) Upper reservoir inlet/outlet works
 - a. Depths to TPWR and TFR were determined with the available data at the location of the sinking cut for the inlet/outlet works, the gate shaft, and the vertical access shaft to the vertical shaft. These depths were incorporated in the most recent excavation plan (08/06/2021).
 - b. The soil/saprolite/weathered rock on the west side of the proposed sinking cut will be relatively thin when laid back at 1.5H:1V. A retaining wall was added to the most recent excavation plan (08/06/2021) to account for this characteristic. A grout curtain is also planned for this area.
- 2) Lower reservoir inlet/outlet works
 - a. The landslide/rockslide will assert a major influence on the excavation methods and support for the excavation and construction of the inlet-outlet works. (Note the most recent excavation plan and sections are dated 07/20/2021.)
 - b. The landslide extents near the works are shown in **Figure 3** and on the excavation plan in Attachment B.
 - c. A retaining wall west of the inlet/outlet works will be needed to retain the slide material before excavation and for permanent stabilization.
 - d. HDR's interpretation of the vertical extent of the landslide/rockslide at the works places the base of the slide at the TFR in the crown of the northernmost tailrace tunnel and just above the crown in the southernmost tailrace tunnel at the inlet/outlet (see Excavation Sections 1a-1a, 2-2a, and 3-3a in Attachment B). Options for supporting the tailrace tunnel crowns as they advance toward the inlet/outlet works need to be considered and included in the cost opinion.
 - e. The portal face for the main access tunnel is within slide material based on HDR's interpretation of the data to date (see Excavation Section 7-7 in Attachment 2). Options for advancing the tunnel through the slide material until competent rock is encountered should be included in the cost opinion.

Recommendations

• Additional boreholes are needed in the locations of the upper reservoir inlet/outlet works, gate shafts, and vertical shafts to further define the TPWR, TFR, and condition of the rock in the gate shafts and the vertical access shafts.

- Additional boreholes (and possibly seismic lines) are needed at the lower reservoir inlet/outlet works to determine the lateral and vertical extent of the slide deposits at the location of the structure, at the location of the tie-back wall west of the works, and the portal area of the main access tunnel as presently configured.
- The cost opinion needs to take into account the uncertainties associated with the extent of the slide materials in the lower reservoir works. A larger than normal contingency is justified due to the unknowns at this stage of study.

References

- GEL Solutions. 2021a. Seismic Refraction and Multi-Channel Analysis of Surface Wave Surveys for Mapping Bedrock, Bad Creek II Pumped Storage Project, Salem, South Carolina: Draft Report Prepared for HDR Engineering Inc., Dated March 23, 2021.
- GEL Solutions. 2021b. Seismic Refraction and Multi-Channel Analysis of Surface Wave Surveys for Mapping Bedrock, Bad Creek II Pumped Storage Project, Salem, South Carolina: Final Report Prepared for HDR Engineering Inc., Dated August 4, 2021.
- Schaeffer, M. F. 2016. Engineering geology of the Bad Creek Pumped Storage Project, northwestern South Carolina, in 24th Annual David S. Snipes/Clemson Hydrogeology Symposium Field Trip Guidebook, March 20, April 1, and April 28, 2016, 72p.

FX



Figure 1: Profile lines at upper reservoir inlet/outlet works, gate shafts, and vertical shafts.

FC



Figure 2: Profile lines at lower reservoir inlet/outlet works and main access tunnel.

FS



Figure 3: Landslide (yellow shading) at the lower reservoir inlet/outlet works and main access tunnel portal. Red dashed line – approximate contact of landslide with residual material, green-filled circles – mapping point, red-shaded boxes around circles – mapped landslide deposits or features. See figure 2 for actual extent of geophysical lines, primarily Line I5-6.





Photograph 1: Standing above the south scarp of the landslide/rockslide at the lower reservoir inlet/outlet works. Note the rock blocks within the slide proper.



Photograph 2: Within the landslide/rockslide above the lower reservoir inlet/outlet works. Note the rock blocks and various orientations of the blocks.

ATTACHMENT A

Upper Reservoir Inlet/Outlet Works

1) Seismic Lines and Borehole Interpretations

2) Seismic Lines and Borehole Interpretations Superimposed on Preliminary Intake Structure, Tunnels, Gate Shafts, and Vertical Power Shafts



















| HDRE00121 3/22/2021 | Seismic Refraction and MASW Surveys for Mapping Bedrock Bad Creek II Pumped Storage Project, Salem, South Carolina | |
|------------------------|---|--|
| | | |







| HDRE00121 3/22/2021 | Seismic Refraction and MASW Surveys for Mapping Bedrock Bad Creek II Pumped Storage Project, Salem, South Carolina | |
|------------------------|---|--|
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| HDRE00121 3/22/2021 | Seismic Refraction and MASW Surveys for Mapping Bedrock Bad Creek II Pumped Storage Project, Salem, South Carolina | | |
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| HDRE00121 3/22/2021 | Seismic Refraction and MASW Surveys for Mapping Bedrock Bad Creek II Pumped Storage Project, Salem, South Carolina | |
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| HDRE00121 3/22/2021 | Seismic Refraction and MASW Surveys for Mapping Bedrock Bad Creek II Pumped Storage Project, Salem, South Carolina | |
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| HDRE00121 3/22/2021 | äeismic Refraction and MASW Surveys for Mapping Bedrock Bad Creek II Pumped Storage Project, Salem, South Carolina | |
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|------------------------|---|--|









SECTION A-A GEL DATA POINTS U1-U2-U2A-U2B-U3 SCALE 1"=40'

40 0 40 SCALE IN FEET





SECTION C-C GEL DATA POINTS U4-U4A-U4B-U5 SCALE 1"=40'

> 40 0 40 8 SCALE IN FEET









B-21-3 located approximately 150 ft downstream of the vertical power shafts.

ATTACHMENT B

Lower Reservoir Inlet/Outlet Works 3) Seismic Lines and Borehole Interpretations 4) Seismic Lines and Borehole Interpretations Superimposed on Lower Reservoir Excavation Cross Sections





| HDRE00121 | | |
|-----------|--|--|
| 3/22/2021 | Seismic Refraction and MASW Surveys for Mapping Bedrock | |
| | Bad Creek II Pumped Storage Project, Salem, South Carolina | |
| | | |



| HDRE00121 3/22/2021 | Seismic Refraction and MASW Surveys for Mapping Bedrock Bad Creek II Pumped Storage Project, Salem, South Carolina | | |
|------------------------|---|--|--|
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| HDRE00121 3/22/2021 | Seismic Refraction and MASW Surveys for Mapping Bedrock Bad Creek II Pumped Storage Project, Salem, South Carolina | |
|------------------------|---|--|
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| HDRE00121 3/22/2021 | Seismic Refraction and MASW Surveys for Mapping Bedrock Bad Creek II Pumped Storage Project, Salem, South Carolina | |
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| HDRE00121 | | |
|-----------|--|--|
| 3/22/2021 | Seismic Refraction and MASW Surveys for Mapping Bedrock | |
| | Bad Creek II Pumped Storage Project, Salem, South Carolina | |
| | | |



| HDRE00121 3/22/2021 | Seismic Refraction and MASW Surveys for Mapping Bedrock Bad Creek II Pumped Storage Project, Salem, South Carolina | |
|------------------------|---|--|
| | | |



MASW



| HDRE00121 | Seismic Refraction and MASW Surveys for Mapping Bedrock | - |
|-----------|--|---|
| 3/22/2021 | Bad Creek II Pumped Storage Project, Salem, South Carolina | - |







| HDRE00121 |
|-----------|
| 3/22/2021 |

Seismic Refraction and MASW Surveys for Mapping Bedrock Bad Creek II Pumped Storage Project, Salem, South Carolina



















Attachment 2

Attachment 2 – Geotechnical Studies Report
Bad Creek II Power Complex Feasibility Study

Volume 8: Geotechnical Studies

Salem, South Carolina September 1, 2022





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Contents

| 1 | Intro | duction | | 1 |
|---|--------|----------------------------------|--|----------------------|
| 2 | Regio | onal Phy | siography and Geology | 2 |
| | 2.1 | Region | al Physiography | 2 |
| | 2.2 | Region | al Geology | 2 |
| 3 | Site I | nvestiga | ation Program | 3 |
| | 3.1 | Site Ac | cess and Restoration | 3 |
| | | 3.1.1 3.1.2 3.1.3 | Standard Penetration Test (SPT) Sampling Method HQ-3 Triple-Tube Rock Coring Water Pressure (Packer) Testing | 6 6 7 |
| | 3.2 | Monito | ring Wells | 7 |
| | 3.3 | Surface | e Geophysical Surveys | 7 |
| | 3.4 | Downh | ole Geophysical (Optical and Acoustic) Logging | 8 |
| | 3.5 | Labora | tory Testing | 8 |
| | | 3.5.1 3.5.2 | Soil Testing Rock Testing | 9 9 |
| 4 | Field | Investig | ation Results | 9 |
| | 4.1 | Subsur | face Data Evaluation Process | 9 |
| | | 4.1.1 4.1.2 4.1.3 4.1.4 | Standard Penetration Test, Recovery, and Rock-Quality Designation Water Pressure Test Results Downhole Optical and Acoustic Televiewer Data Surface Geophysical Refraction and MASW Results | 10 11 15 17 |
| | | 4.1.5 | Monitoring Wells | 19 |
| | 4.2 | Boreho | ble Discussion | 19 |
| | | 4.2.1 | Individual Boreholes | 19 |
| 5 | Labo | ratory To | esting Results | 21 |
| | 5.1 | Soil Te 5.1.1 | sting Results Laboratory Soil Testing | 21 21 |
| | 5.2 | Rock T | esting Results | 23 |
| 6 | Geot | echnical | Conditions | 29 |
| | 6.1 | Site Ge | eotechnical Conditions | 29 |
| | | 6.1.1 6.1.2 6.1.3 | Overburden Soil Bedrock Landslide/Rockslide Material | 30 30 31 |
| 7 | Sumi | mary and | d Considerations | 32 |
| 8 | Limita | ations | | 33 |
| 9 | Refe | rences | | 34 |

Tables

| Table 1. Boring Summary | 3 |
|---|----|
| Table 2. Soil Sample Laboratory Testing | 9 |
| Table 3. Rock Core Laboratory Testing | 9 |
| Table 4. RQD Variations in the Borings | 11 |
| Table 6. Rock Structure Types | 15 |
| Table 7. Foliation Orientations | 16 |
| Table 8. Major Discontinuity Fracture Sets | 16 |
| Table 9. Shear Zones and Fault Features | 16 |
| Table 10. Surface Geophysics Line Transects | 18 |
| Table 11. Monitoring Wells and Groundwater Levels | 19 |
| Table 12. Soil Sample Laboratory Test Results | 22 |
| Table 13. Results of Unconfined Compressive Strength Tests (ASTM D7012-C and D7012-D) | 24 |
| Table 14. Results of Uniaxial Compression Test with Elastic Modulus (ASTM D7012D) | 25 |
| Table 15. Results of Splitting Tensile Strength Tests (ASTM D3967) | 28 |
| Table 16. Statistical Analysis of Rock Core Laboratory Data | 29 |
| Table 17. Soil Thickness and Description | 30 |

Figures

Figure 1. Bad Creek II Geotechnical Investigation General Site Features Geotechnical Drilling......5

Appendices

- Appendix A Project Drawings
- Appendix B Boring Logs and Photographs
- Appendix C Water Pressure Test Results and Data Sheets
- Appendix D SCDHEC Monitoring Well Approval Letter
- Appendix E GEL Solutions Surface Geophysical Report
- Appendix F GEL Solutions Downhole Geophysical Survey Report
- Appendix G Soil Sample Laboratory Testing Report
- Appendix H Rock Core Sample Laboratory Testing Results
- Appendix I HDR Downhole Data Stereonets

Acronyms and Abbreviations

| acre-ft | acre-feet |
|---------------------------|--|
| ASTM | ASTM International (formerly American Society for Testing and Materials) |
| Bad Creek II or Project | Bad Creek II Power Complex |
| cm | centimeters |
| Duke Energy | Duke Energy Carolinas, LLC |
| EM | elastic modulus |
| ft | feet/foot |
| HDR | HDR Engineering, Inc. |
| I/O | Intake/Outlet |
| k | hydraulic conductivity |
| MASW | multi-channel assessment of surface waves |
| psi | pounds per square inch |
| pcf | pounds per cubic feet |
| PWR | partially weathered rock |
| RQD | rock quality designation |
| sec | second |
| Standard Penetration Test | SPT |
| S&ME, Inc. | S&ME |
| TFF | Tallulah Falls Formation |
| TFR | Top of Firm Rock |
| TGn | Toxaway Gneiss |
| UWR | unweathered rock |
| UCS | unconfined compressive strength |
| Vp | P-wave: compressional wave velocity |
| Vs | S-wave: shear wave velocity |
| Water pressure | WP |

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1 Introduction

As part of the Bad Creek II Power Complex (Bad Creek II or Project) feasibility study being performed by HDR Engineering, Inc. of the Carolinas (HDR) in coordination with Duke Energy of the Carolinas, LLC (Duke Energy), a geotechnical field exploration program was carried out at the site of the existing Bad Creek Pumped Storage Station near Salem, SC from February 2021 through June 2021. Geotechnical site investigation efforts were organized and implemented by HDR and various subcontractors with logistical and site access support provided by Duke Energy. The Bad Creek II Geotechnical Investigation was performed to support the feasibility study of the Bad Creek II water conveyance tunnels and shafts, access tunnels and shafts, and underground powerhouse, and appurtenant structures including the proposed Upper Reservoir Intake/Outlet works (Upper Reservoir I/O) and Lower Reservoir Intake/Outlet works (Lower Reservoir I/O).

Five borings were drilled at the Project site and included downhole logging, packer testing, and water level monitoring wells in two of the borings. Four of the five borings (B-21-1, B-21-2, B-21-3, and B-21-4) were drilled at locations along the proposed water conveyance alignment. B-21-1 is located at the Upper Reservoir I/O, Boring B-21-2 in the area of the low pressure headrace tunnels just downstream of the low pressure headrace gates, Boring B-21-3 downstream of the vertical intake shaft, and Boring B-21-4 at the Lower Reservoir I/O. Boring B-21-5 was completed to investigate the Upper Reservoir I/O area, verify surface geophysical profiles, and to determine the location in the subsurface of a previously mapped shear zone in the Bad Creek Upper Reservoir. Boring locations are shown on drawings P-58, P-59, and P-61 in Appendix A.

The borings were drilled to obtain geotechnical data including soil properties, depth to top of weathered rock, depth to top of competent rock, lithology and rock hardness, rock recovery, and Rock Quality Designation (RQD), depth and thickness of shear zones, and rock permeability data water pressure (i.e., packer tests). Downhole geophysical logging of the borings was performed to assess rock mass fractures, foliation/banding, and other rock mass discontinuities. The borings were drilled vertically to depths ranging from 120.3 to 500.3 feet (ft) below existing grade. Sampling methods included Standard Penetration Test (SPT) sampling and HQ coring methods.

Surface geophysical investigations including seismic refraction surveys to establish compressional wave velocities (V_p) and multi-channel assessment of surface waves (MASW) to establish shear wave velocities (V_s) of subsurface materials that are utilized in the interpretation of subsurface materials (overburden, weathered rock, firm/sound rock). Drawings P-59 and P-61 in Appendix A show the locations of the geophysical lines.

Geologic investigations were conducted by HDR in tandem with the geotechnical investigation as part of an overall geological and geotechnical assessment the site. The investigations have been used to develop a geologic model of the proposed Bad Creek II tunnel alignment. The results of the assessments are presented in Volume 7 (Geology and Seismology Report) of the feasibility report.

2 Regional Physiography and Geology

2.1 Regional Physiography

The proposed Project site is situated in the Blue Ridge physiographic province, a mountainous zone that extends northeast-southwest from southern Pennsylvania to central Alabama and varies in width from less than 15 miles up to 70 miles. It is characterized by rugged terrain with valleys ranging in elevation from 1,000 ft in the south to greater than 1,500 ft in the north. Several mountain peaks have elevations greater than 6,000 ft with relief of up to 3,500 ft. In South and North Carolina. Massive and resistant basement gneiss, metaigneous, and metasedimentary rocks underlie most of the province with the valleys tending to follow weaker-rock outcrops (e.g., schist or minor carbonate rocks) and fracture or shear zones. The underlying geologic structure has a strong influence on local topography. Drainage is generally to the west; however, the slopes separating the Blue Ridge from the Piedmont physiographic province are typically steep and provide the initial run-off (headwaters) for some of the largest streams of the Piedmont, which drain to the east and southeast. The Project site is northwest of the Blue Ridge escarpment, which forms the southeastern boundary of the Blue Ridge physiographic province, with the Piedmont physiographic province to the south and southeast.

2.2 Regional Geology

The crystalline rocks of the southern Appalachians occur in northeast-trending parallel geologic terranes. The Project is within the Tugaloo terrane, which includes rocks of the eastern Blue Ridge province northwest of the Brevard zone (Hatcher 2002; Hatcher et al. 2007). The Blue Ridge province is a complex crystalline terrane consisting of Precambrian gneissic basement structurally overlain by a vast thickness of metasedimentary and metavolcanic rocks of Precambrian to lower Paleozoic age (Hatcher 1978a, 1978b). Numerous igneous bodies of mafic to felsic composition intrude into the basement core and into the overlying metasedimentary and metavolcanic sequences. The structure of the Blue Ridge is controlled by major thrust faults, associated complex polyphase folding, and subsequent brittle faulting (Hatcher 1978a; Clendenin and Garihan 2007a; 2007b).

The principal rock units of the western Tugaloo terrane (eastern Blue Ridge belt) at the Project site are the Tallulah Falls Formation (TFF) and the Toxaway Gneiss (TGn). The TFF consists of biotite gneiss (metagraywacke), pelitic schist, mafic volcanic rocks, and quartzite; the rocks of the TFF are migmatitic¹ in places. These rocks are intruded by Paleozoic granitoid rocks and overlie 1,150 to 1,200 million years ago (Ma) Precambrian Grenville basement rocks in the Toxaway Dome. The regional and site geology are discussed in detail in Volume 7 (Geology and Seismology Report) of the feasibility report.

¹ Migmatite – Rock consisting of alternating layers or lenses of granitic material in gneisses and schists; related to partial melting of the rock during deformation and metamorphism and then re-crystallization of the melt during the waning stages of metamorphism.

3 Site Investigation Program

The field program included five borings drilled by sub-contractor S&ME, Inc. and logged by HDR geologists. Packer testing was performed in all five borings after they were drilled to the required depths. The results are discussed in Section 4. Soil and rock samples obtained from the borings for testing were shipped to S&ME and GeoTesting Express, respectively.

The five borings were left open to the surface after drilling was completed to allow for downhole optical and acoustic televiewer logging to the maximum depth achievable by GEL Solutions before grouting them to the surface or monitoring well installation Borings B-21-2and B-21-5 had cloudy water that prevented complete optical televiewer surveys. The results of the televiewer data are discussed in Section 4.1.3.

After completion of the downhole logging, the casing through the overburden was pulled from borings B-21-1, B-21-4, and B-21-5 and boreholes backfilled with grout. Borings B-21-2 and B-21-3 were backfilled with grout to depths of 70 and 90 ft respectively before installation of monitoring wells.

Boring logs include lithology descriptions, packer testing intervals, and laboratory testing results. The logs and photographs of rock core and soil SPT samples are included in Appendix B. A boring summary is provided in Table 1.

| Boring | Total Depth (ft) | Inclination | Azimuth | Soil Depth (ft) | Number of Water Pressure Tests | Well screen depths (ft) ¹ | Acoustic and Optical Televiewer |
|--------|---------------------|-------------|---------|--------------------|--------------------------------------|---|---------------------------------------|
| B-21-1 | 250.8 | 90 | NA | 4.0 | 5 | NA | Yes |
| B-21-2 | 300.8 | 90 | NA | 4.0 | 11 | 50-70 | Yes |
| B-21-3 | 500.4 | 90 | NA | 6.4 | 7 | 70-90 | Yes |
| B-21-4 | 150.4 | 90 | NA | 29.9 | - | NA | Yes |
| B-21-5 | 120.3 | 90 | NA | 46.6 | 2 | NA | Acoustic only |

Table 1. Boring Summary

¹ Well screens are 2-inch diameter PVC

In addition to drilling and testing, surface geophysics including seismic refraction and MASW line surveys were completed by GEL Solutions. Geophysical surface investigations were carried out to better understand the subsurface conditions at the proposed locations of the Upper Reservoir I/O structure, the Lower Reservoir I/O structure, the low-pressure gate shafts and tunnels and the vertical water intake shafts.

3.1 Site Access and Restoration

All work related to the Bad Creek II Geotechnical Investigation was performed on land owned by Duke Energy. The Project site was accessed daily from HWY 130 and Bad Creek Road. Daily safety and pre-job briefings were held each morning in Duke Energy's gated warehouse area where S&ME maintained a laydown area for equipment and supplies. All drilling and surface geophysical survey locations were within fenced areas and accessed through Duke Energy gates. Keys and automatic gate operators were provided to S&ME and HDR staff to facilitate efficient access and execution of work. GEL Solutions was accompanied by HDR staff for gate access to geophysical survey line

locations. One of the drilling locations (Boring B-21-4) did not require any road improvement or drill pad construction. Boring B-21-2 required installation of a steel plate across the Bad Creek Road ditch and application of gravel for a limited distance off Bad Creek Road to prevent rutting of the soil due to daily support vehicle and water truck traffic. Borings B-21-1 and B-21-5 required some grading and clearing on the existing gravel road adjacent to the Upper Reservoir to facilitate drill rig set up and daily support vehicle and water truck access. Boring B-21-3 required construction of a new road and drill pad to provide drill rig, water truck, and support vehicle access on the southeast facing slope east of Bad Creek Road. Sumps to collect drill water and cuttings were constructed at borings B-21-1, B-21-2, B-21-3, and B-21-5. Duke Energy staff completed all site access improvements.

After completion of drilling, Duke Energy backfilled the sump areas and graded the ground surface. S&ME's subcontractor (Strickland, Inc.) completed drill site restoration including spreading and grading of any ruts and drill cuttings and application of seeding and straw to restore grass cover over the soil. Figure 1 shows the general site configuration.



Figure 1. Bad Creek II Geotechnical Investigation General Site Features Geotechnical Drilling

Borings were advanced vertically using either a track-mounted Burley D50 or ATV CME 550. Drilling through overburden/soil was accomplished using a 2 and 7/8-inch wash rotary bit with SPT at 5-ft intervals. Upon refusal at top of rock, the borings were reamed using a 4 and 7/8-inch-diameter wash rotary bit then HW casing installed into bedrock. Drilling in bedrock was achieved using HQ triple tube wireline coring with advancement of HW casing using a tri-cone bit at the casing shoe when needed to stabilize potentially unstable zones encountered during rock coring.

3.1.1 Standard Penetration Test (SPT) Sampling Method

Samples were collected from each borehole for purposes of geologic evaluation and geotechnical testing. SPTs were performed in general accordance with ASTM International (formerly American Society for Testing and Materials; ASTM) D1586-11, Test Method for Penetration Test and Split-Barrel Sampling of Soils. An 18-inch-long, 2-inch-outside-diameter, 1.375-inch-inside-diameter, split-spoon sampler was driven with an automatic 140-pound hammer, falling from a height of 30 inches. The number of blows required to achieve each of three, 6-inch increments of sampler penetration was recorded. The number of blows required to cause the last 12 inches of penetration is termed the Standard Penetration Resistance (N-value). When penetration resistances exceeded 50 blows for 6 inches or less of penetration, the test was generally terminated and the number of blows, along with the penetration distance, was recorded on the borehole log. All recovered SPT samples were transported to S&ME for laboratory testing as described in Section 3.5. Thirty-three of the samples recovered sufficient soil material for laboratory testing.

3.1.2 HQ-3 Triple-Tube Rock Coring

Rock core samples were obtained using a 5-ft-long, HQ-size, triple-tube core barrel. The triple-tube core barrel consists of inner and outer barrels and a split inner core tube. The outer barrel rotates while the inner barrel and inner split tube remain stationary. This system protects the core from the drilling fluid and reduces the torsional forces transmitted to the core. In addition, the split inner tube allows for detailed visual analysis of the relatively undisturbed core sample once it is extracted from the borehole. Most core runs were 5 ft long, although runs as short as 0.3 ft were made to improve recovery where low-rock-quality material was encountered. Cuttings were removed from the borehole circulating water through the drill steel and casing. The water used for drilling was obtained from the fire protection pond located in the former construction yard where Duke Energy has a warehouse, office, and maintenance facilities.

The drilling performed throughout the geotechnical investigation was high quality. Core drilling in 5-ft runs with an HQ triple barrel resulted in high recovery. There were few instances of core damage/loss from the drilling. When bedrock was severely weathered, there were indications of wash out and core loss. Careful extraction of the inner barrel using water pressure to push the inner barrel allowed extraction of the core without mechanical disturbance. In some cases, HWT casing was advanced into the bedrock to case through potentially unstable zones and prevent borehole collapse.

Rock core was logged and placed into wooden core boxes. In each core box, rock core was arranged in descending sequence beginning at the upper left end of the core box partition and continuing in the other partitions from left to right. Each core run was separated from the preceding run by blocks labeled with the depth. Each rock core box was photographed in the field after it was completely filled and the box properly labeled. On completion of drilling, core boxes were delivered by HDR personnel to the core shed located within the Duke Energy facilities area. Select core

samples were designated for laboratory testing after a detailed core review. Rock core samples were wrapped with pipe insulation and duct tape and shipped to the selected laboratory GeoTesting Express of Acton, MA for the specified testing.

3.1.3 Water Pressure (Packer) Testing

Water pressure (WP) tests were performed in each borehole in bedrock to estimate in-situ hydraulic conductivity (k). WP tests were performed after drilling to final depth using a double packer system test apparatus, a water pump, and clean water obtained from the Duke Energy fire pond water supply. The rock core was evaluated as it was recovered and later transported to the storage facility where zones for WP testing were evaluated. Fractures in the bedrock were the main contributing factor to rock mass hydraulic conductivity. For borehole intervals where there were few or no fractures, the rock mass had an extremely low hydraulic conductivity (no water take at the maximum test pressure).

The Longyear Wireline Packer Type II system was used for packer testing at intervals specified by HDR geologists in the field. The packer system used a double packer with the stem length between packers at 5.5 ft. The HQ Wireline Packer has a deflated outer diameter of 2.13 inches (Gland) and inflated outer diameter of 4.6-inches which provided for successful packer seal in the nominal 3.8-inch HQ core hole. Packers were connected to a nitrogen gas source at the ground surface and expanded once in place at the proper depth. The nitrogen tanks were provided by S&ME and had readout pressure gauges mounted on the tank assembly lines. A Moyno[™] pump bolted to the side of the drill rig was used to inject water at pressures specified by HDR into the rock at the packer test zone. A water flow meter and readout gauge were monitored by the HDR geologist to record the water inflow and pressure. The water pressure remained relatively constant during the WP tests with a few exceptions where test pressure could not be obtained in the test zone.

Testing was performed using the procedure outlined in the U.S. Bureau of Reclamation (1995) manual, which is a variation of Houlsby's (1976) method. As per of the USBR (1995) procedure using a series of stages, the test pressure was stepped up to a maximum pressure, calculated based on the estimated overburden pressure and the hydrostatic water level at the time of the testing, and then stepped back up and down over five stages with the third stage being the maximum. Houlsby's (1976) interpretative procedure was used to characterize the type of flow in the subsurface fractures. The pressure and flowmeter readings were taken at regular intervals and were used in the calculation of the k value. Results of the WP testing are presented in Appendix C and Table 5 and are discussed in Section 4.1.2.

3.2 Monitoring Wells

To monitor groundwater elevations, monitoring wells were installed in borings B-21-2 and B-21-3. Two-inch-inner diameter PVC screen and two-inch inner diameter PVC riser was used to construct the wells. Monitoring well construction details are presented in Appendix D.

3.3 Surface Geophysical Surveys

To investigate the subsurface conditions at the proposed locations of the Upper Reservoir I/O structure, the Lower Reservoir I/O structure, the proposed low pressure headrace tunnels and gate shafts, and the vertical water intake shafts area, seismic refraction and MASW line surveys were carried out by GEL Solutions. Twenty-three transects totaling approximately 6,000 linear ft were

surveyed. The objective of the surface geophysical investigations was to produce profiles along the transects allowing the interpretation of the top of partially weathered rock (PWR) and top of unweathered rock (UWR) in conjunction with the boring and downhole logging data. The work was conducted from February 23, 2021, through March 5, 2021.

Prior to collecting seismic data, the transects were located with a Trimble 6 RTK/GPS and vegetation was cleared using hand tools as needed. GEL Solutions utilized an existing LiDAR topographic survey of the site to adjust the profiles for surface elevation variations.

Seismic refraction surveys were conducted using 10-hertz geophones spaced 10 ft apart and using a16 pound sledgehammer striking a plate (energy source) space every 30 ft along the line. MASW surveys were conducted using 10-hertz geophones spaced 10 ft apart with 16-pound sledgehammer strikes at 10 ft spacing along the transect. GEL Solutions collected and processed data using SeisImager software by Geometrics. Seismic refraction surveys provide two-dimensional V_p profiles and MASW surveys provide two-dimensional V_s profiles

The locations of the surface geophysical survey lines are presented on Project Drawings P-58, P-59, and P-61 presented in Appendix A. The GEL Solutions surface geophysical survey report is included in Appendix E.

3.4 Downhole Geophysical (Optical and Acoustic) Logging

Downhole optical and acoustic televiewer and three-arm caliper logs were completed by GEL Solutions and used to log each boring as far as the probes were able to go. Each borehole was flushed prior to downhole logging to provide the clearest possible borehole image. First, the optical image televiewer was used for the entire boring and the results were examined. In portions of the boring where water was present, an acoustic probe was used to survey the borehole in addition to optical logging. For zones where water within the borehole became cloudy even after flushing, the acoustic televiewer image was relied on to provide borehole information. Three-armed caliper logging was completed in each boring to measure the borehole diameter and its variations that are used to assess zones of poor recovery and specific features such as weathered zones observed in the rock core.

During post-processing, the optical and acoustical images are unwrapped, analyzed, and displayed. The displays show an image that simulates an intact core sample, which can be compared to the extracted sample. These images were analyzed for foliation, natural fractures and joints, fracture openness or width, and shear zones and provide orientation (dip and dip direction) of each feature. When compared with the actual core samples obtained from the boreholes, intervals of core loss and where core damage occurred were identified and the downhole images used to update information missing from the core logs. The GEL Solutions downhole geophysical report is presented in Appendix V.

3.5 Laboratory Testing

Soil and rock sample selection for testing was carried out by HDR from June 28 through July 2, 2021.

3.5.1 Soil Testing

Soil samples from SPT sampling were stored in sample jars and labelled at the time of drilling for laboratory testing and subsequently shipped to S&ME for testing (see Appendix G). Of the 43 SPT's completed, 33 of the soil samples recovered enough material for laboratory analysis to characterize the properties for the residual soil bedrock overburden and the soil portion of the landslide deposit at the Lower Reservoir I/O. In addition, one sample of soil material from rock core (RC-1) was obtained in B-21-4 and shipped to S&ME for testing. The laboratory testing summary for all soil samples is shown in Table 2 and the results are discussed in Section 5.1.

| Table | 2. | Soil | Sample | Laboratory | Testing |
|-------|----|------|--------|------------|---------|
|-------|----|------|--------|------------|---------|

| Laboratory | Test Method Name | ASTM Test Designation | Number of Tests |
|----------------------|---------------------------------|-----------------------|-----------------|
| | Gradation without Hydrometer | D6913 | 34 |
| S&ME, Greenville, SC | Atterberg Limits | D4318 | 34 |
| | Natural Moisture | | 34 |

ASTM: American Society for Testing and Materials

3.5.2 Rock Testing

Rock core samples were selected to characterize the splitting tensile strength, unconfined compressive strength (UCS), and intact rock modulus of the major lithologies of the TGn discussed in Section 2. The rock core samples were selected at the time of detailed core review after completion of the drilling program, packaged to prevent breakage, and shipped to GeoTesting Express for testing (see Appendix H).

The laboratory testing summary for rock samples is shown in Table 3 and the results are discussed in Section 5.2.

| Laboratory | Test Method Name | ASTM Test Designation | Number of Tests |
|-----------------------|---|-----------------------|-----------------|
| Geotesting | Unconfined Compression Strength with Modulus | D7012-D | 15 |
| Express, Acton, MA | Unconfined Compression Strength | D7012-C | 20 |
| | Splitting Tensile Strength | ASTM D3967 | 20 |

Table 3. Rock Core Laboratory Testing

4 Field Investigation Results

4.1 Subsurface Data Evaluation Process

Site investigation data was derived from several different methods (e.g., borehole drilling, downhole geophysical logging, surface geophysical surveys, WP testing, laboratory testing, engineering evaluation). All exploration methods and associated data may not have been obtained in some or all portions of each boring (for example, packer tests were performed at selected intervals based on review of the rock core).

Boring logs present data from each borehole (with the exception of downhole geophysical data that

is presented in Appendix F). The borehole depth is the first column on the left side of the log. The next column to the right provides the sample type and number including soil or rock core. The sample type is either an SPT as described in Section 3.1.1 or rock core run as described in Section 3.1.2. The next column to the right provides the number of blow counts in the SPT sampling process followed by the number of inches of soil recovery in the SPT sampler. The following columns provide rock core recovery and RQD. The material descriptions in each log represent a standardized field method of describing soil and rock developed by an HDR Senior Engineering Geologist based on a synthesis of published logging procedures. Material descriptions provide detailed information about the soil and/or rock unit encountered and contains information on soil/rock type, grain size, color, strength, weathering, plasticity (soil), and fracture spacing. Material descriptions are important for gaining an overall understanding of the rock or soil. Additional details such as drilling methods and conditions, casing depth, laboratory test results, WP test intervals, water level measurements, loss drilling fluid circulation, and any other pertinent information are detailed in the "Remarks" column on the right of the boring log sheets.

Rock cores were placed in core boxes, described in the field, then photographed and transported to the Duke Energy warehouse for storage, final core logging and subsequent review, and laboratory testing sample selection.

4.1.1 Standard Penetration Test, Recovery, and Rock-Quality Designation

As described in Section 3.1.1, SPT was performed within the overburden soils and the resulting N-values in blows/foot reported in parentheses on the boring logs. Fifty or more blows per 6 inches was considered refusal. This is represented with a notation showing the penetration in inches after 50 blows on the logs. For example, 50/2", is read as 50 blows for 2 inches of split-spoon penetration.

At the soil rock interface, the data collection method transitioned from SPT to rock coring where recovery and RQD were measured for each core run. Recovery represents the portion (reported as a percent) of the total core run length (typically 5 ft) that remains in the triple tube barrel when extracted from the boring. High recovery is desirable for understanding and interpreting the bedrock. Most of the core runs resulted in 100 percent recovery and recoveries less than 90 percent were limited to the upper 15 ft of rock when severely weathered rock with very close joint spacing was encountered in Boring B-21-1 and B-21-3. RQD is an approximate measure of rock quality and the jointing or fracturing of the rock mass. RQD is defined as the percentage of the length of intact core pieces longer than 100 millimeters (4 inches) divided by total length of the core run.

Based on the borings completed for this Phase II Geotechnical Study RQD increases with depth. Some exceptions across the site emerge when the RQD data is parsed into depth intervals and location as shown in Table 4. Boring B-21-1, B-21-3, and B-21-4 all have lower RQD values in the upper 50 ft indicating a more fractured and weathered rock mass. Boring B-21-2 and B-21-5 do not show the same trend. In addition, the RQD value of 56 percent in Boring B-21-3 occurs at a weathered shear zone at depth of 266.2 to 269.2 ft. There are borings from previous investigations near the proposed water conveyance alignment that are not included in this general assessment of RQD.

| Borings | Depth Interval Below Refusal (ft) | Minimum | Average | Maximum |
|---------|--------------------------------------|---------|---------|---------|
| | 37.5-87.5 | 42 | 85.8 | 100 |
| B-21-1 | 87.5-137.5 | 80 | 96.2 | 100 |
| | 137.5-250.8 | 98 | 99.9 | 100 |
| | 61.5-111.5 | 86 | 94.3 | 100 |
| B-21-2 | 111.5-161.5 | 83 | 91.7 | 100 |
| | 161.5-300.8 | 77 | 96.4 | 100 |
| | 20.5-70.5 | 0 | 77.4 | 100 |
| B-21-3 | 70.5-120.5 | 96 | 99.6 | 100 |
| | 120.5-500.4 | 56 | 99.2 | 100 |
| D 01 4 | 90.5-140.5 | 52 | 79.7 | 92 |
| D-21-4 | 140.7-151.0 | 70 | 85 | 100 |
| P 21 5 | 59.2-109.2 | 91 | 99.1 | 100 |
| D-21-3 | 109.2-120.3 | 100 | 100 | 100 |

Table 4. RQD Variations in the Borings

4.1.2 Water Pressure Test Results

WP tests were performed in the borings after drilling was completed to evaluate the in-situ hydraulic conductivity as described in Section 3.1.3. WP tests were performed at selected intervals designated by HDR based on the anticipated potential for fractures or fracture systems to conduct water. The data from the WP testing were entered into a spreadsheet for processing and analysis. These spreadsheets are included with this report in Appendix C.

• Twenty-five WP tests were performed. Seven were performed in Boring B-21-1, eleven in Boring B-21-2, seven in Boring B-21-3, and two in Boring B-21-5.

Table 5 shows the results of all WP tests with the red text highlighting values that may be caused by leakage of the packer system for four tests in Boring B-21-2. The similarity of these values at 1.3 to 2.7E-06 centimeters/second (cm/sec) raised suspicion of a system leak. In three tests, pressure could not be built due to high permeability zones. These zones were:

- B-21-1: 45.2 to 50.7 ft. (8.3 ft below auger refusal). Bypass of upper packer due to fractured rock. Core logged as having moderate to severe weathering, close to very close joint spacing, and two open joints.
- B-21-3: 265.0 to 270.5 ft. Weathered shear zone from 266.2 to 269.2 ft.
- B-21-3: 75.0 to 80.5 ft (54.3 ft below auger refusal). Open joints at 79.2 and 79.3 ft with iron staining. One test in Boring B-21-3 from 68.5 to 74.0 ft (47.8 ft below auger refusal) had an open iron-stained fracture logged at 69.5 ft and resulted in K=1.1E-04 cm/sec.

Five tests resulted in no measured water take at injection pressures of 60 to 70 pounds per square inch (psi). These zones were selected for WP due to the presence of at least one fracture. These zones were:

- B-21-3: 286.1 to 291.6 ft (70 psi)
- B-21-3: 250.0 to 255.5 ft (70 psi)

- B-21-3: 244.5 to 250.0 ft (70 psi)
- B-21-3: 92.0 to 97.5 ft (70 psi)
- B-21-5: 67.5 to 73.0 ft (60 psi)

The remaining thirteen WP tests resulted in k values ranging from 5.7E-06 to 9.3E-05 cm/sec. The tests resulting in values higher than the 5.7E-06 to 9.3E-05 cm/sec range occurred at depths less than 55 ft below refusal (interpreted as TWR) with the exception of the shear zone encountered in Boring B-21-3 at a depth range of 266.2 to 269.2 ft below ground surface. The WP test data show that rock mass permeability is highest within an upper weathered zone generally within 50 ft below TWR and along a weathered shear zone at greater depths. Outside of these upper weathered and the weathered shear zone, the rock mass permeability is within the range of k 5.7E-06 to 9.3E-05 cm/sec due to fracture flow. Unfractured rock has no measurable permeability within the parameters of the water pressure injection test procedures.

Table 5. Water Pressure Test Results

| Borehole | Test No. | Top of Borehole (Elevation - Feet) | Depth (ft) | | Depth (ft) Elevation (ft) | | | Depth of Hole (ft) | Water Level (ft) | Hydraulic Conductivity, k (cm/sec) | Remarks - Test Interval Description | Test Interpretation | |
|----------|----------|---------------------------------------|------------|----|---------------------------|--------|----|-----------------------|------------------------|--|-------------------------------------|--|--|
| | Test 1 | 2320.5 | 91.4 | to | 96.9 | 2229.1 | to | 2223.6 | 250.8 | 22.4 | 2.4E-05 | GRANITIC GNEISS, very hard, medium- to coarse-grained, fractures close to moderately close, very slight weathering to fresh. | Laminar flow. Decrease in flow with step-down pressures likely due to infilling/clogging of fractures during the test. |
| | Test 2 | 2320.5 | 75.2 | to | 80.7 | 2245.3 | to | 2239.8 | 250.8 | 25.6 | 7.3E-05 | GRANITIC GNEISS, very hard, medium- to coarse-grained, fractures close to moderately close, very slight weathering to fresh. | Laminar flow. Decrease in flow with step-down pressures likely due to infilling/clogging of fractures during the test. |
| B-21-1 | Test 3 | 2320.5 | 60.2 | to | 65.7 | 2260.3 | to | 2254.8 | 250.8 | 25.6 | 5.4E-05 | GRANITIC GNEISS, very hard, medium- to coarse-grained, fractures close to moderately close, very slight weathering to fresh. | Laminar flow in low permeability zone. Some removal of material in the fractures shown by the increase in flow rate during the step-down pressures. |
| | Test 4 | 2320.5 | 45.2 | to | 50.7 | 2275.3 | to | 2269.8 | 250.8 | 25.6 | _ | GRANTIC GNEISS, very hard, medium- to coarse-grained, fractures close to moderately close, slight to very slight weathering. | High permeability zone - Not able to build pressure due to leakage around the upper packer at maximum pump capacity. k in 10 ⁻¹ to 10 ⁻² cm/sec range. |
| | Test 5 | 2320.5 | 39.9 | to | 45.4 | 2280.6 | to | 2275.1 | 250.8 | 25.6 | 3.1E-05 | GRANITIC GNEISS, very hard, medium- to coarse-grained, fractures close to moderately close, slight to very slight weathering. | Laminar flow in low permeability rock fracture zone. |
| | Test 1 | 2283.1 | 187.5 | to | 193.0 | 2095.6 | to | 2090.1 | 300.8 | 36.4 | 9.2E-06 | GRANITIC GNEISS, very hard, medium- to coarse-grained, moderate weathering to fresh, fractures tight to open at 10-to- 45-degree dips, iron-staining present. | Practically Impermeable - Minimal Intake with an overall decrease in permeability with pressure and time indicating incomplete blockage of fractures by transported material. |
| | Test 2 | 2283.1 | 179.5 | to | 185.0 | 2103.6 | to | 2098.1 | 300.8 | 31.9 | 6.5E-05 | GRANITIC GNEISS, very hard, medium- to coarse-grained, fresh joints, tight to open, 180.0' to 181.2' - highly fractured, Mn- and iron-staining present. | Low permeability with some washing out of material from the fractures increasing the permeability over Steps 4 and 5. |
| | Test 3 | 2283.1 | 167.0 | to | 172.5 | 2116.1 | to | 2110.6 | 300.8 | 33.2 | 6.4E-05 | GRANITIC GNEISS, very hard, medium- to coarse-grained, moderately severe weathering, very close joints (168.5'-169.3' - highly fractured), tight to open, iron-staining. | Flow is laminar without removal of material or on clean fractures, discharge proportional to pressure head. |
| | Test 4 | 2283.1 | 161.5 | to | 167.0 | 2121.6 | to | 2116.1 | 300.8 | 26.4 | 2.8E-05 | GRANITIC GNEISS, very hard, medium- to coarse-grained, fresh, hornblende augen, tight fractures at 20-to-50-degree dips, minor iron-staining. | Laminar flow, low permeability with some washing out of material from the fractures increasing the permeability during the duration of the test. |
| | Test 5a | 2283.1 | 166.5 | to | 172.0 | 2116.6 | to | 2111.1 | 300.8 | 20.5 | 8.7E-05 | GRANITIC GNEISS, hard, moderately severe weathering, very close joints, tight to open, with some iron-staining. | Laminar flow with low permeability and slight washing out of fractures. |
| B-21-2 | Test 5 | 2283.1 | 123.4 | to | 128.9 | 2159.7 | to | 2154.2 | 300.8 | 38.8 | 2.7E-06 | GRANITIC GNEISS, very hard, medium- to coarse-grained, unweathered, and unfractured. | Low permeability zone; irregular flow that did not stabilize during pressure stages of the test. Estimated permeability k = 2.7E-06 cm/sec. Estimated value is questionable; could be due to leakage in the system and not water intake into rock fractures. |
| | Test 6 | 2283.1 | 115.5 | to | 121.0 | 2167.6 | to | 2162.1 | 300.8 | 33.1 | 1.5E-06 | GRANITIC GNEISS, very hard, medium- to coarse-grained, fresh. | First run of test leakage around upper packer at 95 psi at start of Stage 3. Second run = Low permeability zone; irregular flow that did not stabilize during pressure stages of the test. Estimated permeability $k = 1.5E-06/$ cm/sec. Estimated value is questionable; could be due to leakage in the packer system and not water intake into rock fractures. |
| | Test 7 | 2283.1 | 99.5 | to | 105.0 | 2183.6 | to | 2178.1 | 300.8 | 37.7 | 1.7E-06 | GRANITIC GNEISS, soft, moderate weathering, close to very close iron-stained joints, highly fractured zone. | Low permeability zone; irregular flow that did not stabilize during pressure stages of the test. Estimated permeability $k = 1.7E-06$ cm/sec Estimated value is questionable; could be due to leakage in the packer system and not water intake into rock fractures. |
| | Test 8 | 2283.1 | 85.5 | to | 91.0 | 2197.6 | to | 2192.1 | 300.8 | 26.5 | 1.2E-04 | GRANITIC GNEISS, light gray, hard, thickly banded, very slight weathering, single open joint with iron-staining. | Water flow back up drill steel when reducing pressure from Stage 3 to 4 and Stage 4 to 5. Water table at end of test at 16.90 feet indicating leakage above the upper packer. Estimated permeability, $k = 1.2E-04$ cm/sec, is suspect and questionable because of water backflow and upper packer leakage; could be due to leakage in the packer system and not water intake into rock fractures. |

| Borehole | Test No. | Top of Borehole (Elevation - Feet) | Depth (ft) | | Elevation (ft) | | | Depth of Hole (ft) | Water Level (ft) | Hydraulic Conductivity, k (cm/sec) | Remarks - Test Interval Description | Test Interpretation | |
|----------|----------|---------------------------------------|------------|----|----------------|--------|----|-----------------------|------------------------|--|-------------------------------------|---|--|
| | Test 9 | 2283.1 | 70.5 | to | 76.0 | 2212.6 | to | 2207.1 | 300.8 | 21.3 | 1.2E-05 | GRANITIC GNEISS, medium- to coarse-grained, thinly to thickly banded with thin quartz bands, joints spaced close, 72.2' - 74.4' - 10- to 30-degree dip, close to open foliation joints, iron-staining. | Relatively low permeability, laminar flow with minor washing out of material from fractures. |
| | Test 10 | 2283.1 | 64.5 | to | 70.0 | 2218.6 | to | 2213.1 | 300.8 | 34.6 | 3.8E-05 | GRANITIC GNEISS, medium- to coarse-grained, thinly to thickly banded with thin quartz bands, moderately weathered, joints spaced close, open foliation joints 10- to 40-degree dips, iron-staining. | Relatively low permeability, laminar flow with deceasing permeability due to incomplete blocking of fractures be transported materials. |
| | Test 1 | 2230.1 | 286.1 | to | 291.6 | 1944.0 | to | 1938.5 | 500.4 | 149.0 | - | GRANITIC GNEISS, very hard, medium- to coarse-grained, fresh (rock), fractures, iron- and Feldspar staining present, 288.7' to 289.9', fault zone 50° to 70° dip. | No take at 70 psi. |
| | Test 2 | 2230.1 | 265.0 | to | 270.5 | 1965.1 | to | 1959.6 | 500.4 | 149.0 | - | GRANITIC GNEISS, moderately hard to hard, moderate to slight weathering, shear zone from 265.4' to 269.2' consisting of numerous low angle open fractures with iron-staining. | Pumped ~200 gallons at 26 gpm; interval did not build pressure; high permeability related to the shear zone that crosses the test interval. |
| B-21-3 | Test 3 | 2230.1 | 250.0 | to | 255.5 | 1980.1 | to | 1974.6 | 500.4 | 149.0 | - | QUARTZ FELDSPAR GNEISS, very hard, medium- to very coarse-grained, very hard; at 253.4' contact with GRANITIC GNEISS hard to very hard, fine- to coarse-grained, slight weathering to fresh, fractures at 21.2', 30° dip, chlorite mineralization, 254.0', 30° dip, partially open, 254.0' 30° dip, iron-staining, trace clay. | No take at 70 psi. |
| | Test 4 | 2230.1 | 244.5 | to | 250.0 | 1985.6 | to | 1980.1 | 500.4 | 144.4 | - | GRANITIC GNEISS, very hard, fine-grained, thinly to thickly laminated, at 249.2' contact with QUARTZ FELDSPAR GNEISS, very hard, medium- to very coarse-grained, fractures at 248.3', 60° dip, tight, chlorite mineralization, 278.2', 20° dip, tight, chlorite mineralization. | No take at 70 psi. |
| | Test 5 | 2230.1 | 92.0 | to | 97.5 | 2138.1 | to | 2132.6 | 500.4 | 145.6 | - | GRANITIC GNEISS, very hard, medium-grained, thinly to thickly laminated, fresh weathering, open fracture at 94.8', 15° dip. | No take at 70 psi. |
| | Test 6 | 2230.1 | 75.0 | to | 80.5 | 2155.1 | to | 2149.6 | 500.4 | 155.7 | - | GRANITIC GNEISS, very hard, medium-grained, foliated, thinly to thickly laminated, fresh weathering, open fractures at 79.2' - 20° dip; 79.3' - 30° dip. | Flow rate at 24.5 gpm at 5 psi. Flow too high for a complete test. High permeability zone. |
| | Test 7 | 2230.1 | 68.5 | to | 74.0 | 2161.6 | to | 2156.1 | 500.4 | 150.2 | 1.1E-04 | GRANITIC GNEISS, very hard, medium-grained, very slight weathering to fresh, fractures at 69.5', 25° dip, tight, minor iron-staining, 72.9', 20° dip, biotite (?). | Flow is laminar without removal of material or on clean fractures, discharge proportional to pressure head. |
| | Test 1 | 2314.0 | 67.5 | to | 73.0 | 2246.5 | to | 2241.0 | 120.3 | 21.4 | - | GRANITIC GNEISS, with fractures along foliation, slight iron- staining. | No take at 60 psi. |
| B-21-5 | Test 2 | 2314.0 | 62.5 | to | 68.0 | 2251.5 | to | 2246.0 | 120.3 | 16.3 | 5.5E-06 | GRANITIC GNEISS, with fractures along foliation with minor iron-staining. | Low permeability zone: irregular flow that did not stabilize during pressure stages of the test. Estimated permeability $k = 5.7E-06$ cm/sec (Stage 5 pressure excluded due to no take). |

4.1.3 Downhole Optical and Acoustic Televiewer Data

Optical televiewer logging was performed below any installed casing and acoustic televiewer logging was performed below the water level in the borings at the time of logging as described in Section 3.5.

The results of the televiewer data are presented in Appendix F and include:

- **Unwrapped Televiewer Image:** The walls of the boreholes unwrapped to a flat surface. The 360-degree unwrapped image begins with the zero degree representing magnetic north (azimuth).
- **Structure:** Discontinuity structure data is presented as dip direction, dip, and structure type on a tadpole plot. The dip direction is indicated by the orientation of the tick on each tadpole with up being 0/360 degrees. The dip is indicated by the x-axis location on the graphic column ranging from 0 (horizontal) to 90 (vertical) degrees.
- Stereonet Plots: Rose diagram plots developed by GEL Solutions and lower hemisphere stereonet plots developed by HDR (Appendix I) present the sources of identification of foliation and prominent joint/fracture sets.

The televiewer data were analyzed to identify rock type, joint structure, and other defects and characteristics that may influence hydraulic conductivity, excavation methods, stability, and treatment/stabilization requirements. Rock structure types identified from the televiewer data are presented in Table 6.

| Designation | Rock Structure Type |
|-------------|--------------------------------|
| S-F | Fracture/Joint Along Foliation |
| F | Joint |
| S | Foliation |
| Sh-F | Shear Plane |
| Flt | Fault Plane |

 Table 6. Rock Structure Types

Review of the televiewer data and other structural characteristics indicated a limited range of discontinuity orientations throughout the site subsurface. Foliation generally dips to the southeast with dip ranging from 19 degrees in Boring B-21-4 at the proposed Lower Reservoir I/O location to 36 degrees at the proposed Upper Reservoir I/O structure. Table 7 presents the statistical maximum of foliation at each boring location based on stereonet plots of the downhole data utilizing DIPS Version 8.008 software. The downhole data used was generated by GEL Solutions through downhole televiewer analysis wherein foliation was identified and measured approximately every 10 ft for each borehole. The stereonets for each boring presenting foliation and joint sets based on the downhole structural data as interpreted by HDR are presented in Appendix I Downhole Data Stereonets.

| Boring | Orientation |
|--------|-------------|
| B-21-1 | N34E, 36SE |
| B-21-2 | N43E, 28SE |
| B-21-3 | N27E, 23SE |
| B-21-4 | N43E, 19SE |
| B-21-5 | N40E,35SE |

Table 7. Foliation Orientations

Most joints observed in the downhole televiewer data are joints along foliation. One additional discontinuity set strikes generally N70E and dips 60 to 65 degrees to the NW. An additional discontinuity set strikes N76E and dips 35 degrees to the NW. Table 8 presents the discontinuity sets identified in each boring from the downhole optical and acoustic televiewer data. The set number corresponds to the set identified on the stereonets presented in Appendix I.

| Boring | Set Number ¹ | Orientation | Discontinuity type |
|--------|-------------------------|-------------|------------------------------------|
| B-21-1 | 1m | N36E;17SE | Foliation Joint (S-F) ² |
| B-21-1 | 2m | N45E; 5NW | Joint (F) |
| B-21-2 | 1m | N48E; 25SE | Foliation Joint (S-F) |
| B-21-2 | 2m | N69E; 63NW | Fault/Joint (Flt & F) |
| B-21-2 | 3m | N76E; 35NW | Joint (F) |
| B-21-3 | 1m | N46E; 21SE | Foliation Joint (S-F) |
| B-21-4 | 1m | N28E;11SE | Foliation Joint (S-F) |
| B-21-5 | 1m | N60E; 30SE | Foliation Joint (S-F) |
| B-21-5 | 2m | N71E; 65NW | Foliation Joint |

Table 8. Major Discontinuity Fracture Sets

1. From Stereonets in Appendix I.

2. Abbreviation for Rock Structures used on the Stereonets in Appendix I.

A number of specific discontinuities comprised of faults and shear zones were identified during rock core inspection and then compared to the optical and acoustic televiewer logs. Some but not all of the faults and shear zones were discernible in the optical and acoustic logs. Table 9 presents the boring in which each feature was observed, the depth, strike, dip, and description. The shear zones are parallel to foliation/banding in the TGn consistent with previous observations and geologic mapping (Schaeffer 2016). Faults generally dip 55 to 70 degrees to the northwest.

| Boring/Set Number | Strike | Dip | Description | Depth in Borehole |
|----------------------|--------|------|-------------|----------------------|
| | N78E; | 56NW | Flt | 167.6 |
| | N72E | 54NW | Flt | 168.2 |
| | N68E | 62NW | Flt | 168.5 |
| B 01 0 | N67E | 60NW | Flt | 168.6 |
| D-21-2 | N67E | 63NW | Flt | 180.4 |
| | N88W | 66S | Flt | 180.5 |
| | N65E | 62NW | Flt | 180.6 |
| | N66E | 65NW | Flt | 180.8 |

Table 9. Shear Zones and Fault Features

| Boring/Set Number | Strike | Dip | Description | Depth in Borehole |
|----------------------|--------|-------|-------------|----------------------|
| | N68E | 61NW | Flt | 214.5 |
| | N45E | 24SE | Sh-F | 253.0 |
| | N47E | 28SE | Sh-F | 253.0 |
| | N69E | 27SE | Sh-F | 253.1 |
| | N66E | 28SE | Sh-F | 253.1 |
| | N62E | 26SE | Sh-F | 253.2 |
| | N59E | 27SE | Sh-F | 253.3 |
| | N60E | 32SE | Sh-F | 253.3 |
| B-21-3 | N77W | 28SSE | Sh-F | 253.7 |
| | N64E | 30SE | Sh-F | 254.0 |
| | Ν | 11E | Sh-F | 265.2 |
| | N49E | 16SE | Sh-F | 266.4 |
| | N15W | 10ENE | Sh-F | 266.5 |
| | N22E | 31SE | Sh-F | 266.7 |
| | N31E | 32SE | Sh-F | 266.8 |
| | N59E | 28SE | Sh-F | 267.1 |
| | N65E | 21SE | Sh-F | 267.2 |
| | N66E | 70NW | Flt | 287.8 |
| | N64E | 62NW | Flt | 287.9 |

4.1.4 Surface Geophysical Refraction and MASW Results

GEL Solutions collected seismic refraction and MASW data along 23 transects that varied in length from 31 to 602 ft each (see Table 10). The total length of transects completed along ground surface is 6,078 ft. Site conditions dictated that the transect locations varied somewhat from the planned locations. Three sections of the initially proposed transects were excluded due to areas of steep terrain that were not safely accessible and that presented technical challenges related to the reliability of data collection on steep slopes. Sections between U2A and U2B, L5A and L6A, and L9A and L9B were eliminated due to these limitations. Drawings P-58, P-59, and P-61 in Appendix A present the locations of the geophysical lines.

| Transect | Length (ft) |
|------------|-------------|
| U1 to U2 | 270 |
| U2 to U2A | 280 |
| U2A to U2B | 109 |
| U2B to U3 | 141 |
| U4 to U4A | 140 |
| U4A to U4B | 207 |
| U4B to U5 | 161 |
| U6 to U7 | 499 |
| U8 to U9 | 400 |
| U10 to U11 | 400 |
| U12 to U13 | 602 |
| U14 to U15 | 400 |
| L1 to L2 | 453 |
| L3 to L4 | 280 |
| L5 to L5A | 89 |
| L5A to L6A | 462 |
| L6A to L6 | 462 |
| L7 to L8 | 233 |
| L8 to L9B | 205 |
| L9B to L9A | 31 |
| L9A to L9 | 161 |
| L10 to L11 | 170 |
| L12 to L13 | 270 |

Table 10. Surface Geophysics Line Transects

The purpose of conducting the seismic refraction and MASW surveys is to develop reasonably accurate profiles of PWR and UWR that can be used by HDR in estimates of excavation requirements for the proposed Upper and Lower Reservoir I/O works and gate and vertical intake shafts yards. GEL Solutions used both the seismic refraction and MASW data to interpret top of PWR and top of UWR that are presented as dashed pink lines for PWR and dashed cyan lines for UWR on the seismic refraction and MASW profiles presented in Appendix F. Borings from the previous investigations for the Bad Creek 1 construction were provided to GEL Solutions to assist with calibration of interpretations with available drilling data. GEL Solutions interpretations of the PWR and UWR were reviewed and revised by HDR prior to developing preliminary excavation objectives. Using borehole data and knowledge of the characteristics of the granitic gneisses at the site (including V_p and V_s values in partially and un-weathered TGn) gained from previous site investigations that include drilling, surface geologic mapping, detailed mapping of the existing Bad Creek subsurface structures, and current geologic mapping of a landslide at the Lower Reservoir I/O. HDR reinterpreted the seismic data and those interpretations are discussed in Volume 7 – Appendix D.

4.1.5 Monitoring Wells

Table 11 lists the borings and monitoring well screened interval depths and measured static water level. The water levels reported in Table 11 were measured on June 26, 2021. Drilling was completed in Boring B-21-2 on May 13, 2021, and water pressure tests were completed on May 20, 2021. Drilling was completed on May 12, 2021, in Boring B-21-3 and water pressure tests completed on May 20, 2021. Due to the duration of time (36 days) between the completion of water pressure tests and the final water level measurement, the water levels reported in Table 11 are considered representative of static water levels free of the influence from drilling and water pressure testing. Boring B-21-3 was bailed on June 14, 2021, and the water levels measured before and after bailing of 75.3 ft and 75.5 ft indicate rapid recovery and that a reliable static water level has been measured.

| Table 11 | . Monitoring | Wells and | Groundwater | Levels |
|----------|--------------|-----------|-------------|--------|
|----------|--------------|-----------|-------------|--------|

| Borehole | Elevation | Screei De | Screened Interval Depth (ft) | | Screened Interval Elevation (ft) | Depth of Water (ft) | Water Level Elevation (ft) |
|----------|-----------|--------------|---------------------------------|------|-------------------------------------|------------------------|-------------------------------|
| B-21-2 | 2283.1 | 20.0 | to | 50.0 | 2263.1 to 2233.1 | 33.0 | 2250.1 |
| B-21-3 | 2230.1 | 26 | to | 91 | 2204.1 to 2139.1 | 75.5 | 2154.6 |

4.2 Borehole Discussion

The drilling program consisted of five borings as shown on the Project Drawings in Appendix A. A brief discussion of the main findings from each boring is presented below.

4.2.1 Individual Boreholes

B-21-1: Boring B-21-1 was drilled at elevation 2320.5 ft above mean sea level to a depth of 250.8 ft below ground surface. Overburden consisted of silty gravel (fill) and residual soil/saprolite derived from the bedrock. SPT values ranged from 50/4" to 50/1". Alternating soft and hard layers were encountered during drilling to refusal. Drilling, SPT, and HW casing was continued with the casing advanced to 37.5 ft. HQ coring began at 37.5 ft in slightly weathered, hard granitic gneiss. Joint spacing ranged from close to moderately close with limited zones of very close joint spacing to approximate depth of 109 ft. From 109 ft to the bottom of the boring at 250.8 ft, joint spacing was very wide and weathering fresh to slightly weathered. During drilling operations water level measurements in the open borehole ranged from 22.4 to 25.6 ft below ground surface. After drilling was complete and immediately prior to water pressure testing, groundwater was measured at 36 ft below ground surface. Significant intervals/features observed included:

- <u>46.8-47.5 ft</u>: Moderately severe weathering and very close joint spacing; core loss 47.0-47.5 ft, could not build pressure during water pressure test from 45.2 to 50.7 ft.
- <u>78.9-79.1 ft</u>: Fault healed with chlorite with 2-cm displacement.
- <u>184.6 ft</u>: Fault zone with brecciation; calcite and chlorite healing. NE strike; NW dip.
- <u>201.8-202.3 ft.</u>: Fault zone with brecciation; calcite and chlorite healing. NE strike; 70° NW dip.

B-21-2: Boring B-21-2 was drilled at elevation 2,283.1 ft above mean sea level to a depth of 300.8 ft below ground surface. Overburden consisted of 7.5 ft of silty gravel with cobbles and boulders (fill

material) and sandy silt and silty sand saprolite derived from bedrock to 57.0 ft then sandy gravel with silt (PWR) to 61.8 ft. SPT N-values ranged from 5 to 50/5". HW casing was advanced to 61.4 ft and HQ coring began at 61.8 ft in moderately weathered, hard granitic gneiss to 66.5 ft then slightly weathered to fresh gneiss with limited zones of moderate weathering to the bottom of the borehole. Joint spacing ranged from close to very close to 66.5 ft then moderately close to close to 75.8 ft. From 75.8 ft to 250.8 ft, joint spacing was wide to very wide with limited zones of close joint spacing. After drilling was complete the water level in the borehole was measured at 34.7 ft below ground surface on April 19, 2021. Significant intervals/features observed included:

- <u>167.2 ft</u>: Fault zone dipping 30 degrees, with brecciated quartz and feldspar in chlorite matrix.
- <u>215.3-215.8 ft</u>: Fault zone with brecciation; calcite and chlorite healing; dipping 60 degrees.
- <u>293.9-294.5 ft</u>: Fault zone, 75-degree dip, chlorite and calcite on fault planes, trace pyrite, 1-6 cm displacement, NE strike/NW dip.

B-21-3: Boring B-21-3 was drilled at elevation 2,230.1 ft above mean sea level to a depth of 500.4 ft below ground surface. Overburden consisted of micaceous clayey sand at the ground surface then silty sand and sand with trace gravel (saprolite) to 20.5 ft. SPT N-values ranged from 6 to 50/0" at refusal at 20.5 ft. HW casing was advanced to 20.5 ft. and HQ coring began at 20.5 ft in moderately to slightly weathered, moderately hard to hard granitic gneiss with zones of severe weathering and close to moderately close joint spacing. At a depth of 45.4 ft, there was a change to slightly weathered rock and joint spacing to wide with limited zones of close joint spacing and increased weathering. From 80.5 to 265.4 ft, drilling encountered fresh gneiss with wide to very wide joint spacing. A shear zone was encountered from 266.2-269.2 ft. From a depth of 270 ft. to the bottom of the boring at depth of 500.4 ft, bedrock was slightly weathered to fresh with wide to very wide joint spacing and limited zones of close joint spacing. During drilling on April 29, 2021, water level in the borehole was measured at 56.3 ft below ground surface. On May 11, 2021, water level was measured at 146.6 ft below ground surface. The significant drop in water elevation is related to the shear zone at 266.2 ft where drill water circulation was lost. Significant intervals/features observed in Boring B-21-3 included:

- <u>41.0 ft:</u> Complete loss of drilling water.
- <u>61.4-61.5 ft</u>: Very severely weathered, saprolitic material.
- <u>75.0-80.5 ft</u>: Maximum pumping rate during a water pressure test could not build pressure; 20-degree dipping open joint with iron staining at 79.2 ft; likely cause of high flow.
- <u>253.8-254.1 ft</u>: Shear zone dipping 30 degrees along foliation. Iron staining on shear plane with clay and sand infilling.
- <u>266.3-269.3 ft</u>: Zone of sheared weathered rock; 100% loss of drill water; could not build pressure in water pressure test.
- <u>288.7-289.2 ft</u>: Fault Zone, 50-degree dip, open, slickensides indicated oblique slip movement, iron staining, chlorite, clay infilling, NE strike/NW dip.
- <u>289.6-289.9 ft</u>: Fault plane, 70-degree dip, open, slickensides indicate oblique slip movement, iron staining, clay infilling, NE strike/NW dip.

B-21-4: Boring B-21-4 was drilled at elevation 1,119.4 ft above mean sea level to a depth of 151.0 ft below ground surface. Overburden extended to a depth of 90.7 ft and consisted of large blocks of banded augen granitic gneiss (15 to 17-ft diameter) in a soil matrix of silty sand and clayey sand. Overburden is interpreted as landslide material. HW casing was advanced to 90.7 ft. HQ coring began at 90.7 ft in moderately to moderately to severely weathered banded augen granitic gneiss with closely to moderately closely spaced jointing and iron staining observed on most of the joints to a depth of 141 ft, then a reduction in iron staining from a depth of 141 ft to the boring termination depth of 151 ft. Significant intervals/features observed in Boring B-21-4 included.

• A zone of hard, sheared, mylonitic rock was observed from 126.1 ft to 126.9 ft below ground surface.

B-21-5: Boring B-21-5 was drilled at elevation 2,314.0 ft above mean sea level to a depth of 120.3 ft below ground surface. This boring was added to the original scope to investigate an anomalously low area in top of (PWR) and top of firm rock (TFR) along seismic line U4A-U4B and to investigate the presence, depth, orientation, and characteristics of a shear zone mapped immediately to the west in the Upper Reservoir. Overburden extended to a depth of 59.2 ft and consisted of silty sand (saprolite) with zones of PWR as defined by SPT blow counts of 50/0" to 50/3". HW casing was advanced to 59.2 ft and HQ coring began at a depth of 59.2 ft and advanced to a final depth of 120.3 ft. Bedrock consisted of granitic gneiss with 0.4 to 0.6-ft thick zones of quartz-feldspar gneiss. The shear zone mapped in the Upper Reservoir to the west was not identified in the rock core during drilling. Based on possible variability in the dip and dip direction of the shear zone, it may have been drilled through in the saprolite or may be deeper than the boring termination depth.

5 Laboratory Testing Results

5.1 Soil Testing Results

As described in Section 3.5.1, index soil testing was performed at S&ME laboratories. Samples were placed in jars (labeled at the time of SPT sampling), boxed up, and shipped to the S&ME laboratory.

5.1.1 Laboratory Soil Testing

Within each of the five boreholes, 33 soil samples were taken from the SPT split-spoon during drilling of the five borings in the overburden materials that contained enough material for laboratory testing. In addition, one soil/saprolite sample from rock core (RC-1) in B-21-4 retrieved enough material for testing. The sample depths range from 0 to 60.7 ft across the five borings. The soil is predominantly silty sand with poorly-graded sand with silt and well-graded sand with silt in the upper 0 to 5 ft. The natural moisture content across the site where the borings were conducted ranges from 2.1 to 26.4 percent. The percent fines of the samples range from 1.4 to 46.8 percent. The soil is predominately non-plastic with the exception of ten samples that exhibited minor plasticity. The ranges for the Atterberg Limits for the plastic samples are as follows: The liquid limit range is from 27 to 33 percent and the plasticity index range is from 1 to 11 percent. A summary of soil sample results is included in Table 12 and complete laboratory test results are in Appendix G.

| Darahala | Sample | Sample | USCS | | Natural | Percent | Atterber | g Limits |
|----------|--------|--------|--------|---------|---------|---------|----------|----------|
| Borenoie | ID | Depth | Symbol | 5PT (N) | (%) | #200 | LL (%) | PI (%) |
| | SS-1 | 0.3 | SP-SM | 81 | 3.0 | 10.0 | NP | NP |
| B-21-1 | SS-2 | 3.1 | SP-SM | - | 8.6 | 11.4 | NP | NP |
| | SS-3 | 8.1 | SM | 50/6" | 12.0 | 12.0 | NP | NP |
| | SS-1 | 0 | SW-SM | 23 | 2.9 | 10.8 | NP | NP |
| B-21-2 | SS-2 | 5 | SP-SM | 40 | 4.3 | 8.6 | NP | NP |
| | SS-3 | 8.5 | SC | 9 | 19.2 | 46.5 | 33 | 11 |
| | SS-4 | 13.5 | SM | 5 | 16.7 | 33.3 | 30 | 5 |
| | SS-5 | 18.5 | SM | 7 | 15.1 | 23.0 | NP | NP |
| B-21-2 | SS-6 | 23.5 | SM | 9 | 20.9 | 35.8 | 32 | 5 |
| | SS-7 | 28.5 | SM | 11 | 14.4 | 22.8 | NP | NP |
| | SS-8 | 33.5 | SM | 22 | 22.5 | 20.7 | NP | NP |
| | SS-11 | 48.5 | SM | 15 | 26.4 | 22.9 | NP | NP |
| | SS-12 | 53.5 | SM | 42 | 20.4 | 25.6 | NP | NP |
| | SS-13 | 58.5 | SM | - | 17.5 | 24.0 | NP | NP |
| | SS-1 | 0 | SM | 6 | 16.3 | 46.8 | 33 | 8 |
| D 01 0 | SS-2 | 2.7 | SM | 21 | 13.6 | 22.3 | NP | NP |
| B-21-3 | SS-3 | 7.7 | SM | 13 | 18.0 | 20.6 | NP | NP |
| | SS-4 | 12.7 | SM | 50/6" | 13.9 | 17.6 | NP | NP |
| | SS-1 | 0 | SP-SM | 23 | 3.9 | 9.3 | NP | NP |
| | SS-2 | 3.5 | SW | 58 | 5.9 | 1.4 | NP | NP |
| | SS-3 | 18.5 | SM | 5 | 23.4 | 30.5 | 28 | 2 |
| B-21-4 | SS-4 | 23.5 | SM | 8 | 23.2 | 33.4 | 27 | 1 |
| | SS-5 | 28.5 | SM | 16 | 16.6 | 19.2 | NP | NP |
| | SS-6 | 33.5 | SM | 6 | 20.1 | 29.6 | 27 | 2 |
| | RC-1 | 60.7 | SM | - | 2.1 | 27.9 | NP | NP |
| | SS-1 | 2.6 | SM | - | 14.5 | 20.1 | NP | NP |
| | SS-2 | 7.6 | SM | 26 | 15.1 | 27.8 | NP | NP |
| | SS-3 | 12.6 | SM | 62 | 13.7 | 24.3 | NP | NP |
| | SS-4 | 17.6 | SM | - | 12.5 | 16.1 | NP | NP |
| B-21-5 | SS-6 | 27.6 | SM | - | 21.3 | 27.3 | NP | NP |
| B-21-5 | SS-10 | 47.6 | SM | - | 14.4 | 26.1 | NP | NP |
| | SS-17 | 32.6 | SM | 50/6" | 19.3 | 29.8 | 27 | NP |
| | SS-18 | 37.6 | SM | 50/6" | 18.7 | 29.7 | 27 | NP |
| | SS-21 | 52.6 | SC-SM | 93 | 17.6 | 36.0 | 27 | 5 |

Table 12. Soil Sample Laboratory Test Results

PI = plasticity index; LL = liquid limit; NP =non-plastic

SP = Poorly graded sands and gravelly sands, little or no fines; SM = silty sands, sand-silt mixtures; SC = Clayey sands, sand-clay mixtures; SW = Well-graded sands and gravelly sands, little or no fines; S = Sands

5.2 Rock Testing Results

The results of the rock testing program described in Section 4.1.3 are provided in Table 13 through Table 15 along with boring number, depth interval of sample, and sample lithology. Appendix H includes the GeoTesting Express rock testing summary and forms.

Table 13 presents the results of UCS test results on 34 rock core samples with the ASTM D7012C procedure. One sample from Boring B-21-3 (depth 278.7 ft) arrived at the laboratory broken and not tested. Unit weight in pounds per cubic foot (pcf) was calculated for each rock core specimens prior to testing. Twenty-five of the UCS tests were performed on granitic gneiss, one on quartz feldspar gneiss, three on biotite gneiss, and five on banded augen granitic gneiss.

Table 14 presents the results of uniaxial compression test with elastic modulus results on 15 rock core samples with the ASTM D7012D procedure. Eleven tests were performed on samples of granitic gneiss, three tests were performed on banded augen gneiss, and one test performed on biotite gneiss.

| Borehole | Sample Number | Depth Interval | Date Sample Tested | Testing | Field Lithology | Unit Weight (pcf) | UCS (psi) | Failure Type | Meets ASTM D4543 | Meets ASTM D7012 | Note(s) |
|--|------------------|----------------|--------------------------|-----------|---------------------------|-------------------------|-----------|-----------------|------------------------|------------------------|---------|
| | B-21-1-2C | 103.51-103.95 | 8/16/2021 | UCS | Granitic Gneiss | 166 | 17412 | 3 | Yes | | |
| Borehole B-21-1 B-21-2 B-21-3 | B-21-1-4C | 125.03-125.47 | 8/16/2021 | UCS | Granitic Gneiss | 166 | 23733 | 1 | Yes | | |
| | B-21-1-6C | 174.31-174.75 | 8/16/2021 | UCS | Granitic Gneiss | 168 | 17884 | 1 | Yes | | |
| D-21-1 | B-21-1-8C | 212.34-212.78 | 8/16/2021 | UCS | Granitic Gneiss | 169 | 20886 | 1 | Yes | | |
| | B-21-1-5CM | 146.28-146.72 | 8/30/2021 | UCS w/ EM | Granitic Gneiss | 168 | 20681 | 1 | | Yes | |
| | B-21-1-10CM | 231.4-231.84 | 8/25/2021 | UCS w/ EM | Granitic Gneiss | 168 | 19967 | 1 | | Yes | |
| | B-21-2-14C | 295.1-295.54 | 8/16/2021 | UCS | Granitic Gneiss | 168 | 19903 | 1 | No | | 2,* |
| | B-21-2-2C | 106.28-106.72 | 8/16/2021 | UCS | Granitic Gneiss | 168 | 19973 | 3 | Yes | | |
| | B-21-2-5C | 159.9-160.4 | 8/16/2021 | UCS | Granitic Gneiss | 167 | 18775 | 3 | Yes | | |
| | B-21-2-8C | 219.9-220.34 | 8/16/2021 | UCS | Granitic Gneiss | 168 | 18747 | 3 | Yes | | |
| P 21 2 | B-21-2-10C | 238.59-239.03 | 8/16/2021 | UCS | Granitic Gneiss | 166 | 22699 | 1 | Yes | | |
| D-21-2 | B-21-2-3CM | 132.21-132.65 | 8/25/2021 | UCS w/ EM | Granitic Gneiss | 167 | 18760 | 1 | | Yes | |
| | B-21-2-6CM | 166.29-166.73 | 8/25/2021 | UCS w/ EM | Granitic Gneiss | 168 | 18161 | 1 | | Yes | |
| | B-21-2-11CM | 255.26-255.7 | 8/30/2021 | UCS w/ EM | Granitic Gneiss | 168 | 19552 | 1 | | Yes | |
| | B-21-2-12CM | 267.15-267.65 | 8/25/2021 | UCS w/ EM | Granitic Gneiss | 169 | 20648 | 1 | | Yes | |
| | B-21-2-15CM | 299.09-299.52 | 8/30/2021 | UCS w/ EM | Granitic Gneiss | 169 | 19803 | 1 | | Yes | |
| | B-21-3-21C | 481.77-482.21 | 8/16/2021 | UCS | Granitic Gneiss | 168 | 18086 | 3 | Yes | | |
| | B-21-3-2C | 233.17-233.61 | 8/16/2021 | UCS | Granitic Gneiss | 167 | 18446 | 3 | Yes | | |
| | B-21-3-5C | 250.68-251.12 | 8/16/2021 | UCS | Quartz-Feldspar Gneiss | 162 | 32661 | 1 | Yes | | |
| | B-21-3-9C | 332.35-332.79 | 8/16/2021 | UCS | Granitic Gneiss | 168 | 21079 | 1 | Yes | | |
| | B-21-3-11C | 364.7-365.2 | 8/16/2021 | UCS | Granitic Gneiss | 167 | 18777 | 1 | Yes | | |
| B-21-3 | B-21-3-13C | 380.6-381.04 | 8/16/2021 | UCS | Biotite Gneiss | 169 | 19250 | 3 | Yes | | |
| | B-21-3-15C | 285.5-286.24 | 8/16/2021 | UCS | Biotite Gneiss | 168 | 20357 | 1 | Yes | | |
| | B-21-3-18C | 433.02-433.46 | 8/16/2021 | UCS | Granitic Gneiss | 168 | 22047 | 3 | Yes | | |
| | B-21-3-3CM | 237.50-237.94 | 8/25/2021 | UCS w/ EM | Granitic Gneiss | 169 | 14789 | 1 | | Yes | |
| | B-21-3-10CM | 356.21-356.65 | 8/30/2021 | UCS w/ EM | Granitic Gneiss | 168 | 19577 | 1 | | Yes | |
| | B-21-3-16CM | 389.4-389.9 | 8/30/2021 | UCS w/ EM | Biotite Gneiss | 167 | 22228 | 1 | | Yes | |
| | B-21-3-19CM | 434.59-435.03 | 8/30/2021 | UCS w/ EM | Granitic Gneiss | 169 | 20417 | 1 | | Yes | |

Table 13. Results of Unconfined Compressive Strength Tests (ASTM D7012-C and D7012-D)

| Borehole | Sample Number | Depth Interval | Date Sample Tested | Testing | Field Lithology | Unit Weight (pcf) | UCS (psi) | Failure Type | Meets ASTM D4543 | Meets ASTM D7012 | Note(s) |
|--------------------|------------------|----------------|--------------------------|-----------|---------------------------------|-------------------------|-----------|-----------------|------------------------|------------------------|---------|
| | B-21-3-22CM | 483.68-484.12 | 8/25/2021 | UCS w/ EM | Granitic Gneiss | 169 | 10642 | 1 | | Yes | |
| | B-21-3-7C | 278.7 | | UCS | Granitic Gneiss | | | | | | 5 |
| | B-21-4-2C | 122.06-122.50 | 8/16/2021 | UCS | Banded Augen Granitic Gneiss | 168 | 15546 | 1 | Yes | | |
| | B-21-4-5C | 130.4-130.95 | 8/16/2021 | UCS | Banded Augen Granitic Gneiss | 168 | 16463 | 1 | Yes | | |
| Borehole B-21-4 | B-21-4-3CM | 124.19-124.63 | 8/25/2021 | UCS w/EM | Banded Augen Granitic Gneiss | 168 | 12121 | 1 | | Yes | |
| | B-21-4-6CM | 135.21-135.65 | 8/30/2021 | UCS w/EM | Banded Augen Granitic Gneiss | 168 | 20238 | 1 | | Yes | |
| | B-21-4-8CM | 141.75-142.19 | 8/30/2021 | UCS w/EM | Banded Augen Granitic Gneiss | 168 | 15555 | 1 | | Yes | |

Failure types: 1=Intact material failure; 3=Intact material failure and discontinuity failure. Notes: 2= The core (as-received by the lab) did not meet the ASTM side straightness tolerance due to irregularities in the sample as cored. 5= Sample received broken by lab and unfit for testing. *Because the indicated test specimens did not meet the ASTM D4543 standard tolerances, the results reported here may differ from those for a test specimen within tolerances. Notes: UCS = unconfined compressive strength; EM=elastic modulus

 Table 14. Results of Uniaxial Compression Test with Elastic Modulus (ASTM D7012D)

| Borehole | Sample Number | Depth Interval (ft) | Date Sample Tested | Testing | Field Lithology | Stress Range (psi) | Young's Modulus (psi) | Poisson's Ratio | Peak Compressive Strength (psi) | Unit Weight (pcf) |
|----------|------------------|---------------------------|--------------------------|-----------|-----------------|--|----------------------------------|----------------------|---------------------------------------|-------------------------|
| B-21-1 | B-21-1-5CM | 146.28- 146.72 | 8/30/2021 | UCS w/ EM | Granitic Gneiss | 2100-7600 7600-13100 13100-18600 | 3.24E+06 3.98E+06 3.72E+06 | 0.21 0.34 0.49 | 20,681 | 168 |
| | B-21-1-10CM | 231.4- 231.84 | 8/25/2021 | UCS w/ EM | Granitic Gneiss | 2000-7300 7300-12600 12600-18000 | 3.43E+06 4.43E+06 4.63E+06 | 0.24 0.40 | 19.967 | 168 |
| | B-21-2-3CM | 132.21- 132.65 | 8/25/2021 | UCS w/ EM | Granitic Gneiss | 1900-6900 6900-11900 11900-16900 | 3.22E+06 4.13E+06 4.30E+06 | 0.28 | 18,760 | 167 |
| | B-21-2-6CM | 166.29- 166.73 | 8/25/2021 | UCS w/ EM | Granitic Gneiss | 1800-6700 6700-11500 11500-16300 | 3.71E+06 5.17E+06 5.58E+06 | 0.21 0.33 0.42 | 18,161 | 168 |
| B-21-2 | B-21-2-11CM | 255.26- 255.7 | 8/30/2021 | UCS w/ EM | Granitic Gneiss | 2000-7200 7200-12400 12400-17600 | 3.85E+06 4.54E+06 4.50E+06 | 0.20 0.30 0.44 | 19,552 | 168 |
| | B-21-2-12CM | 267.15- 267.65 | 8/25/2021 | UCS w/ EM | Granitic Gneiss | 2100-7600 7600-13100 13100-18600 | 4.23E+06 5.01E+06 5.31E+06 | 0.18 0.30 | 20,648 | 169 |
| | B-21-2-15CM | 299.08- 299.52 | 8/30/2021 | UCS w/ EM | Granitic Gneiss | 2000-7300 7300-12500 | 3.42E+06 4.51E+06 | 0.17 0.26 | 19,803 | 169 |

| Borehole | Sample Number | Depth Interval (ft) | Date Sample Tested | Testing | Field Lithology | Stress Range (psi) | Young's Modulus (psi) | Poisson's Ratio | Peak Compressive Strength (psi) | Unit Weight (pcf) |
|----------|------------------|---------------------------|--------------------------|-----------|---------------------------------|--|----------------------------------|----------------------|---------------------------------------|-------------------------|
| | | | | | | 12500-17800 | 4.26E+06 | 0.32 | | |
| | B-21-3-3CM | 237.50- 237.94 | 8/25/2021 | UCS w/ EM | Granitic Gneiss | 1500-5400 5400-9400 9400-13300 | 2.26E+06 3.59E+06 4.01E+06 | 0.15 0.30 0.38 | 14,789 | 169 |
| | B-21-3-10CM | 356.21- 356.65 | 8/30/2021 | UCS w/ EM | Granitic Gneiss | 2000-7200 2.93E+06 nitic Gneiss 7200-12400 4.21E+06 12400-17600 4.92E+06 | | 0.27 | 19,577 | 168 |
| B-21-3 | B-21-3-16CM | 389.4- 389.9 | 8/30/2021 | UCS w/ EM | Biotite Gneiss | 2200-8200 8200-14100 14100-20000 | 3.25E+06 4.14E+06 3.85E+06 | 0.17 0.31 | 22,228 | 167 |
| | B-21-3-19CM | 434.59- 435.03 | 8/30/2021 | UCS w/ EM | Granitic Gneiss | 2000-7500 7500-12900 12900-18400 | 3.74E+06 4.70E+06 4.62E+06 | 0.19 0.30 0.46 | 20,417 | 169 |
| | B-21-3-22CM | 483.68- 484.12 | 8/25/2021 | UCS w/ EM | Granitic Gneiss | 1100-3900 3900-6700 6700-9600 | 3.54E+06 3.74E+06 4.77E+06 | 0.33 | 10,642 | 169 |
| | B-21-4-3CM | 124.19- 124.63 | 8/25/2021 | UCS w/ EM | Banded Augen Granitic Gneiss | 1200-4400 4400-7700 7700-10900 | 1.90E+06 2.87E+06 3.52E+06 | 0.21 0.30 0.38 | 12,121 | 168 |
| B-21-4 | B-21-4-6CM | 135.21- 135.65 | 8/30/2021 | UCS w/ EM | Banded Augen Granitic Gneiss | 2000-7400 7400-12800 12800-18200 | 3.13E+06 4.21E+06 4.17E+06 | 0.16 0.29 0.39 | 20,238 | 168 |
| | B-21-4-8CM | 141.75- 142.19 | 8/30/2021 | UCS w/ EM | Banded Augen Granitic Gneiss | 1600-5700 5700-9900 9900-14000 | 2.28E+06 2.95E+06 3.52E+06 | 0.13 0.27 | 15,555 | 168 |

Note: UCS = unconfined compressive strength; EM=elastic modulus

Table 15 presents the results of the Splitting Tensile Strength Tests. Of the twenty rock samples, fourteen were granitic gneiss, three were samples banded augen granitic gneiss, two were biotite gneiss, and one sample was quartz feldspar gneiss. The granitic gneiss splitting tensile strength results ranged from 5,217 psi to 7,106 psi with a mean of 6,249 psi. The banded augen granitic gneiss results ranged from 5,220 psi to 3,834 psi. The biotite gneiss sample test results were 6,267 and 6,736 psi. The lone quartz feldspar gneiss sample splitting tensile strength result was 6,999 psi. All specimen failures were intact failures, meaning that discontinuities did not influence the failure.

Table 16 presents a statistical analysis of the unit weight, UCS, and splitting tensile strength. One quartz feldspar gneiss sample had the highest UCS of 32,661 psi with only one sample tested. As presented in Table 16, the granitic gneiss test values ranged from 10,642 to 23,733 psi. with a Mean value of 19,258 psi. Biotite gneiss results ranged from 19,250 to 22,258 psi with a Mean value of 20,611 psi. Banded augen gneiss results ranged from 12,121 to 20,238 psi. The mean value was 15,985 psi. There is not enough data to draw conclusions regarding the relative strength of the quartz feldspar gneiss when compared to the other tested rock types. Based on the data, biotite and granitic gneiss have similar UCS values. The banded augen granitic gneiss appears to be slightly lower in UCS when compared to the other lithologies but the fact that the samples were all from the upper 50 ft (TFR) makes any such conclusion premature. Unit weight ranged from 166 to 169 pcf with the mean value 167.8 pcf.

| Borehole | Sample Number | Test No. | Depth Interval | Date Sample Tested | Testing | Field Lithology | Failure Load (Ibs) | Splitting Tensile Strength (psi) | Failure Type |
|----------|------------------|-------------|----------------|--------------------------|-------------------|---------------------------------|--------------------------|---|-----------------|
| B-21-1 | B-21-1-1T | ST-1 | 102.88-102.97 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 5,973 | 1,410 | 1 |
| B-21-1 | B-21-1-3T | ST-2 | 122.20-122.29 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 6,573 | 1,650 | 1 |
| B-21-1 | B-21-1-7T | ST-3 | 174.97-175.06 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 6,938 | 1,590 | 1 |
| B-21-1 | B-21-1-9T | ST-4 | 212.93-213.02 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 6,233 | 1,520 | 1 |
| B-21-2 | B-21-2-1T | ST-5 | 105.84-105.93 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 6,578 | 1,620 | 1 |
| B-21-2 | B-21-2-4T | ST-6 | 159.40-159.49 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 6,806 | 1,780 | 1 |
| B-21-2 | B-21-2-7T | ST-7 | 217.29-217.38 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 6,351 | 1,510 | 1 |
| B-21-2 | B-21-2-9T | ST-8 | 238.06-238.15 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 5,217 | 1,240 | 1 |
| B-21-2 | B-21-2-13T | ST-9 | 289.78-289.87 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 5,284 | 1,320 | 1 |
| B-21-3 | B-21-3-1T | ST-10 | 232.81-232.90 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 5,810 | 1,380 | 1 |
| B-21-3 | B-21-3-4T | ST-11 | 249.87-249.96 | 7/27/2021 | Splitting Tensile | Quartz-Feldspar Gneiss | 6,999 | 1,770 | 1 |
| B-21-3 | B-21-3-6T | ST-12 | 277.61-277.70 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 7,106 | 1,650 | 1 |
| B-21-3 | B-21-3-8T | ST-13 | 331.43-331.52 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 6,886 | 1,780 | 1 |
| B-21-3 | B-21-3-12T | ST-14 | 379.68-379.77 | 7/27/2021 | Splitting Tensile | Biotite Gneiss | 6,267 | 1,530 | 1 |
| B-21-3 | B-21-3-14T | ST-15 | 383.82-383.91 | 7/27/2021 | Splitting Tensile | Biotite Gneiss | 6,736 | 1,610 | 1 |
| B-21-3 | B-21-3-17T | ST-16 | 430.89-430.98 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 5,595 | 1,350 | 1 |
| B-21-3 | B-21-3-20T | ST-17 | 480.48-480.57 | 7/27/2021 | Splitting Tensile | Granitic Gneiss | 6,140 | 1,510 | 1 |
| B-21-4 | B-21-4-1T | ST-18 | 120.02-120.11 | 7/27/2021 | Splitting Tensile | Banded Augen Granitic Gneiss | 5,220 | 1,270 | 1 |
| B-21-4 | B-21-4-4T | ST-19 | 129.95-130.04 | 7/27/2021 | Splitting Tensile | Banded Augen Granitic Gneiss | 4,821 | 1,170 | 1 |
| B-21-4 | B-21-4-7T | ST-20 | 136.06-136.15 | 7/27/2021 | Splitting Tensile | Banded Augen Granitic Gneiss | 3,834 | 929 | 1 |

Table 15. Results of Splitting Tensile Strength Tests (ASTM D3967)

Note: Strain rate= 2.5%/min; Failure Type: 1= Intact Material Failure; lbs=pounds

| | | | | Granitic Gneiss | | | | | |
|---------|-----------------|-----------|-----------|-----------------|-----------|-------------|----------|-----------|-----------|
| | | | | UW (pcf) | UCS (psi) | STS (psi) | | | |
| | | | | 168 | 18086 | 1,410 | | | |
| | | | | 167 | 18446 | 1,650 | | | |
| | | | | 168 | 21079 | 1,590 | | | |
| | | | | 167 | 18777 | 1,520 | | | |
| | | | | 168 | 22047 | 1,620 | | | |
| | | | | 169 | 14789 | 1,780 | | | |
| | | | | 168 | 19577 | 1,510 | | | |
| | | | | 169 | 20417 | 1,240 | | | |
| | | | | 169 | 10642 | 1,320 | | | |
| | | | | 168 | 19903 | 1,380 | | | |
| | | | | 168 | 19973 | 1,650 | | | |
| | | | | 167 | 18775 | 1,780 | | | |
| | | | | 168 | 18747 | 1,350 | | | |
| | | | | 166 | 22699 | 1,510 | | | |
| | | | | 167 | 18760 | | | | |
| | | | | 168 | 18161 | | | | |
| | | | | 168 | 19552 | | | | |
| | Banded | l Augen | | 169 | 20648 | | | | |
| | Granitic Gneiss | | | 169 | 19803 | | | | |
| | UW (pcf) | UCS (psi) | STS (psi) | 166 | 17412 | | Biotite | Gneiss | |
| | 168 | 15546 | | 166 | 23733 | | Diotite | Gileiss | |
| | 168 | 16463 | | 168 | 17884 | | UW (pcf) | UCS (psi) | STS (psi) |
| | 168 | 12121 | 1,270 | 169 | 20886 | | 167 | 22228 | |
| | 168 | 20238 | 1,170 | 168 | 20681 | | 169 | 19250 | 1,530 |
| | 168 | 15555 | 929 | 168 | 19967 | | 168 | 20357 | 1,610 |
| Count= | 5 | 5 | 3 | 25 | 25 | 14 | 3 | 3 | 2 |
| Mean= | 168 | 15984.6 | 1123.0 | 167.8 | 19257.8 | 1522.1 | 168.0 | 20611.7 | 1570. |
| Median= | 168 | 15555 | 1170 | 168 | 19577 | 1,515 | 168 | 20,357 | |
| SD= | 0 | 2593.2 | 143.1 | 0.9 | 2502.3 | 161.0 | 0.8 | 1229.0 | |
| 4.65 | 1 1 1 0 0 | | 1200 1 | 160 0 | 21760 1 | 1 1 (0 2 2 | 1000 | 21040 7 | |

Table

Note: UW = Unit Weight; UCS = Unconfined Compressive Strength; STS = Splitting Tensile Strength

166.9

166

169

16755.4

10,642

23,733

1361.1

1320

1780

167.2

167

169

19382.6

19250

22228

979.9

1,270

929

Geotechnical Conditions 6

13391.4

12121

20238

-1 SD

Min=

Max=

168.0

168

168

6.1 Site Geotechnical Conditions

The proposed Bad Creek II tunnel alignment is located entirely within the TGn and all tunnels and shafts will be in constructed within sound, unweathered TGn except possibly a portion of the tailrace tunnels at the Lower Reservoir I/O. Partially weathered TGn, residual soil and saprolite derived from the TGn, colluvium, and minor amounts of fill material will require excavations to reach elevations for construction of the Upper Reservoir I/O, vertical shafts, and gate shafts. Excavation to achieve construction elevations for the Lower Reservoir I/O structure will be primarily in fill, silty sandy gravel with boulders (landslide/rockslide materials, partially weathered rock, and unweathered rock.

6.1.1 Overburden Soil

Overburden materials primarily consists of residual soil and/or saprolite classified primarily as nonplastic silty sand. Soils close to the bedrock interface contained PWR fragments. Residual soil consistency ranges from loose (N value of 5 to 10) to very dense with N values 50 or greater. More specifically soils in Boring B-21-2 are loose to medium dense to a depth of 52 ft and Boring B-21-3 soils are loose to medium dense to a depth of 10 ft then very dense to refusal at 17.7 ft. Soils in Boring B-21-1 and B-21-5 are dense to very dense.

Soil sampled in Boring B-21-4 is colluvium/landslide material and was primarily loose however, Standard Penetration Resistance values or N-values were not assessed past 35 ft below ground surface as the drilling operations switched to HQ coring due to the presence of a boulder. The material is identified as landslide/colluvium due to the presence of large, rotated blocks of TGn in a soil matrix that was identified in the borehole and during field mapping. Results of field mapping are presented in Volume 7 - Geology and Seismology Report. Table 17 presents soil thickness and basic descriptions using the Unified Soil Classification System (USCS) (ASTM 2020) as determined from laboratory tests of overburden soils.

| Boring | Soil Thickness (ft) | Classification (in order of prevalence) |
|--------|---------------------|--|
| B-21-1 | 36.9 | SP-SM, SM (Residual/Saprolite) |
| B-21-2 | 61.8 | SM, SC, SP-SM, SW-SM (classifications SP-SM and SW-SM are fill) |
| B-21-3 | 20.5 | SM |
| B-21-4 | 90.7 | SW, SM (fine fraction of colluvium) |
| B-21-5 | 59.2 | SC-S |

Table 17. Soil Thickness and Description

Note: SP = Poorly graded sands and gravelly sands, little or no fines; SM = silty sands, sand-silt mixtures; SC = Clayey sands, sand-clay mixtures; SW = Well-graded sands and gravelly sands, little or no fines; S = Sands

6.1.2 Bedrock

The proposed tunnel alignment is located entirely within the TGn. A total of 1,054 ft of TGn was cored during this phase of geotechnical investigations. Detailed geologic mapping of the underground excavations during construction of the existing Bad Creek Project resulted in subdivision of ten rock types within the TGn. Of those ten identified rock types, six were encountered during the current investigation as follows:

(1) **Granitic Gneiss**, medium light gray to light gray, medium to coarse-grained, gneiss consisting of layers of light-colored quartz feldspar bands and darker biotite quartz feldspar bands, distinctly/well foliated; comprises over 90 percent of the total cored rock.
- (2) Quartz-Feldspar Gneiss, light gray to white, coarse to very coarse-grained, distinctly foliated, trace biotite and hornblende, occurs predominantly in 0.3- to 1.0 ft-thick zones along foliation with thicker zones of 1.5 ft. Encountered in borings B-21-1, (5.0 ft), B-21-2-(1.1 ft), B-21-3, (16.2 ft), B-21-5, (5.3 ft). Comprises approximately 2.6 percent of the total cored rock.
- (3) Banded Augen Granitic Gneiss, medium light gray, medium to coarse-grained gneiss consisting of foliated (banded) augen 0.2 to 2.5 centimeters (cm). Only encountered in Boring B-21-4, 59.5 ft of the 60.3 ft cored. Comprises approximately 5.7 percent of the total cored rock.
- (4) **Biotite Gneiss**, medium dark gray to dark gray, hard fine to medium-grained, thinly foliated with interlayered quartz-feldspar veins. Encountered 11 ft of this rock type in Boring B-21-3. Comprises approximately 1 percent of the total cored rock.
- (5) Weathered sheared rock, encountered in Boring B-21-3 (3.0 ft), and comprises less than 1 percent of total cored rock.
- (6) Hard sheared rock, encountered in Boring B-21-4 (0.8 ft) and B-21-5 (1.9 ft)

The TGn is typically massive with few joints in slightly weathered to fresh rock (Schaeffer et al. 1979; Schaeffer 2016). Jointing decreases with depth and the majority of the cored bedrock is very slightly fractured. Based on data collected during Bad Creek II Geotechnical Investigation, the most prominent discontinuity set consists of joints developed along foliation. The orientation of foliation dipping to the southeast is significant in that it aligns with the slope topography along portions of the proposed Bad Creek II tunnel alignment. Discontinuity sets are discussed in more detail in Section 4.1.3. Detailed soil and rock descriptions are presented on the boring logs in Appendix B.

6.1.3 Landslide/Rockslide Material

B-21-4 was drilled in a landslide/rockslide at the location of the Lower Reservoir I/O. In B-21-4 colluvium is present with an interpreted thickness of 90.7 ft based on the boring data and the seismic lines. The colluvium consists of augen granitic gneiss boulders and quartz feldspar gneiss boulders in a matrix of sandy silt in the upper portions of the boring. Boulders encountered in the boring were slightly to severely weathered. SPT sampling was attempted to 5.7 ft below ground surface and HQ coring proceeded to a depth of 17.0 ft in order to facilitate drilling through boulder material. SPT sampling was resumed from a depth of 17.0 ft to a depth of 38.5 ft. HQ coring was used for the remainder of the borehole past 38.5 ft. Top of rock was encountered at a depth of 90.7 ft. Core recovery in the landslide material interval ranged from 0 to 100 percent and four of the core runs had a recovery of 0 percent. Recovered core was from large blocks of rock within the landslide. Large blocks of TGn were observed in the landslide/rockslide near the location of B-21-4. The blocks are tilted and rotated within a soil matrix. Blow counts of soils in the landslide material indicated loose to medium dense for non-cohesive soils and soft for cohesive soils. A map showing the location of the landslide based on surface mapping and preliminary excavation and stabilization concepts has been developed and is presented in Volume 7 (Geology and Seismology Report).

7 Summary and Considerations

The Bad Creek II Geotechnical Investigation obtained data regarding subsurface conditions and rock and soil properties along the proposed Bad Creek II Power Complex alignment and specifically in the vicinity of the Upper and Lower Reservoir I/O excavations, vertical Intake shafts, and gate shafts. The following observations based on the field program data and analysis present a summary of the most pertinent geotechnical characteristics of the proposed Bad Creek II alignment.

- The bedrock is composed entirely of TGn and up to seven lithologic variations exist within the drilled zones. Granitic gneiss is the predominant lithology (90 percent of drilled core) with minor amounts of biotite gneiss, hard sheared rock, quartz feldspar gneiss, banded augen granitic gneiss, and weathered sheared rock.
- A zone of severely to moderately weathered, intensely to moderately fractured (with some very intensely fractured zones) rock and significant iron staining on fracture surfaces ranges from TWR to approximate depths of 0-35 ft below TWR.
- In the borings at depths ranging from 15 to 35 ft below the top of PWR and extending to depths as great as 220 ft, the TGn is moderately hard to very hard, moderately to slightly weathered with some moderately to severely weathered fracture surfaces, and moderately to slightly fractured with few limited intensely fractured zones. The top of this zone would generally be consistent with the TFR interpreted from the surface seismic refraction and MASW surveys.
- From depths ranging from 75 to 220 ft below the top of PWR and extending to total boring depth, the Toxaway gneiss is hard to very hard, fresh to slightly weathered, and predominantly slightly fractured to unfractured. This rock condition, if reached with surface seismic survey depth, would present the highest velocities on the refraction and MASW surveys.
- Foliation dips to the SE 19 to 36 degrees (with the exception of zones of intense folding) with dip generally decreasing to the SE. Foliation strikes N34E to N-60E.
- Foliation joints are the most predominant (in terms of number) discontinuity in the borings in the rock mass.
- Zones of sheared hard rock occur along foliation exist in the rock mass and were developed under ductile conditions.
- A series of faults dipping generally 55 to 70 degrees to the NW exist in the Toxaway Gneiss. From core description fault zones range from 5-10 millimeters thick and are healed with chlorite, calcite, epidote, and quartz.
- The rock mass exhibits low hydraulic conductivity, k = E-05 to E-06 cm/sec, with permeability only along discontinuities. Exceptions to the low permeability exist in the weathered zone in the upper 35 ft of the rock profile and along distinct continuous weathered shear zones as in the case of Boring B-21-3 at depth 266.2-269.2 ft.
- Zones of sheared weathered rock parallel to foliation exist in the rock mass and exhibited enhanced hydraulic conductivity in B-21-3.

• The landslide/rockslide at the proposed Lower Reservoir I/O is of significant width (see Figure 1) and a depth of 91 ft based at the location of Boring B-21-5.

Geotechnical conditions at the proposed Bad Creek II location present a number of advantages as well as potential challenges for consideration:

- The Toxaway Gneiss exhibits overall excellent rock mass quality with respect to rock strength, discontinuity frequency, low permeability, and weathering profile.
- The consistent dip of foliation to the SE and the prevalence of joints along foliation could present conditions of lowered stability in the north to west sides of excavations if foliation joints are continuous.
- Depending on orientation of excavation slopes, weathered shear zones present in excavation slopes could present lowered stability conditions.
- Weathered shear zones (as encountered in Boring B-21-3 at depth 266.2-269.2 ft) have significant permeability and may require mitigation or water management if encountered significant depths.
- Landslide/colluvium is a significant geotechnical hazard at the Lower Reservoir I/O.
- Depending on orientation, biotite gneiss layers daylighting in excavation slopes could present planes of weakness if weathered.
- Dense to very dense soils are favorable for excavation slope geometry. Loose to medium dense soils may require decreased slope angle to maintain stability.
- Northwest dipping faults encountered in the borings with chlorite (low shear strength) mineralization are planes of weakness that may impact excavation slopes.

8 Limitations

Recommendations and findings provided in this report are based on limited subsurface explorations, laboratory testing, and field observations. Subsurface conditions including soil and bedrock conditions may vary between or beyond the points explored or observed. Groundwater conditions may vary from the conditions observed at the time of data collection. Information and recommendations presented in this report should not be used for other projects on this site, should not be extrapolated to other areas, and should not be used for projects in other locations without HDR's review and approval.

9 References

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Appendix A

Project Drawings





| | | 7 | | | | 8 | 3 | | |
|---------------------------------------|--|---|--|--------------------|---------------------|------------------------------------|-------------------------------|---------------------------|----------------|
| | | | | Ν | DRAWING NO. |)481 - F | P-5 9 | | REV. |
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| | | | | | U8 1 | TO U9 | 4 | .00 | |
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| 58 | | | 206 | 0 | | | | | |
| | | | 208 | | POINT | NORT | HING | EASTI | NG |
| | | | 200 210 | | U1 | 1163 | 323 | 13975 | 550 |
| | | | 210 | | U2 | 1163 | 323 | 13978 | 321 |
| | | | 2120 | | U2A | 1163 | 209 | 13980 |)77 |
| 0 | | | 2140 | | U2B | 1163 | 165 | 13981 | 176 |
| | | | | | U3 | 1163 | 108 | 13983 | 305 |
| | | | | | U4 | 1163 | 043 | 13976 | 60 |
| BOUNDA | RY | | | | U4A | 1163 | 164 | 13975 | 590 |
| | | | | | U4B | 1163 | 372 | 13975 | <u>.</u> 94 |
| | | | | | U5 | 1163 | 508 | 13975 | 609 |
| DIT | | | | | U6 | 1162 | 973 | 13977 | ′ 41 |
| | | | | | U7 | 1163 | 472 | 13977 | '41 |
| | | | | | U8 | 1162 | 999 | 13980 | 99 |
| | (U15) | | | | U9 | 1163 | 399 | 13980 | 98 |
| | | | | | U10 | 1162 | 909 | 13983 | 323 |
| | | | N 1,163,00 | 0 | U11 | 1163 | 307 | 13982 | 283 |
| | | | | | U12 | 1163 | 075 | 13983 | 85 |
| | | | ////////////////////////////////////// | | U13 | 1162 | 804 | 13989 | 922 |
| | | SHAFT | | | U14 | 1162 | 748 | 13986 | 647 |
| 21-3 | | | | | U15 | 1163 | 038 | 13989 |)23 |
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| | | | | | EXISTING | NORT | HING | EASTI | NG |
| | | | | | B-43 | 1163 | 863 | 13978 | 364 |
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| | | | | | B-65 | 1163 | 488 | 13983 | 329 |
| 2200 | | | | | B-66 | 1163 | 3220 | 13983 | 362 |
| | () / / / / / / / / / / / / / / / / / / / | 27) | | | B-67 | 1162 | 916 | 13983 | 386 |
| | 83) | IND | | | B-68 | 1163 | 8489 | 13987 | '84 |
| | NAL | 72 (J | | | B-114 | 1163 | 3432 | 13983 | 307 |
| | 00 | 84.7 | | | B-115 | 1162 | 2886 | 13983 | 353 |
| | 0.66 | 5,869 | | | B-172 | 1162 | 2738 | 13983 | 379 |
| | | 2 | | | B-225 | 1163 | 3176 | 13979 | 965 |
| | | ₩ N 1,1 N 72 | 62,500 (NAD8 |) <u>-</u> 7) | B-226 | 1163 | 3101 | 13982 | 218 |
| 2 | 120 | | | | B-227 | 1162 | 2840 | 13981 | 84 |
| | | | | | B-228 | 1162 | 929 | 13979 | 953 |
| | | | | | BA-2 | 1163 | 8068 | 13975 | 515 |
| | | | | | BA-3 | 1163 | 818 | 13975 | 514 |
| | 1 | | ı | | BA-9 | 1163 | 818 | 13967 | <i>'</i> 64 |
| BORING | | EASTING | ELEVATION | | BA-10 | 1163 | 8068 | 13967 | ' 65 |
| B-21-1 | 1163323 | 1397590 | 2320.6 | | BA-10A | 1163 | 8068 | 13967 | ' 65 |

| RING | NORTHING | EASTING | ELEVATION |
|-------|----------|---------|-----------|
| -21-1 | 1163323 | 1397590 | 2320.6 |
| -21-2 | 1163161 | 1398203 | 2283.0 |
| -21-3 | 1162877 | 1398891 | 2235.0 |
| -21-5 | 1163165 | 1397601 | 2315.0 |

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P-10

| | | | | | JOALE. I LE | .1 | |
|----|------|------|---------------------|------------|------------------------------|-----------------|---|
| | | | DRAWN BY: | CIVIL | DUKE ENERGY CAR | OLINAS, LLC | 1 |
| | | | RM MAKEE | | BAD CREEK II PUMPED S | STORAGE PROJECT | |
| | | | DESIGNED BY: | MECHANICAL | | | 1 |
| | | | DR GRADY | — | FEASIBILITY | ' STUDY | A |
| | | | CHECKED BY: | ELECTRICAL | UPPER RESERVOIR | INLET/OUTLET | |
| | | | | — | GEOTECHNICAL EXP | LORATION PLAN | |
| | | | APPROVED BY: | DATE: | | | |
| _ | | | | | SCALE: DRAWING/SHEET NO. | REV. | 1 |
| ΊL | ELEC | месн | PROJECT NUMBER: 102 | 70481 | 10270481 - | P-59 - | |
| | | | 7 | | | 8 | 1 |
| | | | | | | | |





GENERAL NOTES:

HORIZONTAL DATUM: SOUTH CAROLINA STATE PLANE, NAD83 2011 VERTICAL DATUM: NGVD29

| GEOPHYSICAL LINE | LENGTH (FT) |
|---------------------|----------------|
| L1 TO L2 | 453 |
| L3 TO L4 | 280 |
| L5 TO L5A | 89 |
| L5A TO L6A | 115 |
| L6A TO L6 | 462 |
| L7 TO L8 | 233 |
| L8 TO L9B | 205 |
| L9B TO L9A | 31 |
| L9A TO L9 | 161 |
| L10 TO L11 | 170 |
| L12 TO L13 | 270 |

| POINT | NORTHING | EASTING |
|-------|----------|---------|
| L1 | 1160895 | 1402752 |
| L2 | 1161283 | 1402985 |
| L3 | 1161121 | 1402817 |
| L4 | 1160978 | 1403057 |
| L5 | 1160688 | 1402841 |
| L5A | 1160765 | 1402887 |
| L6 | 1161260 | 1403181 |
| L6A | 1160863 | 1402946 |
| L7 | 1160756 | 1402569 |
| L8 | 1160736 | 1402801 |
| L9 | 1160607 | 1403176 |
| L9A | 1160662 | 1403025 |
| L9B | 1160670 | 1402995 |
| L10 | 1160991 | 1403194 |
| L11 | 1161078 | 1403047 |
| L12 | 1160785 | 1403185 |
| L13 | 1160923 | 1402953 |
| | | |
| | | |

| BORING | NORTHING | EASTING |
|--------|----------|---------|
| B-21-4 | 1160990 | 1403032 |
| | | |

| EXISTING BORING | NORTHING | EASTING |
|--------------------|----------|---------|
| B-1 | 1160601 | 1403199 |
| B-2 | 1160680 | 1403086 |
| B-3 | 1160732 | 1402815 |
| B-4 | 1160757 | 1402566 |
| B-19 | 1160330 | 1403118 |
| B-60 | 1160346 | 1402875 |
| B-88 | 1160333 | 1402967 |
| B-92 | 1160347 | 1402938 |
| B-101 | 1160309 | 1402983 |
| B-102 | 1160367 | 1403004 |
| B-145 | 1160450 | 1403056 |
| B-146 | 1160395 | 1403016 |
| B-147 | 1160333 | 1403016 |
| B-270 | 1160360 | 1403086 |
| B-271 | 1160420 | 1403066 |
| B-278 | 1160340 | 1402886 |
| B-279 | 1160365 | 1402898 |
| B-280 | 1160390 | 1402936 |
| B-281 | 1160370 | 1402971 |
| B-283 | 1160430 | 1403031 |
| B-284 | 1160444 | 1403006 |

| 60 | 0 | 60 |
|--------|------|----|
| SCALE: | FEET | |

| | UKE ENERGY CAROLINAS, LLC | D | CIVIL | DRAWN BY: | | | |
|--------|---------------------------|----------|------------|--------------------|------|------|----|
| ROJECT | K II PUMPED STORAGE PR | BAD CREE | | RM MAKEE | | | |
| | FEASIBILITY STUDY | | MECHANICAL | DESIGNED BY: | | | |
| LET | R RESERVOIR INLET/OUTL | | DR GRADY | | | | |
| PLAN | CHNICAL EXPLORATION PI | GEOTE | ELECTRICAL | CHECKED BY: | | | |
| | | | | | | | |
| | | | DATE: | APPROVED BY: | | | |
| REV. | DRAWING/SHEET NO. | SCALE: | | | | | - |
| - | 10270481 - P-61 | AS NOTED | 270481 | PROJECT NUMBER: 10 | МЕСН | ELEC | ΊL |
| | 8 | - | | 7 | | · ' | |



N 736,179.33 (NAD27)

A MARIE STORAGE

-2200-

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EXISTING MAJOR CONTOUR EXISTING MINOR CONTOUR FERC LICENSE PROJECT BOUNDARY MAX NORMAL POND MIN NORMAL POND PROPOSED GEOPHYSICAL LINES PROPOSED BORING EXISTING BORING WITH LOGS EXISTING BORING

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N 1, 161,000

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Appendix B

Boring Logs and Photographs

| ┣ | 5 | 440 S Charl Phon hdrine | S. Church lotte, NC 2 le: 704-33 c.com/follo | Street 28202- 8-6700 ow-us | , Suite 900 2075) | BORING NUMBER B-21-1 PAGE 1 OF 11 | | | |
|-----------------|-----------------------------------|----------------------------------|---|-------------------------------------|--|---|--|--|--|
| | אנוס א ד | | RGY | | | PROJECT NAME BAD CREEK II | | | |
| PRO | | /BER | 10270481 | | | PROJECT LOCATION SALEM. SOUTH CAROLINA | | | |
| DAT | E STARTE | = D 4/6 | /21 | | COMPLETED 4/13/21 | GROUND ELEV | ATION TBD HOLE SIZE(S) 3.782 inches | | |
| DRIL | LING CO | NTRAC | | ME, In | C. | | BD EASTING TRD | | |
| DRIL | LING ME | THOD _ | TWR, HC | Q Core | | GROUND WAT | ER LEVELS: | | |
| LOG | GED BY | C. Gru | enberg | | CHECKED BY N. Yacobi | | E 4/16/2021 _36.01 ft Before downhole testing 4/16/21 | | |
| NOT | ES | | | | | | E 4/19/2021 34.65 ft Before grouting 4/19/21 | | |
| o DEPTH (ft) | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | | REMARKS | | |
| | SS - 1 | 17-31- 50/0" | 12 | | .0.3 Silty GRAVEL (GM) from pace Poorly Graded SAND with S GRAVEL (SP-SM), grayish (10YR 4/2), very dense, me to coarse grained SAND. fit | I (FILL) ILT and dark brown bist to wet, fine ne to coarse | 0.0 - 37.5': Tricone Wash Rotary 0.3': USCS=SP-SM, LL=, PL=NP, PI=NP, NMC=3.0, %200=10.0 1.2': Drill rig chatter HW/ casing advanced to 2.0' | | |
| | ⊠ <u>SS - 2</u> ,- | 50/4" | 4 | | grained GRAVEL, micaced 0.6': Gray (10 R 6/1), moist, o GRAVEL, subangular, som 3.1': Grayish brown (10YR 5/ | ous, (PWR) coarse grained ne to little biotite (2), moist to wet | 3.1': USCS=SP-SM, LL=, PL=NP, PI=NP, NMC=8.6, %200=11.4 3.4': Drill rig chatter; Flushing hole | | |
| | SS - 3 | 50-50/5" | 10 | | 5.8 Silty SAND with GRAVEL (Si (10YR 6/1), very dense, mo medium grained SAND, co GRAVEL, subangular, som biotite, (PWR) 8.5': White (10YR 8/1) 8.8': Gray (10YR 6/1) | M), gray oist, fine to arse grained he to little | 8.1': USCS=SM, LL=, PL=NP, PI=NP, NMC=12.0, %200=16.2 8.1': Gneissic gravels and PWR | | |
| | <u>SS - 4</u> | 50/1" | 0 | | | | 13.1 - 36.9': Driller noted alternating hard and soft layers, approximately 0.1 - 0.3' thick | | |
| | ∠(<u>SS - 5</u> , - - - | 50/4" | 0 | | | | | | |
| | \ <u>SS - 6</u> | 50/1″ | 0 | | | | | | |
| |] | | | | | | | | |
| <u>25</u> | | | | | | | | | |



BORING NUMBER B-21-1



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-1

PAGE 3 OF 11

PROJECT NAME BAD CREEK II

| 05 DEPTH (ft) | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|--|------------------------------|-----------------------------|-----------------------|--------------------|------------|--|--|
| | RC - 4 | - | | 100 | 96 | GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), hard, medium to coarse grained, thinly to thickly foliated, trace to few feldspar augen (0.2 - 1.5 cm), trace hornblende (0.2 - 2.0 cm), interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatite, spaced close to moderately close, very light gray (N8), very hard, coarse to very coarse grained, 0.1 - 0.4' thick <i>(continued)</i> 50.8 - 65.5': Very hard | 47.5 - 50.8': Very slight to slight weathering 47.5': JOINT, 30° dip, open 47.6': JOINT, 30° dip, open, trace Fe staining 48.2': JOINT, 30° dip, paritally open 48.3': FOLIATION JOINT, 20°, open, trace clay infilling 49.4': JOINT, 20° dip, open 50.1': JOINT, 15° dip, open 50.2': JOINT, 15° dip, open, trace clay infilling 50.8 - 54.1': Wide joint spacing 50.8 - 65.8': Fresh to very slight weathering 52.9': FOLDING in quartz/feldspar band 54.1 - 55.8': Close joint spacing |
| WURKINGIEAS I01/02014047/BAUCH | RC - 5 | - | | 100 | 100 | | 54.1': JOINT, 0° dip, open, Fe staining 54.3': JOINT, 15° dip, open 54.8': JOINT, 0° dip, open 55.0': FOLIATION JOINT, 30° dip, open 55.8': FOLIATION JOINT, 30° dip, open 55.8 - 71.4': Close to moderately close joint spacing 55.8 - 56.3': Potassium feldspar 56.7 - 57.0': Potassium feldspar 57.0': JOINT, 10° dip, closed 58.4': JOINT, 30° dip, open 59.9': FOLIATION JOINT, 30° dip, closed 60.2 - 65.7': PACKER TEST 3: k=5.4E-05 cm/sec 60.4': JOINT, 30° dip, open |
| 002 LAB: GUI - 14/0/22 11:05 - 0.://www. | RC - 6 | 6 | | 100 | 78 | 65.5 OUARTZ-FELDSPAR GNEISS vellowish | 60.8 - 75.8': FOLIATION dipping 20°- 40° 61.1 - 61.2': Very close joint spacing 61.2': JOINT, 20° dip, open 61.7': JOINT, 0° dip, closed, trace Fe staining 62.2': FOLIATION JOINT, 20° dip, closed, trace Fe staining 62.4': FOLIATION JOINT, 20° dip, trace Fe staining 64.2': JOINT, 10° dip, closed, trace Fe staining 64.8': JOINT, 30° dip, trace Fe staining |
| | RC - 7 | , | | 100 | 94 | 67.9 GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), hard to very hard, medium to coarse grained, thinly to thickly foliated, trace to few feldspar augen (0.2 - 1.5 cm), trace hornblende (0.2 - 2.0 cm), interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatite, spaced close to | 65.8 - 70.8': Fresh weathering 67.1': JOINT, 0° dip 70.2': FOLIATION JOINT, 30° dip, open, Fe staining 70.3': JOINT, 10° dip |
| | RC - 8 | 5 | | 100 | 98 | moderately close, very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick QUARTZ-FELDSPAR GNEISS , yellowish gray (5Y 8/1) to pinkish gray (5YR 8/1), very hard, coarse to very coarse grained, trace biotite and hornblende | 70.8 - 71.4': Close joint spacing 70.8 - 77.6': Fresh to very slight weathering 70.9': JOINT, 30° dip, partially open 71.4': JOINT, 15° dip, open 71.4 - 75.8': Wide joint spacing |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-1

PROJECT NAME BAD CREEK II

| LEPTH (ft) 22 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|---------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|--|---|
| | RC - 9 | - | | 98 | 86 | GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), hard to very hard, medium to coarse grained, thinly to thickly foliated, trace to few feldspar augen (0.2 - 1.5 cm), trace hornblende (0.2 - 2.0 cm), interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatite, spaced close to moderately close, very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick (continued) QUARTZ-FELDSPAR GNEISS, yellowish gray (5Y 8/1) to pinkish gray (5YR 8/1), very hard, coarse to very coarse quarined | 75.2 - 80.7': PACKER TEST 2: k=7.3E-05 cm/sec 75.8 - 77.6': Moderately close joint spacing 75.8': FOLIATION dipping 15° - 30° 77.0': FOLIATION JOINT, 30° dip, closed 77.6 - 78.1': Very close joint spacing 77.6 - 78.2': Moderately severe weathering 77.8 - 77.9': Core loss 77.9': JOINT, healed with chlorite, 75° dip 78.1 - 95.1': Close to moderately close joint spacing 78.2 - 79.8': Very slight to slight weathering 78.2 - 79.4': Increase in potassium-feldspar content |
| 85 | RC - 10 | | | 98 | 86 | 81.1 Very hard, coarse to very coarse grained, trace biotite and hornblende 81.6 trace biotite and hornblende GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), hard, medium to coarse grained, thinly to thickly foliated, trace to few feldspar augen (0.2 - 1.5 cm), trace hornblende (0.2 - 2.0 cm), interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatite, spaced close to moderately close, very light gray (N8), very hard, coarse to very coarse grained 0 1' - 0 4' thick | 78.8 - 79.1': FAULT, normal sense of displacement, healed with chlorite, 2.0 cm displacement 79.8 - 95.1': Fresh to very slight weathering 79.1': JOINT, 20° dip, open, trace Fe staining 79.9': FOLIATION JOINT, 20° - 30° dip, open, clay infilling 80.8': FOLIATION dipping 10° - 30° 81.1': FOLIATION JOINT, 20° dip, open 81.2': FOLIATION JOINT, 20° dip, open 81.3': FOLIATION JOINT, 20° dip, open 81.3': FOLIATION JOINT, 20° dip, open 81.3': FOLIATION JOINT, 20° dip, open |
| | RC - 11 | _ | | 100 | 96 | 80.8 - 90.8': Very hard QUARTZ-FELDSPAR GNEISS, yellowish gray (5Y 8/1) to pinkish gray (5YR 8/1), very hard, coarse to very coarse grained, trace biotite and hornblende GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), hard, medium to coarse grained, thinly to thickly foliated, trace to few feldspar augen (0.4 - 2.2 cm), trace hornblende (0.2 - 2.7 cm), trace epidote, trace garnet (0.2 to 0.6 cm), with | 82.0: FOLIATION JOINT, 25' dip, open 82.3: JOINT, 0° dip, open 82.8: JOINT, 10° dip, open 85.1: JOINT, 10° dip, open 85.6': JOINT, 10° dip, open 85.8': End of day (04/07/2021); Depth to water 35.52' below ground surface, casing at 37.5' below ground surface (04/08/2021); Driller reported slower, harder drilling, switched from series 8 bit to series 10 bit 86.8': JOINT, 20° dip, open 87.2': JOINT, 20° dip, open 88.0 - 95.1': Very close joint spacing, slight to |
| | RC - 12 | | | 98 | 92 | feldspar-, hornblende- pegmatite, spaced close to moderately close, very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick | moderate weathering 88.0': JOINT 20° dip, open 88.1': JOINT, 15° dip, open 89.9': FOLDING 90.8': FOLIATION dipping 20° - 40° 91.4 - 97.1': PACKER TEST 1: 2.4E-05 cm/sec 93.7': JOINT, 20° dip, open 95.1 - 95.3': Slight weathering |
| 100 | RC - 13 | - | | 98 | 94 | | 95.1 - 95.8': Very close joint spacing 95.1': JOINT, 30° dip, open 95.1 - 95.2': Core loss 95.2': JOINT, 30° dip, open 95.3 - 104.3': Fresh to very slight weathering 95.5': JOINT, 30° dip, open 95.8 - 100.8': Wide joint spacing 95.8': FOILIATION dipping 0° - 10° 95.9 - 96.0': Core loss 96.1': JOINT, 30° dip, open |
| | | | | | | Page 4 | |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-1

PROJECT NAME BAD CREEK II

| HL 100 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|-------------------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|--|---|
| | | | | | | GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), hard, medium | 100.9 100.1's Mederately close to close init appoint |
| REEKII GEOTECHNICAL GINT.GPJ | RC - 14 | _ | | 96 | 80 | to coarse grained, thinly to thickly foliated, trace to few feldspar augen (0.4 - 2.2 cm), trace hornblende (0.2 - 2.7 cm), trace epidote, trace garnet (0.2 to 0.6 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatite, spaced close to moderately close, very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick (continued) 100.8 - 105.8': Thickly foliated | 100.8 - 105.1 - Moderately close to close joint spacing 100.8': FOLIATION dipping 0° - 30° 102.8': JOINT, 20° dip 102.85 - 103.35': SAMPLE B-21-1-1T , Splitting Tensile Test, TS= 1,410 psi 103.35 - 104.0': SAMPLE B-21-1-2C , UCS, uw= 166 pcf, ucs= 17,412 psi 104.3 - 109.1': Very close to close joint spacing 104.3 - 105.8': Very slight to slight weathering |
| WORKING/EAST01/D2014647/BADC | RC - 15 | _ | | 100 | 100 | 110.1 - 125.8': Medium grained | 104.5 - 104.7': Core loss 104.6': JOINT, 0° dip, closed 105.3': JOINT, 10° dip, open 105.8 - 135.8': Fresh to very slight weathering 105.8 - FOLIATION dipping 10° - 20° 106.6': FOLIATION JOINT, 20° dip, closed 107.1': FOLIATION JOINT, 10° dip, closed 107.9': FOLIATION JOINT, 20° dip, closed 109.1 - 250.8': Very wide joint spacing 110.1': FOLIATION dipping 10° - 25° |
| D US LAB.GDT - 4/6/22 11:08 - C:\PW | RC - 16 | _ | | 100 | 100 | | |
| | RC - 17 | | | 100 | 100 | | |
| NORTH CAROLINA BORING L | RC - 18 | | | 100 | 100 | | 121.9 - 122.35': SAMPLE B-21-1-3T , Splitting Tensile Test, TS= 1,650 psi |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-1

PROJECT NAME BAD CREEK II

| | (tt) (125 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|-------------------------------------|------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|---|
| | | | | | | | GRANITIC GNEISS, medium light gray | 125.0 - 125.5': SAMPLE B-21-1-4C , UCS, uw= 166 pcf. ucs= 23.733 psi |
| | 130 | RC - 19 | | - | 100 | 100 | to coarse grained, thinly to thickly foliated, trace to few feldspar augen (0.4 - 2.2 cm), trace hornblende (0.2 - 2.7 cm), trace epidote, trace garnet (0.2 to 0.6 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatite, spaced close to moderately close, very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | |
| | |] | | - | | | | 130.8': FOLIATION dipping 0° - 20° |
| VURNING/EAS IU I/IDZU 1404 / IBADU | _ 135 | RC - 20 | | | 100 | 100 | | |
| US LAD.GU I - 4/0/22 11.U0 - U./FWV | <u>140</u> | RC - 21 | | | 100 | 100 | | 135.8": FOLIATION dipping 20° - 30° 135.8": End of day (04/08/2021); Depth to water 24.40' below ground surface, casing at 37.5' below ground surface (04/09/2021) 135.8 - 180.8': Fresh weathering |
| OG-INO METEL CUEUNIN - GINI SID | _ 145 | RC - 22 | | | 100 | 100 | | |
| | | RC - 23 | | | 100 | 100 | | 145.8": FOLIATION dipping 15° - 30° 146.2 - 146.8': SAMPLE B-21-1-5CM (UCS/EM), uw= 168 pcf, ucs= 20,681 psi, em=3.24E+06 psi, PR= 0.21, at the low stress range (2,100-7,600 psi) 149.5 - 156.0': FOLDING |
| - 1 | | | | | | | | |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-1

PAGE 7 OF 11

PROJECT NAME BAD CREEK II

| HLd3D 150 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|--|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|---|
| di Geotechnical gint.gpJ | RC - 24 | _ | | 100 | 100 | GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), hard, medium to coarse grained, thinly to thickly foliated, trace to few feldspar augen (0.4 - 2.2 cm), trace hornblende (0.2 - 2.7 cm), trace epidote, trace garnet (0.2 to 0.6 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatite, spaced close to moderately close, very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | 150.8': FOLIATION dipping 30° - 60° |
| ORKING/EAST01/02014647/BADCREEK | RC - 25 | - | - | 100 | 100 | | 155.8': FOLIATION dipping 20° - 30° |
| D US LAB.GDT - 4/6/22 11:08 - C:/PWW 91 | RC - 26 | - | - | 98 | 98 | | 160.8': FOLIATION dipping 30° - 40° 165.8': FOLIATION dipping 20° - 30° |
| C 100-N0 MELL COLUMN - GINT STI | RC - 27 | - | | 100 | 100 | | 170.8': FOLIATION dipping 10° - 20° |
| | RC - 28 | | | 100 | 100 | | 174.2 - 174.9': SAMPLE B-21-1-6C , UCS, uw=168 pcf, ucs= 17,884 psi |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-1

PAGE 8 OF 11

PROJECT NAME BAD CREEK II

| | | | | | | | - |
|----------|-------------------|------------------------------|-----------------------------|---|------------|---|--|
| | (t) (t) 175 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
| Γ | | | | | | GRANITIC GNEISS, medium light gray | 174.9 - 175.35': SAMPLE B-21-1-7T , Splitting Tensile Test_TS= 1 590 psi |
| | | RC - 29 | - | 100 | 100 | to coarse grained, thinly to thickly foliated, trace to few feldspar augen (0.4 - 2.2 cm), trace hornblende (0.2 - 2.7 cm), trace epidote, trace garnet (0.2 to 0.6 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatite, spaced close to moderately close, very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | 175.8': End of day (04/09/2021); Depth to water 25.50' below ground surface, casing at 37.5' below ground surface (04/12/2021) |
| 1 1 | | | | | | | 180.8 - 185.8': Very slight weathering 180.8': FOLIATION dipping 20° - 30° 181.5 - 182.2': FOLDING |
| | | RC - 30 | | 100 | 100 | | 183.0 - 184.0': JOINT, healed with potassium feldspar, 65° - 70° dip |
| - NIX | 185 | | | | | | 184.6': FAULT ZONE , 60° dip, brecciation of feldspar and quartz grains, biotite-epidote-garnet in matrix, |
| | | RC - 31 | - | 100 | 100 | | chlorite and calcite on fault planes, foliation planes offset, NE strike/ NW dip 184.9 - 194.0': Potassium feldspar 185.8': FOLIATION dipping 10° - 30° 185.8 - 190.8': Fresh to very slight weathering 189.0 - 189.4': JOINT, healed with potassium feldspar, 30° - 35° dip |
| | | | - | | | | 190.8': FOLIATION dipping 10° - 20° 190.8 - 200.8': Fresh weathering 190.8 - 191.8': FOLDING |
| | - | RC - 32 | | 100 | 100 | | |
| | 195_ | | | | | | |
| | _ | | - | | | | 195.8': FOLIATION dipping 10° - 20° |
| | - | RC - 33 | | 100 | 100 | | |
| YON N | 200 | | | | | | |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-1

PAGE 9 OF 11

PROJECT NAME BAD CREEK II

| HLd=Q | G (ft) SAMPLE TYPE/ | NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|--------------------------------------|------------------------|--------------|-----------------------------|-----------------------|--------------------|------------|--|---|
| | | | | | | | GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), hard, medium | 200.8 - 205.8': Fresh to very slight weathering |
| | - - - 95_ | RC - 34 | | | 100 | 100 | trace to few feldspar augen (0.4 - 2.2 cm), trace to few feldspar augen (0.4 - 2.2 cm), trace hornblende (0.2 - 2.7 cm), trace epidote, trace garnet (0.2 to 0.6 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatite, spaced close to moderately close, very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | 201.8 - 202.3': FAULT ZONE, 70° dip, brecciation of quartz, potassium feldspar, and plagioclae in matrix, chlorite on fault planes, foliation planes offset, NE stike/ NW dip |
| DCKEEK | ╂ | | | | | | | 205.8': FOLIATION dipping 10° - 15° |
| 0RKING\EAST01\D2014647\BAI | - - - 0_ | °C - 35 | | | 100 | 100 | | 205.8 - 250.8 : Fresh weathering |
| AB.GDI - 4/6/22 11:08 - C:\PWWW 7 | F 5 | ₹C - 36 | | | 100 | 100 | 210.8 - 235.8': Few to little feldspar augen (0.7 - 2.2 cm) | 210.8': FOLIATION dipping 0° - 10° 210.8': End of day (04/12/2021); Depth to water 25.00' below ground surface, casing at 37.5' below ground surface (04/13/2021) 212.3 - 212.9': SAMPLE B-21-1-8C , UCS, uw=169 pcf, ucs= 20,886 psi 212.9 - 213.3': SAMPLE B-21-1-9T , Splitting Tensile Test, TS= 1,520 psi |
| | ╂ | | | | | | | |
| OG-NO WELL COLUMN - GINT 5 | - - - 20 | RC - 37 | | | 100 | 100 | | 216.3°: JOINT, healed with potassium feldspar and chlorite, 70° dip |
| I CAROLINA BORING LC | | ₹C - 38 | | | 100 | 100 | | |
| | 25 | | | | | | | |
| | | | | | | | | |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-1

PAGE 10 OF 11

PROJECT NAME BAD CREEK II

| H⊥d∃Q 225 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|--------------|------------------------------|-----------------------------|---|------------|---|---|
| | | | | | GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), hard, medium | |
| | - - RC - 39 | | 100 | 100 | to coarse grained, thinly to thickly foliated, trace to few feldspar augen (0.4 - 2.2 cm), trace hornblende (0.2 - 2.7 cm), trace epidote, trace garnet (0.2 to 0.6 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatite, spaced close to moderately close, very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | 225.2': Potassium feldspar |
| | | - | | | | |
| | - - RC - 40 | | 100 | 100 | | 231.4 - 231.95': SAMPLE B-21-1-10CM (UCS/EM), uw= 168 pcf, ucs= 19,967 psi, em= 3.43E+06 psi, PR= 0.24 at the low stress range (2,000-7,300 psi) |
| | - | | | | | 234.2': FOLDING |
| 235 | <u>;</u> | | | | | |
| 240 240 | - - RC - 41 | | 100 | 100 | | |
| | | | | | | |
| | - RC - 42 | | 100 | 100 | 243.5 244.1 QUARTZ-FELDSPAR GNEISS, very light gray (N8), very hard, coarse to very coarse grained, very thinly foliated GRANITIC GNEISS, medium light gray | |
| | | - | | | (N6) to medium gray (N5), very hard, medium to coarse grained, thinly to thickly | |
| | - - RC - 43 | | 100 | 100 | foliated, trace to few feldspar augens (0.8 - 2.0 cm), trace hornblende (0.2 - 0.6 cm), trace epidote, with interlayered quartz-, feldspar-, potassium feldspar-, horblende- pegmatite, spaced close to very close, very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick | 249.3 - 249.5': Potassium feldspar |
| <u> 250</u> | | | | | Page 10 | |
| | | | | | raye iv | |

| F |). | 440 s Char Phor | S. Cl lotte ne: 7 | hurch , NC 2 04-338 | Street 8202- 3-670 | t, Suite 900 -2075 0 | | BORING NUMBER B-21-1 PAGE 11 OF 11 | | |
|---------------------|------------------------------|-----------------------------|-------------------------|---------------------------|--------------------------|--|---------------------------|--|--|--|
| | | ► hdrin | c.co RGY | m/follo | ow-us | | PROJECT NAME BAD CREEK II | | | |
| PROJ | ECT NU | MBER | 102 | 70481 | | | PROJECT LOC | CATION SALEM, SOUTH CAROLINA | | |
| | | | | | | | | | | |
| (t) HLAED 250 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | | REMARKS | | |
| | | | | | | 250.8 | | | | |
| | _ | | | | | Coring termianted at 250.8 fe ground surface Bottom of borehole at 2 | et below 50.8 feet. | 250.8': End of day; Depth to water 22.40' below ground surface, casing at 37.5' below ground surface (04/14/2021); Depth to water 25.58' below ground surface, casing at 37.5' below ground surface (04/15/2021) | | |
| | | | | | | | | | | |
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Photograph 1. **B-21-2:** SS-1 **Depth:** 0.3-1.2 ft **Date:** 04/06/21



Photograph 2. **B-21-2:** SS-2 **Depth:** 3.1-3.4 ft **Date:** 04/06/21



Photograph 3. **B-21-2:** SS-3 **Depth:** 8.1-9.0 ft **Date:** 04/06/21

| E | Dad Creek (HDR) roject # = 10270481 B-21-1 Box 1 of 16 Depth = 37.5'-50.8' Date: 07 April 2021 | RL-1 RL-2 RL-2 | 50.8' 45.8' 42.8' | RL-3 | RL-1 RL-2 RL-3 | Recurr(***) 1.5'/45% 4.9'/48% 4.5'/48% | RQD (**%) 1.4" / 42% 4.4"/88% 4.2" /84% | Dorth (fr) 53.5 - 40.8 - 40.8 - 45.8 45.8 - 50.8 | |
|---|---|----------------------|----------------------|------|---|---|--|---|--|
| | | | Tani Core loss = 1.8 | | A CALL CALL CALL CALL CALL CALL CALL CA | | | | |

Photograph 4. **B-21-1:** Box 1 of 16 **Depth:** 37.5-50.8 ft **Date:** 04/07/21



Photograph 5. **B-21-1:** Box 2 of 16

Depth: 50.8-64.8 ft Da

Date: 04/07/21



Photograph 6. **B-21-1:** Box 3 of 16

of 16 **Depth:** 64.8-78.2 ft

Date: 04/07/21



Photograph 7. **B-21-1:** Box 4 of 16 **Depth:** 78.2-90.8 ft ft **Date:** 04/08/21



Photograph 8. **B-21-1:** Box 5 of 16 **Depth:** 90.8-105.8 ft **Date:** 04/08/21



Photograph 9. **B-21-1:** Box 6 of 16 **Depth:** 105.8-119.6 ft **Date:** 04/08/21



Photograph 10. **B-21-1:** Box 7 of 16 **Depth:** 119.6-133.6 ft **Date:** 04/08/21



Photograph 11. B-21-1: Box 8 of 16 Depth

Depth: 133.6-147.9 ft **Date:** 04/09/21



Photograph 12. **B-21-1:** Box 9 of 16 **Depth:** 147.9-160.8 ft **Date:** 04/09/21



Photograph 13. **B-21-1:** Box 10 of 16 **Depth:** 160.8-175.8 ft **Date:** 04/09/21



Photograph 14. **B-21-1:** Box 11 of 16 **Depth:** 175.8-190.8 ft **Date:** 04/12/21



Photograph 15. **B-21-1:** Box 12 of 16 **Depth:** 190.8-205.8 ft **Date:** 04/12/21



Photograph 16. **B-21-1:** Box 13 of 16 **Depth:** 205.1-219.5 ft **Date:** 04/13/21



Photograph 17. **B-21-1:** Box 14 of 16 **Depth:** 219.5-234.0 ft **Date:** 04/13/21



Photograph 18. **B-21-1:** Box 15 of 16 **Depth:** 234.0-248.4 ft **Date:** 04/13/21



Photograph 19. **B-21-1:** Box 16 of 16 **Depth:** 248.4-250.8 ft **Date:** 04/13/21

| | | _ | 440 | S. CI | hurch | Street | t, Suite 900 | BORING NUMBER B-21-2 | | | |
|---------------------------------------|---------------------|------------------------------|-----------------------------|-----------------------|--------------------|----------------------|--|---|--|--|--|
| | | | Phor | lotte ne: 7 | , NC 2 04-338 | 8202 8-670 | -2075 0 | PAGE 1 OF 13 | | | |
| | | | 🛡 hdrin | IC.CO | m/follo | ow-us | | | | | |
| | CLIEN | IT <u>DUK</u> | | RGY | 70404 | | PROJECT NAM | | | | |
| | PROJ | | | 102 | <u>70481</u> | | | | | | |
| | | | $ED \underline{4/2}$ | | 1 2 S&N | .∕IF In | | GROUND ELEVATION Hole Size(S) _3.782 inches | | | |
| | DRILI | | THOD | HS | а тмі | <u>пс, п</u> Я НО | | TBD EASTING TBD | | | |
| | LOGO | GED BY | N. Yac | cobi/ | J. Ruf | fing | CHECKED BY N. Yacobi/C. Gruenberg DATE/TII | Ground water Levels. | | | |
| | NOTE | s | | | | 0 | | | | | |
| | o DEPTH (ft) | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS | | | |
| GINT.GPJ | | SS - 1 | 10-11-12 (23) | 11 | | | Well Graded SAND with SILT and GRAVEL (SW-SM), dark gray (5Y 4/1), medium dense, dry, fine to coarse grained SAND, (FILL) | 0': Hollow Stem Auger 0': USCS=SW-SM, LL=, PL=NP, PI=NP, NMC=2.9, %200=10.8 | | | |
| BADCREEKIL_GEOTECHNICAL_ | | SS - 2 | 32-23-17 (40) | 9 | | | 3.3 Poorly Graded SAND with SILT and GRAVEL (SP-SM), dark gray (5Y 4/1), dense, dry, fine to coarse grained SAND, (FILL) | 5.0': USCS=SP-SM, LL=, PL=NP, PI=NP, NMC=4.3, %200=8.6 | | | |
| WORKING/EAST01/D2014647 | _ <u>10</u> | SS - 3 | 7-5-4 (9) | 18 | | | 7.5 Clayey SAND (SC), yellowish red (5YR 4/6), loose, low plasticity, moist, fine to medium grained SAND, (SAPROLITE) | 8.5': USCS=SC, LL=33, PL=22, PI=11, NMC=19.2, %200=46.5 | | | |
| S LAB.GDT - 4/6/22 11:16 - C:\PW | | SS - 4 | 2-2-3 (5) | 12 | | | 11.8 Silty SAND (SM), yellowish red (5YR 4/6), loose, low plasticity, moist, fine to medium grained SAND, (SAPROLITE) | - 13.5': USCS=SM, LL=30, PL=25, PI=5, NMC=16.7, %200=33.3 | | | |
| ORING LOG-NO WELL COLUMN - GINT STD U | <u>- 20</u> | SS - 5 | 3-3-4 (7) | 16 | | | 18.5': Brown (10YR 4/3) | 18.5': USCS=SM, LL=, PL=NP, PI=NP, NMC=15.1, %200=23.0 | | | |
| NORTH CAROLINA B | 25 | SS - 6 | 3-4-5 (9) | 19 | | | 23.5': Yellowish red (5YR 6/6) | 23.5': USCS=SM, LL=32, PL=27, PI=5, NMC=20.9, %200=35.8 | | | |



BORING NUMBER B-21-2

CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

PROJECT NAME BAD CREEK II

| (#) 25 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|-----------------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|---|
| AL_GINT.GPJ | - | | | | | Silty SAND (SM), yellowish red (5YR 4/6), loose, low plasticity, moist, fine to medium grained SAND, (SAPROLITE) <i>(continued)</i> | |
| | | 6-5-6 (11) | 18 | - | | 28.5': Yellowish brown (10YR 5/4), medium dense, dry | 28.5': USCS=SM, LL=, PL=NP, PI=NP, NMC=14.4, %200=22.8 30': End of day (4/20/21) 30.1': Switch to mud rotary |
| WORKING/EAST01/D201464 | | 6-8-14 (22) | 14 | - | | 33.5': Fine to medium SAND, trace coarse GRAVEL | 33.5': USCS=SM, LL=, PL=NP, PI=NP, NMC=22.5, %200=20.7 |
| B.GDT - 4/6/22 11:16 - C:IPW 0 | - - - | 4-6-9 (15) | 12 | - | | | |
| COLUMN - GINT STD US LA | - | | | | | | |
| BORING LOG-NO WELL (| - - - | 6-8-11 (19) | 14 | | | | |
| NORTH CAROLINA 0 0 | - | 4-6-9 (15) | 13 | | | | 48.5': USCS=SM, LL=, PL=NP, PI=NP, NMC=26.4, %200=22.9 |



BORING NUMBER B-21-2

PAGE 3 OF 13

PROJECT NAME BAD CREEK II

PROJECT LOCATION _SALEM, SOUTH CAROLINA

SAMPLE TYPE/ NO./CORE RUN BLOW COUNTS (N VALUE) SOIL RECOVERY (in) ROCK RECOVERY ROCK RQD DEPTH (ft) REMARKS DESCRIPTION 50 Silty SAND (SM), yellowish red (5YR 4/6), loose, low plasticity, moist, fine to medium grained SAND, (SAPROLITE) (continued) NORTH CAROLINA BORING LOG-NO WELL COLUMN - GINT STD US LAB. GDT - 4/6/22 11:16 - C.)PWWORKING/EAST01/D2014647/BADCREEKII GEOTECHNICAL GINT. GPJ 52.0': Grayish brown (10YR 5/2), dense, moist, poorly graded 53.5': USCS=SM, LL= --, PL=NP, PI=NP, NMC=20.4, %200=25.6 11-18-24 SS (42) 12 12 55 56.8 Silty SAND with GRAVEL (SM), gravish brown (10YR 5/2), very dense, moist to wet, fine to coarse SAND, fine to coarse GRAVEL, round to angular, (PWR) 58.5': USCS=SM, LL= --, PL=NP, PI=NP, 🛛 ss -50/5" NMC=17.5, %200=24.0 3 13 60 61.5 HW casing advanced to 61.4' GRANITIC GNEISS, light gray (N6) to 61.45': Start HQ coring medium dark gray (N4), moderately hard, 61.45 - 66.5': Moderate weathering, close to very fine to very coarse grained, thickly close joint spacing 62.2': FOLIATION JOINT, 30° dip, open, Fe staining foliated, trace to few reddish brown garnets, with interlayered quartz-, 63: FOLIATION JOINT, 40° dip, open, Fe staining 63.8': FOLIATION JOINT, 10° dip, open, Fe staining 100 86 RC - 1 feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to 64.5 - 70.0': PACKER TEST 10: k=3.8E-05 cm/sec moderately close, pinkish light gray (5YR 65 64.6': FOLIATION JOINT, 10° dip, open, Fe staining 65.3': FOLIATION JOINT, 20° dip, open, Fe staining 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick 66': FOLIATION JOINT, 30° dip, open, Fe staining 65.8 - 75.8': Hard to very hard 66.5 - 75.8': Slight weathering, close to moderately close joint spacing 100 97 RC - 2 70 70.5 - 76.0': PACKER TEST 9: k=1.2E-05 cm/sec 72.2': FOLIATION JOINT, 10° dip, open 100 88 73.2': FOLATION JOINT, 10° dip, closed, Fe staining RC - 3 73.6': FOLIATION JOINT, 10° dip, closed, Fe staining 74': FOLIATION JOINT, 25° dip, closed, Fe staining 74.2': FOLIATION JOINT, 30° dip, closed, Fe staining 75



CLIENT _DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-2

PAGE 4 OF 13

PROJECT NAME BAD CREEK II

| 4 DEPTH | (H) 5 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|---------------------|-------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|---|
| Ē | Ĵ | | | | | | GRANITIC GNEISS, light gray (N6) to | 74.4": FOLIATION JOINT, 20° dip, open |
| | _ _ _ 80 | RC - 4 | | | 98 | 91 | fine to very coarse grained, thickly foliated, trace to few reddish brown garnets, with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, pinkish light gray (5YR 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick (continued) 75.8 - 76.2': Moderately hard 76.2 - 88.8': Hard to very hard | 75.8 - 76.2': Moderate weathering 75.8 - 102.2': Wide to very wide joint spacing 75.9': FOLIATION JOINT, 10° dip, open, Fe staining 76': FOLIATION JOINT, 25° dip, open, Fe staining 76.2 - 89.3': Fresh to slight weathering 76.2': FOLIATION JOINT, 30° dip, open, Fe staining 78.0': FOLIATION dipping 30° |
| | - | | | | | | | 81.0 - 81.8': FOLDING |
| EAS 101/U2014647/B/ | | RC - 5 | | | 100 | 100 | | 82.4': FOLIATION dipping 20° |
| 8 NYY | 85 | | | | | | | |
| | | | | - | 97 | 96 | | 85.5 - 91.0': PACKER TEST 8: k=1.2E-04 cm/sec, Questionable results 85.8 - 91.0': FOLDING |
| | - 00 | KC - 0 | | | | | 88.8 89.3 QUARTZ-FELDSPAR GNEISS, white (N8), to yellowish gray (5Y 8/1), very hard, coarse to very coarse, trace potassium feldspar and biotite | 89.3 - 90.1': Slight weathering 90': JOINT, 40° dip, open, Fe staining 90.1 - 102.2': Fresh to very slight weathering |
| | | RC - 7 | | | 96 | 95 | redium dark gray (N4), hard, fine to very coarse grained, thickly foliated, trace feldspar augen (up to 3 cm), trace hornblende (up to 1 cm), trace reddish brown garnets (0.1 - 0.4 cm), with interlayered quartz-, feldspar-, potassium | |
| | - 9 <u>5</u> | | - | - | | | feldspar-, hornblende- pegmatites, spaced close to moderately close, pinkish light gray (5YR 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick | 94.5': FOLIATION dipping 10° - 20° |
| | _ | RC - 8 | | | 100 | 100 | | 98 6 ^{t.} FOLIATION dipping 20° - 30° |
| | - | | | | | | | 99.5 - 105.0': PACKER TEST 7: k=1.7E-06 cm/sec |
| <u> </u> | 00 | | 1 | | | | Page 25 | |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-2

PAGE 5 OF 13

PROJECT NAME BAD CREEK II

| 100 DEPTH (ft) | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|----------------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|--|
| | <u> </u> | - | | | | GRANITIC GNEISS, light gray (N6) to medium dark gray (N4), hard, fine to very | 100 8'' End of day (4/22/21) |
| REEKILGEOTECHNICAL_GINT.GP, | - RC - 9 - | | | 100 | 93 | coarse grained, thickly follated, trace feldspar augen (up to 3 cm), trace hornblende (up to 1 cm), trace reddish brown garnets (0.1 - 0.4 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, pinkish light gray (5YR 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick (continued) 102.2 - 102.7': Soft | 102.2 - 102.7': Moderate weathering, close to very close joint spacing 102.2': Multiple JOINTS, 0 - 20° dip, open, Fe staining, highly fractured 102.7 - 117.6': Fresh weathering, very wide joint spacing 103.5': FOLIATION JOINT, 40° dip, open 103.8': FOLIATION dipping at 20° - 30° |
| WWORKINGIEAST01/02014847/BADCR | RC - 10 | | | 100 | 97 | 102.7 - 125.8': Hard to very hard | 105.8 - 106.25': SAMPLE B-21-2-1T , Splitting Tensile Test, TS= 1,620 psi 106.25 - 106.75': SAMPLE B-21-2-2C , UCS, uw=168 pcf, ucs= 19,973 psi |
| S LAB.GDT - 4/6/22 11:16 - C:/PV | RC - 11 | | | 100 | 100 | | 112.4': FOLIATION dipping 20° - 30° |
| | ╢── | | | | | | 115.5 - 121.0': PACKER TEST 6: k=1.5E-06 cm/sec, Questionable results |
| LOG-NO WELL COLUMN - GINT | RC - 12 | - | | 100 | 83 | | 117.0': FOLIATION dipping 20° - 30° 117.6': JOINT, 10° dip, open, Fe staining 117.6 - 121.0': Moderate weathering, close joint spacing 118': FOLIATION JOINT, 20° dip, tight, Fe staining 118.1': FOLIATION JOINT, 20° dip, tight, Fe staining 118.3': JOINT, 10° dip, tight, Fe staining 118.7': FOLIATION JOINT, 20° dip, tight, Fe staining 118': FOLIATION JOINT, 20° dip, tight, Fe staining |
| NORTH CAROLINA BORING I | RC - 13 | | | 96 | 96 | | 119.4': FOLIATION JOINT, 5° dip, open, Fe staining 120.8': JOINT, 10° dip, open, Fe staining 121.0 - 143.9': Fresh weathering 121.0 - 144.2': Very wide joint spacing 121.2': FOLIATION JOINT, 10° dip, tight, Fe staining 122.2': FOLIATION dipping 30° - 40° 123.4 - 128.9': PACKER TEST 5: k=2.7E-06 cm/sec, Questionable results |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-2

PAGE 6 OF 13

PROJECT NAME BAD CREEK II

| HL430 (#) 125 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|---------------------|------------------------------|-----------------------------|---|------------|--|---|
| | | _ | | | GRANITIC GNEISS, light gray (N6) to medium dark gray (N4), hard, fine to very | |
| | RC - 14 | | 100 | 100 | coarse grained, thickly foliated, trace feldspar augen (up to 3 cm), trace hornblende (up to 1 cm), trace reddish brown garnets (0.1 - 0.4 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, pinkish light gray (5YR 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick (continued) 125 8 - 130 8': Moderately hard | um 127.8': FOLIATION dipping 20° - 30° iced very 1' - |
| | | - | | | 130.8 - 144.2': Hard | 130.79': End of day (4/23/21) 130.8': Depth to water 31.44 feet below ground |
| 135 | RC - 15 | | 94 | 94 | | surface 132.21 - 132.65': SAMPLE B-21-2-3CM , (UCS/EM), uw=167 pcf, ucs= 18,760 psi, em= 3.22E+06 psi, PR= 0.28 at the low stress range (1,900-6,900 psi) |
| | ┢╋─── | - | | | - | 135.8': FOLIATION dipping 0° - 10° |
| | RC - 16 | - | 100 | 93 | | 137.9': FOLIATION JOINT, 10° dip, open |
| | | | | | | |
| 145 | RC - 17 | | 100 | 86 | 144.2 - 145.4': Medium hard 145.4 - 255.8': Hard to very hard | 143.9 - 147.9': Slight weathering 143.9 - 148.5': FOLDING 144': FOLIATION dipping 10° - 30° 144.2': JOINT, 20° dip, open, Fe staining 144.2 - 148.4': Close joint spacing |
| | RC - 18 | | 100 | 84 | | 144.6': JOINT, 10° dip, tight, Fe staining 144.6': JOINT, 10° dip, tight, Fe staining 145.3': FOLIATION JOINT, 0° dip, open, minor Fe staining 145.8': JOINT, 20° dip, open, Fe staining 146.1': FOLIATION JOINT, 20° dip, open, Fe staining 146.5': JOINT, 10° dip, open, Fe staining 147': FOLIATION JOINT, 20° dip, tight, Fe staining 147': JOINT, 20° dip, open, Fe staining |


CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-2

PAGE 7 OF 13

PROJECT NAME BAD CREEK II

| DEPTH | (1) | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|--------------------------------|------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|--|--|
| | | | | | | | GRANITIC GNEISS, light gray (N6) to | 147.8 - 149.3': Multiple JOINTS, 10° - 40° dip, Fe staining, highly fractured |
| CHNICAL_GINT.GPJ | - | RC - 19 | | | 100 | 93 | fieldspar augen (up to 3 cm), trace feldspar augen (up to 3 cm), trace hornblende (up to 1 cm), trace reddish brown garnets (0.1 - 0.4 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, pinkish light | 147.9 - 162.5': Fresh weathering 148.4 - 168.8': Moderately close to close joint spacing 149.4': FOLIATION JOINT, 10° dip, open 149.7 - 154.3': FOLDING |
| EOTE | | | | | | | gray (5YR 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0,1' - | 153.9': JOINT, 5° dip, tight |
| © 1: ≍ | 55_ | | | | | | 0.4' thick <i>(continued)</i> | 155.0': FOLIATION dipping 0° - 10° |
| CREE | _ | _ | - | | | | | 155.6': JOINT, 0° dip, tight, minor clay infilling |
| 014647\BAE | - | | | | | | | 157': FOLIATION dipping 10° - 30° |
| S/EAST01/D2 | - | RC - 20 | | | 100 | 98 | | 158.2': FOLIATION JOINT, 30° dip, open, minor Fe staining 158.9 - 159.2': JOINT, 50° dip, tight 159.25 - 159.9': SAMPLE B-21-2-4T Splitting |
| 1 NKING | 60_ | | | | | | | Tensile Test, TS= 1,780 psi 1594 - 160 4': SAMPLE B-21-2-5C, LICS, uw=167 |
| F - 4/6/22 11:16 - C:\PWWO | - | RC - 21 | | | 100 | 95 | 161 - 220.8': Thinly foliated | pcf, ucs= 18,775 psi 161': Potassium feldspar, Fe staining 161.15': JOINT, 20° dip, tight 161.5 - 167.0': PACKER TEST 4: k=2.8E-05 cm/sec 162.1': JOINT, 20° dip, tight 162.5 - 168.8': Slight to very slight weathering |
| IS LAB.GD1 | 65_ | | | | | | | 164.7': FOLIATION dipping 20° - 30° 165': FOLIATION JOINT, 10° dip, tight |
| OG-NO WELL COLUMN - GINT STD L | - - 70_ | RC - 22 | | | 100 | 87 | | 165.8': JOINT, 65° dip, open, Fe staining, partial clay infilling 166.2 - 166.85': SAMPLE B-21-2-6CM, (UCS/EM), uw= 168 pcf, ucs= 18,161 psi, em= 3.71E+06 psi, PR= 0.21 at the low stress range (1,800-6,700 psi) 166.5 - 172.0': PACKER TEST 5a: k=8.7E-05 cm/sec 166.6': FOLIATION JOINT, 0° dip, tight 166.9 - 167.3': JOINT, healed with potassium feldspar, 60° dip 167.0 - 172.5': PACKER TEST 3: k=6.4E-05 cm/sec 167.2': FAULT ZONE, 30° dip, brecciation of feldspar |
| NORTH CAROLINA BORING L | - - 75 | RC - 23 | | | 100 | 100 | | and quartz, chlorite in matrix, chlorite on fault plane, 3 - 5 mm thick 167.7': FOLIATION dipping 0° - 10° 168': JOINT, 70° dip, tight, Fe staining 168.5 - 169.4': Multiple JOINTS, 70° dip, open, highly fractured 168.8 - 169.4': Very close joint spacing, moderate to moderately severe weathering 169.4 - 170.8': Close joint spacing, very slight |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-2

PAGE 8 OF 13

PROJECT NAME BAD CREEK II

| HLd30 175 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|--|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|---|
| | | _ | | | | GRANITIC GNEISS, light gray (N6) to medium dark gray (N4), hard, fine to very | weathering 170': JOINT, 10° dip, tight, Fe staining |
| SEOTECHNICAL_GINT.GPJ | - - RC - 24 | | | 100 | 100 | coarse grained, thickly foliated, trace feldspar augen (up to 3 cm), trace hornblende (up to 1 cm), trace reddish brown garnets (0.1 - 0.4 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, pinkish light gray (5YR 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' - | 170.8 - 180.1": Wide fracture spacing 173.2": FOLIATION dipping 20° - 30° 175.8": FOLIATION dipping 10° - 20° |
| 0 <u> 180</u> ≅ | -11 | | | | | 0.4' thick (continued) | 180.1 - 182.3': Close to very close fracture spacing |
| DRKING/EAST01/D2014647/BADCREE | - - RC- 25 | - | | 90 | 77 | | 180.8 - 181.3': Moderately severe to moderate weathering 180.8 - 181.3': Core loss 180.8 - 182.3': Multiple JOINTS, 60° dip, open, highly fractured 181.3 - 193.9': Slight to very slight weathering 182': FOLIATION JOINT, 20° dip, tight 182.3 - 190.1': Moderately close joint spacing 183.7': FOLIATION JOINT, 20° dip, open, minor Fe staining |
| DWW4 | - | 1 | | | | | 185.6': JOINT, 20° dip, tight, Fe staining |
| · US LAB.GDT - 4/6/22 11:16 - C:\F 61 06 | - RC - 26 | | | 100 | 96 | | 187.5 - 193.0': PACKER TEST 1: k=9.2E-06 cm/sec 188': FOLIATION dipping 20° - 30° 189.7': JOINT, 45° dip, tight, Fe staining 190.1 - 192.0': Close to very close joint spacing 190.5': JOINTS, 20° and 60°, open, Fe staining |
| | - - RC - 27 | _ | | 97 | 90 | | 190.8': FOLIATION JOINT, 30° dip, open, Fe staining 191.6 - 192.0': Multiple JOINTS, 10° - 30° dip, open, Fe staining, highly fractured 191.9 - 194.5': JOINT, healed with chlorite, 90° dip, Fe staining 192.0 - 228.1': Close to moderately close joint spacing 192.9': JOINT, 10° dip, tight, Fe staining 193.9 - 201.0': Fresh weathering 194.6': JOINT, 5° dip, tight, minor Fe staining |
| NORTH CAROLINA BORING | - RC - 28 | | | 99 | 99 | | 197.1': JOINT, 30° dip, open 198': FOLIATION dipping 20° - 30° 198.9': JOINT, 0° dip |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-2

PAGE 9 OF 13

PROJECT NAME BAD CREEK II

| Top Solution Solution REMARKS 200 | | | | | | | | |
|---|-------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|--|--|
| RC- 33 100 96 RC- 34 100 96 RC- 35 100 96 RC- 36 98 94 RC- 36 98 94 RC- 37 100 90 RC- 38 100 90 RC- 31 100 90 RC- 32 100 90 RC- 33 100 96 RC- 34 100 90 RC- 35 100 90 RC- 34 100 90 RC- 34 100 90 RC- 35 100 90 RC- 35 <td>005 DEPTH (ft)</td> <td>SAMPLE TYPE/ NO./CORE RUN</td> <td>BLOW COUNTS (N VALUE)</td> <td>SOIL RECOVERY (in)</td> <td>ROCK RECOVERY %</td> <td>ROCK RQD %</td> <td>DESCRIPTION</td> <td>REMARKS</td> | 005 DEPTH (ft) | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
| RC - 30 98 94 210 RC - 30 100 90 211 RC - 31 100 90 215 RC - 31 100 90 216 RC - 31 100 90 217 Person Tricky, 70° dip, Fe staining 212.7: JOINT, healed with calcite and chlorite (1 - 2 mm thick), 70° dip, Fe staining 212.3 JOINT, Netaled with calcite and chlorite (1 - 2 mm thick), 70° dip, Fe staining 212.7: JOINT, healed with calcite and chlorite (1 - 2 mm thick), 70° | | RC - 29 | | | 100 | 96 | GRANITIC GNEISS , light gray (N6) to medium dark gray (N4), hard, fine to very coarse grained, thickly foliated, trace feldspar augen (up to 3 cm), trace hornblende (up to 1 cm), trace reddish brown garnets (0.1 - 0.4 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, pinkish light gray (5YR 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | 199.9": JOINT, 10° dip, calcite and Fe staining 200.4": JOINT, 30° dip, open 200.8": JOINT, 30° dip, open, trace Fe staining 200.9": FOLIATION dipping 20° - 30° 201.0 - 202.2": Slight to very slight weathering 201.3": JOINT, 30° dip, open 201.6": JOINT, 0° dip, open 202.2 - 207.7": Fresh weathering 203.2 - 203.5": SHEAR ZONE, 30° dip, mylonitic, porphyroclasts of feldspar-quartz-biotite in the matrix, anastomosing planes 205": FOLIATION dipping 20° - 30° |
| RC - 31 100 90 215 100 90 215 100 90 216 100 90 217 RC - 31 100 218 100 90 219 100 90 210 100 90 211 100 90 215 100 100 216 100 100 217 100 100 218 100 100 219 100 100 220 100 100 220 100 100 220 100 100 220 100 100 220 100 100 220 100 100 220.8 - 258.7': Medium gray (N5), thickly 100 220.8 - 258.7': Medium gray (N5), thickly 11.2 * 200.8 * 258.7': Medium gray (N5), thickly 215.7': JOINT, 10° dip, open, calcite infilling 215.2': JOINT, 10° dip, open, calcite infilling 215.7': JOINT, 10° dip, open, calcite infilling 215.3': JOINT, 10° dip, open, calcite | | RC - 30 | _ | | 98 | 94 | | 206.5 - 206.7': SHEAR ZONE, 10° dip, mylonitic, porphyroclasts of plagioclase and quartz 207.4': JOINT, 10° dip, minor Fe staining 207.7 - 228.1': Slight weathering 207.7 - 210.4': JOINT, partially healed with chlorite and calcite, 90° dip 207.8': JOINT, 10° dip, open, minor Fe staining 208.4 - 217.6': Trace potassium feldspar 208.6': JOINT, 0° dip, tight, Fe staining 208.7': JOINT, 10° dip, open, minor Fe staining |
| RC - 32 100 100 100 100 220 100 100 100 100 220 100 100 100 100 232 100 100 100 100 233 100 100 100 100 243 20.8 - 258.7': Medium gray (N5), thickly foliated 215.3': JOINT, 10° dip, tight 214.4' - 214.8': JOINT, healed with calcite and chlorite (1 - 2 mm thick), 70° dip 215.2': JOINT, 10° dip, tight 215.3': JOINT, 10° dip, tight, biotite discolored 8 100 86 RC - 33 100 86 | | RC - 31 | _ | | 100 | 90 | | 211.7 - 212.2': JOINT, healed with calcite and chlorite (1 - 2 mm thick), 70° dip, Fe staining 212.3': JOINT, 20°, open 212.3 - 212.7': JOINT, healed with calcite and chlorite (1 - 2 mm thick), 70° dip, Fe staining 212.7': FOLIATION dipping 10° - 20° 212.8 - 213.3': HEALED JOINT with calcite and chlorite (1 - 2 mm thick), 70° dip, Fe staining 213.3': JOINT, 20° dip, open with crushed rock, highly fractured 213.3 - 213.7': JOINT, healed with calcite and |
| RC - 33 100 86 RC - 53 RC - 53 | 220 | RC - 32 | - | | 100 | 100 | 220.9 259.7": Madium grav (NE) thickly | potassium feldspar (1 - 2 mm thick), 70° dip 213.3 - 213.5': JOINT, healed with calcite and chlorite (1 - 2 mm thick), 70°, Fe staining 214.3': JOINT, 10° dip, tight 214.4 - 214.8': JOINT, healed with calcite and chlorite (1 - 2 mm thick), 70° dip 215.2': JOINT, 10° dip, tight 215.3 - 215.8': FAULT ZONE, 60° dip, brecciated (0.5 - 1.0 cm thick), quartz and potassium feldspar in a quartz-chlorite-calcite matrix, quartz and calcite on fault planes |
| 219.4°: JOINT, 50° dip, tight, minor calcite | 225 | RC - 33 | | | 100 | 86 | 220.8 - 258.7 : Medium gray (N5), thickly foliated | 215.7': JOINT, 10° dip, open, calcite infilling 215.8': End of day (4/27/21), water 31.7' below ground surface 216.9': FOLIATOIN JOINT, 20° dip, tight, biotite discolored 217.1': FOLIATION dipping 10° - 20° 217.2 - 217.9': SAMPLE B-21-2-7T, Splitting Tensile Test, TS= 1,510 psi 219.4': JOINT, 50° dip, tight, minor calcite |



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CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-2

PAGE 10 OF 13

PROJECT NAME BAD CREEK II

| | H1(t) (t) 225 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|-------------------------------------|---------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|---|
| | | | | | | | GRANITIC GNEISS, light gray (N6) to | 219.9 - 220.4': SAMPLE B-21-2-8C , UCS, uw=168 |
| REEKIL GEOTECHNICAL GINT.GPJ | - - 230 | RC - 34 | | | 100 | 96 | feldspar augen (up to 3 cm), trace feldspar augen (up to 3 cm), trace hornblende (up to 1 cm), trace hornblende (up to 1 cm), trace reddish brown garnets (0.1 - 0.4 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, pinkish light gray (5YR 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | 220.4: JOINT, 20° dip, tight, calcite 221.7': FOLIATION dipping 20° - 30° 223.3 - 224.3': JOINTS, 70° dip, with cross cutting joints at 0° (1 - 2 mm wide), druzy quartz and minor calcite, Fe staining and calcite at 224.2' 225.0': JOINT, healed with calcite (1 - 2 mm thick), 60° dip, 225.6': JOINT, healed with calcite (1 - 2 mm thick), 60° dip 225.8': JOINT, 60° dip, partially open 226.3': JOINT, 30° dip, epidote, chlorite, clay infilling 226.4': JOINT, 60° dip, open, epidote, chlorite, and |
| WORKING/EAST01\D2014647\BADCI | - - 235 | RC - 35 | | | 100 | 100 | | calcite 227.3': FOLIATION dipping 10° - 20° 228.1': FOLIATION JOINT dip, 10° - 20°, open, minor chlorite 228.1 - 300.8': Fresh weathering, very wide joint spacing 231.6 - 244.3': FOLDING |
|) US LAB.GDT - 4/6/22 11:16 - C:\PW | - - 240 | RC - 36 | | | 100 | 100 | | 238.0 - 238.55': SAMPLE B-21-2-9T , Splitting Tensile Test, TS= 1,240 psi 238.55 - 239.1': SAMPLE B-21-2-10C , UCS, uw=166 pcf, ucs= 22,699 psi |
| COG-NO WELL COLUMN - GINT STD | - - 245_ | RC - 37 | | | 100 | 100 | | |
| NORTH CAROLINA BORING L | - - 250 | RC - 38 | | | 100 | 100 | | 247.7': FOLIATION dipping 30° - 40° |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-2

PAGE 11 OF 13

PROJECT NAME BAD CREEK II

| HTPT (ff) 520 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|------------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|--|--|
| | | | | | | GRANITIC GNEISS, light gray (N6) to medium dark gray (N4), hard, fine to very | |
| | RC - 39 | | | 100 | 100 | coarse grained, thickly foliated, trace feldspar augen (up to 3 cm), trace hornblende (up to 1 cm), trace reddish brown garnets (0.1 - 0.4 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, pinkish light gray (5YR 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick (continued) | 252.1 - 285.1': FOLDING |
| | ₽— | - | | | | 256.2 255.8 256.2" Madium bard thickly faliated | 255.2 - 255.8': SAMPLE B-21-2-11CM , (UCS/EM), uw= 168 pcf, ucs= 19,552 psi, em= 3.85E+06 psi, |
| VORKING/EAST01/D2014647/BADC | RC - 40 | | | 100 | 94 | 255.8 - 255.8 - 255.2 : Medium nara, tnickly foliated 257.0 BIOTITE SCHIST, black (N1), medium hard, medium to coarse grained GRANITIC GNEISS, light gray (N6) to medium dark gray (N4), medium hard, fine 258.7 to very coarse grained, thickly foliated, trace feldspar augen (up to 3 cm), trace hornblende (up to 1 cm), trace reddish brown garnets (0.1 - 0.4 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende-, pegmatites, | PR= 0.20 at the low stress range (2,000-7,200 psi) 255.8': End of day (5/6/21), water 34.9' below ground surface 256.0': FOLIATION JOINT, 15° dip, open 256.3 - 256.75': B-21-2-A Petrographic Analysis 260.3': FOLIATION dipping 0° - 10° |
| T - 4/6/22 11:16 - C:\PWV | RC - 41 | | | 100 | 100 | spaced close to moderately close, pinkish light gray (5YR 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick QUARTZ-FELDSPAR GNEISS , light gray (N7) to white (N8), very hard, coarse to very coarse grained, trace biotite and hornblende | |
| 19.1265 | | | | | | GRANITIC GNEISS , light gray (N6) to medium dark gray (N4), hard to very hard, fine to very coarse grained, thickly | |
| | RC - 42 | | | 100 | 100 | foliated, trace feldspar augen (up to 3 cm), trace hornblende (up to 1 cm), trace reddish brown garnets (0.1 - 0.4 cm) with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, pinkish light gray (5YR 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick 260.8': Thickly foliated | 267.15 - 267.75': SAMPLE B-21-2-12CM , (UCS/EM), uw= 169 pcf, ucs= 20,648 psi, em= 4.23E+06 psi, PR=0.18 at the low stress range (2,100-7,600 psi) |
| | | | | | | | 270.8': Trace potassium feldspar 270.9 - 271.1': JOINT, healed with chlorite (5 - 6 mm thick), 40° dip |
| | RC - 43 | | | 100 | 100 | | 272.6': FOLIATIONS dipping 20° - 30° |



CLIENT DUKE ENERGY

PROJECT NUMBER _____10270481___

BORING NUMBER B-21-2

PAGE 12 OF 13

PROJECT NAME BAD CREEK II

| (H) HLd3D 275 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|---------------------|------------------------------|-----------------------------|---|------------|--|---|
| | μ | | | | GRANITIC GNEISS, light gray (N6) to medium dark gray (N4), hard to very hard, | 275 8': Epd of doy (5/7/21) |
| | RC - 44 | | 100 | 100 | fine to very coarse grained, thickly foliated, trace feldspar augen (up to 3 cm), trace hornblende (up to 1 cm), trace reddish brown garnets (0.1 - 0.4 cm) with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, pinkish light gray (5YR 8/1) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | 278.0': FOLIATION dipping 20° - 30° |
| 285 | RC - 45 | | 100 | 100 | | 285 1'- EQUATION dipping 20° - 30° |
| | ╂— | - | | | | 285.8': End of day (5/10/21) |
| 290 | RC - 46 | | 100 | 100 | | 289.7 - 290.3': SAMPLE B-21-2-13T , Splitting |
| | ╂— | | | | 200.9 200.9' Modium light grov (NG) to | Tensile Test, TS= 1,320 psi 290 8': Depth to water 36 3 feet below ground surface |
| | RC - 47 | | 100 | 100 | medium gray (N5), fine to coarse grained, thinly to intensely foliated | 293.9 - 294.5': FAULT ZONE, 75° dip, chlorite and calcite on fault planes, trace pyrite, 1 - 6 cm displacement. NE strike/ NW dip |
| | | - | | | | 294.0 - 294.4': B-21-2-B Petrographic Analysis 295.05 - 295.7': SAMPLE B-21-2-14C , UCS, |
| | RC - 48 | | 100 | 100 | 295.8 - 300.8": Very fine to coarse grained | uw=168 pcf, ucs= 19,903 psi 296.8': Large hornblende crystal, roughly 4 cm in length |
| 300 | 1 | | | | | 299.0 - 299.6': SAMPLE B-21-2-15CM , (UCS/EM), uw= 169 pcf, ucs= 19,803 psi, em= 3.42E+06 psi, |

| Hone: 704 Hone: 704 | urch Street, Suite 900 NC 28202-2075 4-338-6700 n/follow-us | BORING NUMBER B-21-2 PAGE 13 OF 13 |
|---|--|--|
| CLIENT DUKE ENERGY | | PROJECT NAME BAD CREEK II |
| PROJECT NUMBER10270 | 0481 | PROJECT LOCATION _SALEM, SOUTH CAROLINA |
| | | |
| B DEPTH (ft) (ft) SAMPLE TYPE/ NO./CORE RUN BLOW BLOW COUNTS (N VALUE) RCOVERY (in) RCCX | % % ØD ØD ØD | REMARKS |
| | 300.8 | PR= 0.17 at the low stress range (2,000-7,300 psi) |
| | Coring termianted at 300.8 fe ground surface Bottom of borehole at 3 | eet below 300.8 feet. |
| | | |

Date: 04/20/21



Photograph 20. **B-21-2:** SS-1 **Depth:** 0-1.5 ft **Date:** 04/20/21



Photograph 21. **B-21-2:** SS-2 **Depth:** 5.0-6.5 ft



Photograph 22. **B-21-2:** SS-3 **Depth:** 8.5-10.0 ft **Date:** 04/20/21



Photograph 23. **B-21-2:** SS-4 **Depth:** 13.5-15.0 ft **Date:** 04/20/21



Photograph 24. **B-21-2:** SS-5 **Depth:** 18.5-20.0 ft **Date:** 04/20/21



Photograph 25. **B-21-2:** SS-6 **Depth:** 23.5-25.0 ft **Date:** 04/20/21



Photograph 26. **B-21-2:** SS-7 **Depth:** 28.5-30.0 ft **Date:** 04/20/21



Photograph 27. **B-21-2:** SS-8

Depth: 33.5-35.0 ft

Date: 04/21/21



Photograph 28. **B-21-2:** SS-9 **Depth:** 38.5-40.0 ft **Date:** 04/21/21



Photograph 29. **B-21-2:** SS-10 **Depth:** 43.5-45.0 ft **Date:** 04/20/21



Photograph 30. **B-21-2:** SS-11 **Depth:** 548.5-50.0 ft **Date:** 04/21/21



Photograph 31. **B-21-2:** SS-12 **Depth:** 53.5-55.0 ft **Date:** 04/21/21



Photograph 32. **B-21-2:** SS-13 **Depth:** 58.5-60.0ft **Date:** 04/21/2



Photograph 33. **B-21-2:** Box 1 of 18

Depth: 61.45-75.8 ft **Date:** 04/21/21



Photograph 34. B-21-2: Box 2 of 18

Depth: 75.8-90.8 ft

Date: 04/22/21



Photograph 35. **B-21-2:** Box 3 of 18

Depth: 90.-105.0 ft

Date: 04/22/21

| Box 3 of 13 | | | - | | 0 |
|---------------------------|---------------------------|--|------------------|--------------|-------------------------|
| Bad Creek B-21-2 | | - | Run Depth | Rec 5 100 | RQD 4. 72 4.85 17 |
| Box 4 of 18 10546-1176 | 智祥 RLA RC-10 家Lの RL-11 | > | RC-11 1104-115-8 | 5 100 | 9.75 97 5 100 0 |
| 23 Apr 2021 | RCH SPECT | Rt-12 cont Box's | QL-12 154-1204 | 5 400 4 | 15 43 |
| J.K. Strang | | | | | |
| | | | | | |
| | | en 2005 anno 1000 anno 1000 anno 1000 Daochadh anno 1000 an | | | |
| | | | e instante fil | | |
| | Caller Street | | | | |

Photograph 36. **B-21-2:** Box 4 of 18

Depth: 105.0-117.6 ft **Date:** 04/23/21



Photograph 37. **B-21-2:** Box 5 of 18

Depth: 117.6-130.8 ft Date: 04/23/21



Photograph 38. **B-21-2:** Box 6 of 18

Depth: 130.8-145.8 ft **Date:** 04/26/21



Photograph 39. **B-21-2:** Box 7 of 18

Depth: 145.8-160.8 ft Date: 04/26/21



Photograph 40. **B-21-2:** Box 8 or 18

Depth: 160.8-175.8 ft Date: 04/26/21



Photograph 41. **B-21-2:** Box 9 of 18

Depth: 175.8-190.8 ft Date: 04/27/21

Bad Creek RRD Fr 1 7 Run fec a Depth / B-21-2 PL-22 190.8-1958 4.85 97 Box 10 of 18 404 - 2054 E 86-27 10 4.5 RC-26 1958-2008 4 45 4.95 99 99 RC-78 27 Apr 2021 D RC-29 700.8.705.4 100 4.40 96 81-29 Ran

Photograph 42. **B-21-2:** Box 10 of 18 **Depth:** 190.8-205.8 ft **Date:** 04/27/21



Photograph 43. **B-21-2:** Box 11 of 18 **Depth:** 205.8-220.8 ft **Date:** 04/27/21



Photograph 44. **B-21-2:** Box 12 of 18 **Depth:** 220.8-230.8 ft **Date:** 05/05/21



Photograph 45. **B-21-2:** Box 13 to 18 **Depth:** 230.8-245.3 ft **Date:** 05/05/21

| -21-2 | | | A | - | | | 0 = | 1-0 | | |
|-------------------------|--------------------------|---------------------------|------------|----------------|----------------------|------|-----|--|--------------------|---|
| ad Creek. -21-Z | 1 1 1 | | | Run | Depth 740-8-245-8 | Gt S | 170 | 4 | QD 170 | |
| Sox 14 of 18 | RL-37 \$ RL-38 | 1- | > / | RC-37 RC-37 | 245-8-250.8 | 5 | 00 | 5 | 100 | - |
| 1453-2558 M . 2021 | RL-34 - 7 \$ RL-39 - | 0 | | RC-39 | 20 250.8 - 255.8 | 5 | 100 | 5 | 180 | |
| or lay well | 1-1-1-1-1-1 | iller - | | | | | | 1 | | |
| 1 R. CFing | 1- 1 | | 0 | | | | | _ | | |
| 1 | | 9 9 9 9 1 2 2 3 | | | 34 B 7 B 5 | | 10 | 4 9 | 6 7 8 1 | |
| | | | | Match | | | 1 | | | |
| CARGAR CAR | MAG & EDATA | A TANK MARK | Mest March | | · BY | | | S. | 12. YZ | |
| ar weinen within of the | Indian State Propagation | ACCOUNTS AND ACCOUNTS AND | | N SPECIAL | New Contraction | | | | | |
| Section 100 | | | | | - AV | | | and the second s | | |
| | | | | | | | | | 1. 199 0-73 | |
| | A CAR AND A CAR | A CARLENS | | | | | | | | |

Photograph 46. **B-21-2:** Box 14 of 18 **Depth:** 245.3-255.8 ft **Date:** 05/05/21



Photograph 47. **B-21-2:** Box 15 of 18 **Depth:** 255.8-270.8 ft **Date:** 05/07/21



Photograph 48. **B-21-2:** Box 16 of 18 **Depth:** 270.8-285.8 ft **Date:** 05/07/21



Photograph 49. **B-21-2:** Box 17 of 18 **Depth:** 285.5-295.8 ft **Date:** 05/11/21



Photograph 50. **B-21-2:** Box 18 of 18 **Depth:** 295.8-300.8 ft **Date:** 05/13/21

| | |) | 440 S Char Phon hdrin | S.C lotte ne:7 ic.co | hurch , NC 2 04-338 m/follo | Street 8202- 8-6700 pw-us | :, Suite 900 2075) | | BORIN | G NUMBER B-21-3 PAGE 1 OF 21 |
|--------------------------------------|------------------------|------------------------------|--------------------------------|-------------------------------|--------------------------------------|------------------------------------|---|--|--|---|
| CL | .IEN | T DUK | E ENER | RGY | | | | PROJECT NAM | E BAD CREEK II | |
| PF | ROJE | | MBER | 102 | 70481 | | | PROJECT LOC | ATION _SALEM, SOUTH C | AROLINA |
| D | ATE | START | ED _4/2 | 20/21 | 1 | | COMPLETED <u>5/12/21</u> | GROUND ELE | VATION TBD | IOLE SIZE(S) 3.782 inches |
| D | RILL | ING CC | NTRAC | TOF | R_S&I | ИE, In | С | NORTHING 1 | rbd EA | STING TBD |
| D | RILL | ING ME | THOD | ΤW | 'R, HQ | Core | | GROUND WAT | ER LEVELS: | |
| L | ogg | ED BY | C. Gru | enb | erg | | CHECKED BY N. Yacobi | | IE 4/29/2021 56.25 ft | |
| N | OTE | s | | | | | | | E 5/11/2021 146.55 ft | |
| DEPTH | (#) 0 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | | F | REMARKS |
| INT.GPJ | | SS - 1 | 2-3-3 (6) | 14 | | | Silty SAND (SM), red (2.5YR nonplastic, dry to moist, no to medium grained SAND v coarse grains, micaceous (| 4/8), loose, ncohesive, fine with trace SOIL) | 0': Tricone Wash Ro 0.1': 2 mm organic le 0.4': Few coarse qua 0.0': USCS=SM, LL=3 %200=46.8 | tary from 0.0' - 20.5' ens rtz sand, few fine gravels i3, PL=25, PI=8, NMC=16.3, |
| SAL_G | | | | | | | 2.1': Brownish yellow (10YR (dense, drv, little biotite, (SA | 6/6), medium APROLITE) | 2 7': USCS=SM = | PI =NP PI=NP NMC=13.6 |
| | _ | SS - 2 | 11-11-10 (21) | 12 | | | 3.2': Biotite lens 3.3': Light gray (10YR 7/2) 4.1 - 20.7': Trace to few gneis | ssic gravel | %200=22.3 3.1 - 3.3': Fe staining 3.1 - 4.2': Foliations | from parent rock |
| WORKING/EAST01/D2014647/BADCR | - - - -/ 0 | SS - 3 | 4-6-7 (13) | 13 | | | 7.7 - 20.7': Trace Fe staining nodules | , trace 3 mm Fe | 7.7': USCS=SM, LL= %200=20.6 | , PL=NP, PI=NP, NMC=18.0, |
| TD US LAB.GDT - 4/6/22 11:19 - C:\PW | 5 | X SS - 4 | 50-50/4" | .10 | | | 12.7': Light gray (10YR 7/1), to moist, fine to coarse grai saprolitic, (PWR) | very dense, dry ined SAND, | 12.7': USCS=SM, LL NMC=13.9, %200=17 | =, PL=NP, PI=NP, .6 |
| WELL COLUMN - GINT S | | SS - 5 | 50/0" | 0 | | | 17.7': NO RECOVERY | | 17.3 - 20.5': Water lo 17.7': SPT refusal | ISS |
| NORTH CAROLINA BORING LOG-NO | | RC - 1 | | | 86 | 35 | 20.7 | | 20.5': TWR Refusal a 20.5 ': Casing advan setting casing 20.5': Start HQ corin 20.5': FOLIATION di 20.7 - 24.0': Slight to 20.7 - 22.2': Very clo 20.7 - 21.5': Fe stain 20.7 - 46.0': Trace po 20.7': End of day (04 | at 20.5' ced to 20.7'; rock crushed when g pping 20° - 30° moderate weathering se joint spacing ing otassium feldspar /20/2021) |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 2 OF 21

PROJECT NAME BAD CREEK II

| DEPTH | (¥) 5 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|-----------------------------------|------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|--|
| EEKIL GEOTECHNICAL_GINT.GPJ | - - - 0 | RC - 2 | | | 98 | 66 | GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), moderately hard to hard, medium to coarse grained, thinly to thickly foliated, trace to few feldspar augens (0.5 - 1.5 cm), trace hornblende (0.1 - 1.3 cm), trace reddish brown garnets (0.2 - 0.9 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick (continued) | 20.9 - 21.2': Partial water loss 21.5': FOLIATION JOINT, 30° dip, open, trace Fe staining 21.7': JOINT, 20° dip, open, trace Fe staining 21.9': JOINT, 40° dip, open, trace potassium feldspar 22.1': JOINT, 40° dip, open 22.2 - 24.4': Close joint spacing 23.1 - 23.4': JOINT, 60° dip, open, Fe staining 23.8 - 23.9': Highly JOINTED, 20° - 30° dip, partially open 23.9': JOINT, 30° dip, open, minor clay infilling, Fe staining 24.0': Highly JOINTED, saprolitic, soil 24.0 - 24 8': Severe to very severe weathering |
| 2014647\BADCR | - | RC - 3 | | | 0 | 0 | | 24.0 - 24.0 : Severe to very severe weathering 24.1 - 24.8': Core loss 24.4 - 24.7': Partial water loss 24.4 - 25.6': Very close joint spacing 24.8 - 25.6': Slight to moderate weathering 25.3': FOLIATION JOINT, 30° dip, open, minor clay |
| KING/EAST01/D | - 5_ | RC - 4 | | | 84 | 60 | | infilling, Fe staining 25.5': JOINT, 10° dip, open, minor clay infilling, Fe staining 25.6': JOINT, 10° dip, open, trace Fe staining 25.6 - 26.4': Slight weathering |
| LAB.GDT - 4/6/22 11:19 - C:\PWWOR | - - - 0 | RC - 5 | | | 100 | 94 | | 25.6 - 26.7': Very close joint spacing 25.8': JOINT, 20° dip, open 26.1': JOINT, 10° dip, open, minor Fe staining 26.2': JOINT, 10° dip, open, minor Fe staining 26.7 - 26.9': Very close joint spacing 26.4': FOLIATION JOINTS, multiple fractures, 20° - 50° dip, open and partially open, minor clay infilling, Fe staining, trace potassium feldspar 26.4 - 26.9': Moderately severe weathering 26.9 - 27.8': Close joint spacing 26.9 - 30.6': Very slight to slight weathering 27.3': JOINT, 30° dip, open, trace Fe staining |
| | _ _ _ 5 | RC - 6 | | | 100 | 100 | | 27.4': JOINT, 10° dip, open, Fe staining 27.8 - 33.3': Moderately close joint spacing 27.9': FOLIATION JOINT, 30° dip, open, minor clay infilling, trace Fe staining 28.9': JOINT, 35° - 40° dip, open, minor clay infilling, Fe staining 30.5 - 30.6': Core loss 30.5': JOINT, 60° dip, open, rough, trace Fe staining 30.6 - 32.6': Driller reported softer drilling HW casing advanced to 32.9' 32.9 - 33.3': Core loss 33.3': JOINT, 0° dip, open |
| NORTH CAROLINA BORING LOC | _ _ _ 0 | RC - 7 | | | 100 | 100 | 48.1 - 48.5': Poorly foliated | 33.3 - 37.5': Close joint spacing 33.3 - 35.4': Very slight to slight weathering 33.9': JOINT, 30° dip, open, minor clay infilling, Fe staining 34.1': FOLIATION JOINT, 0° dip, open, Fe staining, trace potassium feldspar 34.4': JOINT, 20° dip, open 35.4 - 40.4': Very slight weathering 36.4': FOLIATION JOINT, 10° - 15° dip, open, oxidized biotite, Fe staining, trace potassium feldspar |



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CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PROJECT NAME BAD CREEK II

PROJECT LOCATION SALEM, SOUTH CAROLINA

SAMPLE TYPE/ NO./CORE RUN BLOW COUNTS (N VALUE) SOIL RECOVERY (in) % % ROCK RECOVERY **ROCK RQD** DEPTH (ft) REMARKS DESCRIPTION 50 37.3': FOLIATION JOINT, 30° dip, open, oxidized biotite, trace Fe staining 37.5': JOINT, 20° dip, open, oxidized biotite, trace Fe NORTH CAROLINA BORING LOG-NO WELL COLUMN - GINT STD US LAB. GDT - 4/6/22 11:19 - C;\PWWORKING\EAST01\D2014647\BADCREEKII GEOTECHNICAL GINT. GPJ staining 51.8 37.5 - 40.4': Moderately close joint spacing QUARTZ-FELDSPAR GNEISS, light gray 38.8': FOLIATION JOINT, 15° - 20° dip, open, (N7) to white (N9), very hard, coarse to 52.8 oxidized biotite 100 very coarse grained, thinly foliated, trace 100 RC - 8 39.4': FOLDING biotite and hornblende 40.4 - 42.0': Close joint spacing **GRANITIC GNEISS**, medium light gray 40.4 - 45.4': Very slight to slight weathering (N6) to medium gray (N5), very hard, 40.9 - 41.1': Heavily stained feldspars medium to coarse grained, thinly to thickly 55 41.0': Joint, 30° dip, open, oxidized biotite, Fe oxide, foliated, trace feldspar augens (0.4 - 1.6 trace potassium feldspar cm), trace hornblende (0.3 - 2.6 cm), trace 41.0': Complete water loss, driller used EZ mud to epidote, trace reddish brown garnets (0.2 regain circulation 0.8 cm), with interlayered quartz-, 42.0 - 45.4': Moderately close joint spacing feldspar-, potassium feldspar-, 42.1': JOINT, 30° dip, open, oxidized biotite, trace Fe hornblende- pegmatites, spaced close to staining moderately close, very light gray (N8), to 42.9': JOINT, 25° dip, open, oxidized biotite, Fe 100 98 RC - 9 white (N9), very hard, coarse to very staining 45.4': FOLIATOIN JOINT, 15°-20° dip, open, Fe coarse grained, 0.1' - 0.4' thick staining 45.4 - 80.4': Wide joint spacing 60 45.4 - 50.4': Very slight weathering 46.6 - 46.7': FOLDING 48.5 - 49.7': Potassium feldspar 49.2': FOLIATION JOINT, 10° - 15° dip, open, oxidized biotite 50.4 - 50.9': Fresh to very slight weathering 50.4': Driller switched from series 8 to series 12 bit RC -100 98 due to hardness of rock 10 50.9 - 51.6': Slight weathering with trace potassium feldspar 51.6 - 55.6': Fresh to very slight weathering 55.6 - 56.0': Slight weathering with trace potassium 65 feldspar 56.0 - 58.7': Fresh to very slight weathering 58.1': JOINT, 30° dip, open, oxidized biotite, fine sand 58.1 - 58.4' B-21-3-A Petrographic Analysis 58.7 - 58.8': Slight weathering with trace potassium feldspar 58.8 - 60.4': Fresh to very slight weathering RC -100 98 60.4 - 61.4': Very slight weathering 60.4': FOLIATION dipping 0° - 15° 11 61.4 - 61.5': Very severe weathering 61.5': Highly JOINTED, very severe weathering, 0° -70 10° dip, open, saprolitic, build up of silt and sand in joints 61.5 - 85.4': Fresh to very slight weathering 61.5 - 62.3': Trace potassium feldspar 68.5 - 74.0': PACKER TEST 7: k=1.1E-04 cm/sec 69.5': JOINT, 25° dip, open, oxidized biotite, trace Fe staining RC -100 70.4': FOLIATION dipping 10° - 30° 100 12 70.4 - 75.4': Trace potassium feldspar 72.9': FOLIATOIN JOINT, 20° dip, open, oxidized biotite 74.0 - 74.1': Trace potassium feldspar 75



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CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 4 OF 21

PROJECT NAME BAD CREEK II

| 41 DEPTH (ft) 22 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|---------------------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|---|
| I GEOTECHNICAL GINT.GPJ | RC - 13 | | | 100 | 96 | GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), very hard, medium to coarse grained, thinly to thickly foliated, trace feldspar augens (0.4 - 1.6 cm), trace hornblende (0.3 - 2.6 cm), trace epidote, trace reddish brown garnets (0.2 - 0.8 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | 74.6 - 74.8': BIOTITE SCHIST, black (N1), hard, tine grained, lens of quartz-plagioclase, few 0.2 - 0.5 cm reddish brown garnets 75.0 - 80.5': PACKER TEST 6: Flow to high for a complete test. HIGH PERMEABILITY ZONE 75.4': End of day (04/21/2021) 79.2': JOINT, 20° dip, open, trace Fe staining, minor clay infilling 79.3': EOL JATION JOINT, 30° dip, open, sand build |
| RKING/EAST01/D2014647/BADCREEF | RC - 14 | | | 100 | 100 | | 80.4': Driller added EZ mud to help with circulation 80.4 - 265.4': Very wide joint spacing 82.3 - 82.4': Trace potassium feldspar |
| US LAB. GDT - 4/6/22 11:19 - C:\PWWOI | RC - 15 | | | 100 | 100 | | 85.4 - 250.4': Fresh weathering |
| | RC - 16 | | | 100 | 100 | | 92.0' - 97.5': PACKER TEST 5: No take at 70 psi 94.8': FOLIATION JOINT, 15° dip, tight, sand infilling |
| NORTH CAROLINA BORING LOG- 001 | RC - 17 | | | 100 | 100 | | 95.4': HW Casing advanced to 43.7', getting some (25%) return of drilling fluid |

| | | | - | | | | | |
|-------------------------------------|------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|--|
| | DEPTH (ft) | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
| KII_GEOTECHNICAL_GINT.GPJ | <u>105</u> | RC - 18 | | | 100 | 100 | 104.6 105.3 QUARTZ-FELDSPAR GNEISS, light gray | 103.0 - 103.3': B-21-3-B Petrographic Analysis |
| RKING/EAST01/D2014647/BADCREE | | RC - 19 | | | 100 | 100 | (III) to wink (III), very hald, sound to very coarse grained, thinly foliated, trace hornblende GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), very hard, medium to coarse grained, thinly to thickly foliated, trace feldspar augens (0.4 - 2.0 cm), trace hornblende (0.2 - 4.1 cm), trace epidote, trace reddish brown garnets (0.1 - 0.8 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to | 105.4': End of day (04/22/2021); Depth to water 70.79' below ground surface, casing at 43.7' below ground surface (04/23/2021); No return initially, some to most return while coring RC-19 |
| S LAB.GDT - 4/6/22 11:19 - C:\PWWOI | <u>115</u> | RC - 20 | | | 100 | 100 | moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick | |
| 3-NO WELL COLUMN - GINT STD US | _ <u>120</u> | RC - 21 | | | 100 | 100 | | |
| JORTH CAROLINA BORING LOG | | RC - 22 | | | 100 | 100 | | 122.3': FOLIATION dipping 20° |

PROJECT NAME BAD CREEK II

PROJECT LOCATION SALEM, SOUTH CAROLINA

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CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

Page 55



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CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 6 OF 21

PROJECT NAME BAD CREEK II

| (#) HLd30 125 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|---------------------|------------------------------|-----------------------------|---|------------|--|---|
| | - RC - 23 | | 100 | 100 | GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), very hard, medium to coarse grained, thinly to thickly foliated, trace feldspar augens (0.4 - 2.0 cm), trace hornblende (0.2 - 4.1 cm), trace epidote, trace reddish brown garnets (0.1 - 0.8 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick (continued) | 128.1': Trace fine grained pyrite |
| | - RC - 24 | | 100 | 100 | | |
| 0/// | - RC - 25 | | 100 | 100 | | below ground surface, casing at 43.7' below ground surface (04/26/2021); No return, HW casing advanced to 53.6', Driller switched from series 12 to series 10 bit |
| | - - 26 | | 100 | 100 | | 140.4': Driller added EZ mud to help with circulation, half of water return while coring RC-26 |
| | - - - 27 | - | 100 | 100 | | 145.4': Some (25%) fluid return |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 7 OF 21

PROJECT NAME BAD CREEK II

| HLdad 150 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|---|------------------------------|-----------------------------|-----------------------|--------------------|------------|--|---|
| IL GEOTECHNICAL_GINT.GPJ 1211111111111111111111111111111111111 | - - - 28 - | | | 100 | 100 | GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), very hard, medium to coarse grained, thinly to thickly foliated, trace feldspar augens (0.4 - 2.0 cm), trace hornblende (0.2 - 4.1 cm), trace epidote, trace reddish brown garnets (0.1 - 0.8 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick (continued) | 150.4': End of day (04/26/2021); Depth to water 60.25' below ground surface, casing at 53.6' below ground surface (04/27/2021); Driller added EZ mud to help with circulation; HW casing advanced to 63.1', some fluid return after casing advanced |
| RKING/EAST01/D2014647/BADCREEK/ 01 01 | - - - 29 - | _ | | 100 | 100 | | 155.4': Most (75%) fluid return |
| • US LAB.GDT - 4/6/22 11:19 - C.\PWWO 10 | - - - 30 - - | _ | | 100 | 100 | | 160.4': FOLIATION dipping 10° - 30° 160.9 - 161.15': B-21-3-C Petrographic Analysis |
| LOG-NO WELL COLUMN - GINT STD | - - - 31 - - | _ | | 100 | 100 | | |
| NORTH CAROLINA BORING | - - RC - 32 | | | 100 | 100 | | |



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CLIENT DUKE ENERGY

PROJECT NUMBER _ 10270481 _____

BORING NUMBER B-21-3

PAGE 8 OF 21

PROJECT NAME BAD CREEK II

| (#) 175 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|------------|---------------------------------|-----------------------------|---|------------|---|--|
| | - - - 33 | | 100 | 100 | GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), very hard, medium to coarse grained, thinly to thickly foliated, trace feldspar augens (0.4 - 2.0 cm), trace hornblende (0.2 - 4.1 cm), trace epidote, trace reddish brown garnets (0.1 - 0.8 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | |
| | - - - 34 | | 100 | 100 | | 180.4': End of day 04/27/2021); Depth to water 57.20' below ground surface, casing at 63.1' below ground surface (04/28/2021); No fluid return at start of RC-34 |
| | - - - 35 | | 100 | 100 | | 185.4': Some (25%) fluid return initially, most (75%) fluid return at end of RC-35 |
| | - - - - - - - | | 100 | 100 | | 190.4': FOLIATION dipping 10° - 30° |
| | - - - 37 | | 100 | 100 | | 196.1 - 196.4': Lower concentration of biotite |
| | | | | | | |



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CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 9 OF 21

PROJECT NAME BAD CREEK II

| (#) 200 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) ROCK RFCOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|------------|---------------------------------|-----------------------------|---|--|---|---|
| | - - - - - - - | | 100 | 100 | 201.3 202.0 QUARTZ-FELDSPAR GNEISS, light gray (N7) to white (N9), very hard, coarse to very coarse grained, trace hornblende, trace biotite GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), very hard, medium to coarse grained, thinly to thickly foliated, trace feldspar augens (0.5 - 2.1 cm), trace hornblende (0.2 - 1.4 cm), trace | |
| | - - - - - - | | 100 100 | epidote, trace reddish brown garnets (0.3 - 0.6 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick 205.4 - 215.4': Light gray (N7) to medium light gray (N6), little hornblende (0.2 - 1.4 cm) with few epidote | 205.4 - 215.4': Increase concentration of quartz and feldspar; Driller reported harder drilling 205.4': FOLIATION dipping 30° - 35° 205.5': FOLDING 210.0 - 218.9': FOLDING | |
| 215 | - - - - - - - | | 100 | 100 | | 212.2 - 212.3': Trace potassium feldspar 213.0 - 213.1': Trace potassium feldspar 213.7' - 213.9': Trace potassium feldspar |
| | - - RC - 41 | | 100 | 100 | 215.4 - 225.4': Medium light gray (N6) to medium gray (N5) | 215.4': Driller reported harder drilling 215.4': FOLIATION dipping 20° - 30° 217.55 - 217.8': B-21-3-D Petrographic Analysis |
| | - - RC - 42 | | 100 | 100 | | 220.4': End of day (04/28/2021); Depth to water 54.30' below ground surface, casing at 63.1' below ground surface (04/29/2021); No fluid return initially, some return (30%) at end of RC-42 220.4': FOLIATION dipping 10° - 30° 223.2 - 224.8': FOLDING |



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CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 10 OF 21

PROJECT NAME BAD CREEK II

| | н (1) 225 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|------------------------------------|---------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|--|
| EEKIL GEOTECHNICAL_GINT.GPJ | - - 230 | RC - 43 | | | 100 | 100 | GRANITIC GNEISS, medium light gray (N6) to medium gray (N5), very hard, medium to coarse grained, thinly to thickly foliated, trace feldspar augens (0.5 - 2.1 cm), trace hornblende (0.2 - 1.4 cm), trace epidote, trace reddish brown garnets (0.3 - 0.6 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick (continued) 225.4 - 249.4': Light gray (N7) to medium | 225.4': JOINT, healed with quartz and feldspar, 15° - 20° dip 225.9 - 226.7': Higher concentration of quartz and feldspar, very coarse to medium grained, less foliated, massive 228.3 - 228.9': FOLDING 228.9 - 229.2': Quartz vein cross cutting foliation 229.0 - 229.6': Higher concentration of quartz and feldspar, very coarse to medium grained, less foliated, massive |
| VORKING\EAST01\D2014647\BADCRE | - - 2 <u>35</u> | RC - 44 | | | 100 | 100 | light gray (N6) | 230.4': FOLIATION dipping 20° - 30° 232.65 - 233.1': SAMPLE B-21-3-1T , Splitting Tensile Test, TS= 1.380 psi 233.1 - 233.7': SAMPLE B-21-3-2C , UCS, uw=167 pcf, ucs= 18,446 psi |
| JS LAB.GDT - 4/6/22 11:19 - C:\PWM | - - 240 | RC - 45 | | | 100 | 100 | | 237.4 - 238.0': SAMPLE B-21-3-3CM , (UCS/EM), uw= 169 pcf, ucs, 14,789 psi, em= 2.26E+06 psi, PR= 0.15 at the low stress range (1,500-5,400 psi) |
| OG-NO WELL COLUMN - GINT STD L | - - 245 | RC - 46 | | | 100 | 100 | 245.4 - 249.4': Fine to coarse grained | 244.5 - 250.0': PACKER TEST 4: No take at 70 psi |
| NORTH CAROLINA BORING L | - - 2 <u>50</u> | RC - 47 | | | 100 | 100 | 249.4 | 248.3': JOINT, 60° dip, closed, chlorite 248.7': FOLIATION JOINT, 20° dip, closed, chlorite |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 11 OF 21

PROJECT NAME BAD CREEK II

| HLd U 250 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|----------------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|---|
| KII_GEOTECHNICAL_GINT.GPJ | RC - 48 | | | 100 | 100 | QUARTZ-FELDSPAR GNEISS, white (N9) to very light gray (N8), very hard, medium to very light gray (N8), very hard, medium to very light gray (N8), very hard, medium to very light gray (N8) to light gray (N7), medium to very coarse grained, increasing 253.4 Didite content with depth GRANITIC GNEISS, medium gray (N5) to medium dark gray (N4), hard to very hard, fine to coarse grained, thinly to thickly foliated, trace hornblende (0.2 - 1.2 cm), | 249.8 - 250.4': SAMPLE B-21-3-4T, Splitting Tensile Test, TS= 1,770 psi 250.0 - 255.5': PACKER TEST 3: No take at 70 psi 250.2': JOINT, healed with quartz and feldspar, 60° dip 250.4': End of day (04/29/2021); Depth to water 56.25' below ground surface, casing at 63.1' below ground surface (04/30/2021); No fluid return initially, some fluid return at end of RC-48 250.4 - 255.4': Fresh to very slight weathering 250.6 - 251.15': SAMPLE B-21-3-5C, UCS, uw=162 pcf, UCS= 32,661 psi 251.4': JOINT, healed with calcite and chlorite. 30° dip. |
| RKING/EAST01/D2014647/BADCREEI | - RC - 49 | | | 100 | 100 | trace epidote, trace reddish brown garnets (0.2 - 0.6 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick | 251.4: SOINT, headed pyrite 253.4: FOLIATION dipping 30° 253.8 - 254.1: SHEAR ZONE, 30° dip, quartz-biotite-plagioclase in matrix, quartz-biotite-Fe staining on shear plane, clay and sand infilling, S-C Indictor, anastomosing 254.0: Shear plane grooved, 30°, generally parallel to dip 254.5: FOLDING 255.4 - 265.4: Fresh weathering |
| LAB.GDT - 4/6/22 11:19 - C. PWWO | RC - 50 | | | 98 | 98 | 263.3 QUARTZ-FELDSPAR GNEISS, very light gray (N8), very hard, coarse to very coarse grained, thinly foliated, trace biotite and hornblende | 264.3': FOLIATION dipping 0° - 15 264.3': FOLIATION dipping 10° - 20° 264.4 - 265.4': Rock fell in hole while pulling core up, 0.9' was retrieved with many mechanical fractures |
| 0 WELL COLUMN - GINT STD US | - RC - 51 | | | 92 | 56 | 266.2 WEATHERED SHEARED ROCK, light gray (N7), to medium light gray (N6), hard to moderately hard, fine to coarse grained, thinly to thickly foliated, few feldspar augen (0.4 - 1.2 cm), few hornblende (0.2 - 0.5 cm), few reddish brown garnet (0.2 - 269.2 0.4 cm) GRANITIC GNEISS, light gray (N7) to medium light gray (N6), hard fine to | 265.0 - 270.5': PACKER TEST 2: Interval did not build pressure; HIGH PERMEABILITY related to shear zone 265.3 - 265.5': FOLDING 265.4': FOLIATION JOINT, 40° dip, open, chlorite, on limb of fold 265.4 - 270.4': Close joint spacing 265.4 - 267.0': Very slight to slight weathering 266.0': FOLIATION JOINT, 30° dip, open, Fe minor staining 266.1': Slightly stained feldspare |
| NORTH CAROLINA BORING LOG-A | RC - 52 | - | | 100 | 100 | medium grained, thinly to thickly foliated, few feldspar augens (0.4 - 2.0 cm), few hornblende (0.2 - 0.5 cm), trace epidote, few reddish brown garnets (0.2 - 0.7 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1 - 0.4' thick | 266.2': FOLIATION JOINT, 20° dip, open, trace Fe staining; Lost all return at 266.2'; Very close to close joint spacing from 266.2' - 270.4'; Moderate to slight weathering from 266.2' - 267.0' 266.8': JOINT, 10° dip, open, oxidized biotite, trace Fe staining 266.8': FOLIATION dipping 0° - 10° 266.9': JOINT, 20° dip, open, Fe staining, weathered gamets 267.0 - 267.8': Highly JOINTED, 0° to 20° dip, open, Fe staining, clay infilling, sand build up |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 12 OF 21

PROJECT NAME BAD CREEK II

| HLAED 27 | (#) | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|---|-----------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|--|---|
| KII_GEOTECHNICAL_GINT.GPJ | - - - - - | RC - 53 | | | 100 | 100 | 278.0 278.7 gray (N8), to white (N9), very hard, coarse to very coarse grained, trace to few biotite and hornblende GRANITIC GNEISS, light gray (N7) to | 267.0 - 267.8': Moderately severe weathering 267.0 - 267.5': Driller reported softer drilling 267.4 - 267.8': Core loss 267.8 - 270.4': Slight to moderate weathering 268': FOLIATION JOINT, 30° dip, open, Fe staining, minor clay infilling, sand infilling 268.2 - 268.4': Heavily JOINTED, 0° - 20° dip, clay infilling, sand infilling 269': FOLIATION JOINT, 10° dip, open, Fe staining, minor clay infilling, sand infilling 269.1': FOLIATION JOINT, 10° dip, open, Fe staining 269.2': JOINT, 10° dip, open, Fe staining 269.2': JOINT, 10° dip, open, Fe staining 270.4 - 285.4'. Very wide joint spacing |
| KING/EAST01/D2014647/BADCREE | - - - 5_ | RC - 54 | | | 100 | 100 | medium light gray (N6), hard, fine to medium grained, thinly to thickly foliated, few feldspar augens (0.4 - 2.3 cm), trace hornblende (0.2 - 1.8 cm), trace epidote, trace reddish brown garnets (0.2 - 0.6 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1 - 0.4' thick | 270.4 - 280.4': Fresh weathering 275.4': No fluid return 277.55 - 278.1': SAMPLE B-21-3-6T, Splitting Tensile Test, TS= 1,650 psi 278.7 - 279.3': SAMPLE B-21-3-7C NOT TESTED 279.9': 0.5 cm epidote-rich band 280.4 - 285.4': Fresh to very slight weathering 285.4': No return 280.7': 0.3 cm epidote-rich band |
| LAB.GDT - 4/6/22 11:19 - C:\PWWOR 66 | - - - - 00 | RC - 55 | | | 100 | 88 | 285.4': Some light brown (5YR 6/4) | 285.4': End of day (04/30/2021); Depth to water 95.23' below ground surface, casing at 63.1' below ground surface (05/05/2021); No fluid return for remainder of coring to a depth of 500.4' 285.4 - 288.7': Moderately close joint spacing 285.4 - 286.2': Very slight weathering 285.5 - 290.4': Trace potassium feldspar 286.1 - 291.6': PACKER TEST 1: No take at 70 psi 286.2 - 290.4': Slight to moderate weathering 286.3 - 287.3': JOINT, healed with potassium feldspar, 80° dip 287.1': Joint 20° dip open moderately rough sand |
| G-NO WELL COLUMN - GINT STD US | - - - 9 <u>5</u> - | RC - 56 | | | 100 | 100 | | and silt build up 288.7 - 289.2': FAULT ZONE, 60° dip, open, slickensides indicated oblique slip movement, perpendicular fractures throughout, Fe staining, chlorite, clay infilling, NE strike/ NW dip 288.7 - 290.4': Very close to close joint spacing 289.6 - 289.9': Fault plane, 70° dip, open, slickensides indicate oblique slip movement, perpendicular fractures throughout, Fe staining, clay infilling, NE strike/ NW dip 290.4 - 500.4': Very wide joint spacing 290.4 - 295.4': Fresh to slight weathering |
| NORTH CAROLINA BORING LO | - - - 00 | RC - 57 | | | 100 | 100 | | 295.4 - 316.0': Fresh weathering 295.7': JOINT, healed with calcite, 60° dip 295.8': JOINT, healed with calcite, 60° dip |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 13 OF 21

PROJECT NAME BAD CREEK II

| S DEPTH | (ft) 00 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|---------|--------------------------------|------------------------------|-----------------------------|-----------------------|------------|------------|---|--|
| | - - - - 0 <u>5</u> | RC - 58 | | | 100 | 100 | GRANITIC GNEISS, light gray (N7) to medium light gray (N6), hard, fine to medium grained, thinly to thickly foliated, few feldspar augens (0.4 - 2.3 cm), trace hornblende (0.2 - 1.8 cm), trace epidote, trace reddish brown garnets (0.2 - 0.6 cm), with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1 - 0.4' thick (continued) | |
| | - - - 10_ | RC - 59 | | | 100 | 100 | 306.0 QUARTZ-FELDSPAR GNEISS, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, thinly foliated biotite. GRANITIC GNEISS, light gray (N7) to medium light gray (N6), hard, fine to medium grained, thinly to thickly foliated, trace feldspar augens (0.2 - 2.5 cm), trace hornblende (0.1 - 2.5 cm), trace epidote, trace reddish brown garnets (0.1 - 0.8 cm), | |
| | _ _ _ 15_ | RC - 60 | | | 100 | 100 | with interlayered quartz-, feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick | 310.4': FOLIATION dipping 10° - 15° |
| | - - - 20 | RC - 61 | | | 100 | 100 | | 316.0': JOINT, healed with chlorite and calcite, 65°, potassium feldspar 316.0 - 316.4': Fresh to very slight weathering 316.4 - 500.4': Fresh weathering |
| | - - - 25 | RC - 62 | | | 100 | 100 | | 320.8 - 321.1': Less biotite and hornblende |


CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 14 OF 21

PROJECT NAME BAD CREEK II

PROJECT LOCATION SALEM, SOUTH CAROLINA

SAMPLE TYPE/ NO./CORE RUN BLOW COUNTS (N VALUE) SOIL RECOVERY (in) % % ROCK RECOVERY ROCK RQD DEPTH (ft) REMARKS DESCRIPTION 325 GRANITIC GNEISS, light gray (N7) to medium light gray (N6), hard, fine to medium grained, thinly to thickly foliated, NORTH CAROLINA BORING LOG-NO WELL COLUMN - GINT STD US LAB. GDT - 4/6/22 11:19 - C;\PWWORKING\EAST01\D2014647\BADCREEKII GEOTECHNICAL GINT. GPJ trace feldspar augens (0.2 - 2.5 cm), trace hornblende (0.1 - 2.5 cm), trace epidote, trace reddish brown garnets (0.1 - 0.8 cm), RC with interlayered quartz-, feldspar-, 100 100 63 potassium feldspar-, hornblendepegmatites, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 330 0.1' - 0.4' thick (continued) 331.35 - 332.0': SAMPLE B-21-3-8T, Splitting Tensile Test, TS= 1,780 psi 332.25 - 332.9': SAMPLE B-21-3-9C, UCS, uw=168 RC pcf, ucs= 21,079 psi 100 100 64 335 335.4': End of day (05/05/2021); Depth to water 77.83' below ground surface, casing at 63.1' below ground 335.9 - 337.1': Medium gray (N5) to medium surface (05/06/2021) dark gray (N4) 337.1 - 342.7': Medium light gray (N6) to medium gray (N5), fine to coarse grained RC -100 100 65 340 342.7 RC -100 100 QUARTZ-FELDSPAR GNEISS, very light 66 gray (N8) to white (N9), very hard, coarse 343.9 to very coarse grained, sparsely to thinly foliated, trace to few biotite and hornblende 344.5': FOLIATION dipping 15° - 20° 345 GRANITIC GNEISS, light gray (N7) to medium light gray (N6), hard, fine to medium grained, thinly to thickly foliated, few feldspar augens (0.4 - 1.2 cm), trace hornblende (0.2 - 0.5 cm), with trace epidote, trace reddish brown garnets (0.2 - 0.5 cm)347.6': FOLIATION dipping at 10° - 30° 0.4 cm), with interlayered quartz-, RC -100 100 347.8 - 348.3': FOLDING 67 feldspar-, potassium feldspar-, hornblende- pegmatites, spaced close to 349.2 moderately close, very light gray (N8), to white (N9), very hard, coarse to very 350



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 15 OF 21

PROJECT NAME BAD CREEK II

| (#) 350 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | | DESCRIPTION | REMARKS |
|--------------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|------------------------------|--|---|
| | - - - - 68 | - | | 100 | 100 | 350.1 352.8 353.6 | coarse grained, 0.1' - 0.4' thick QUARTZ-FELDSPAR GNEISS , very light gray (N8) to white (N9), very hard, coarse to very coarse grained, trace biotite and hornblende <i>(continued)</i> GRANITIC GNEISS , light gray (N7) to medium light gray (N6), hard, fine to medium grained, thinly to thickly foliated, trace hornblende augen (0.2 - 0.5 cm), trace epidote, trace reddish brown garnets (0.2 - 0.4 cm), trace feldspar augens (0.4 - 1.2 cm), with interlayered | 353.6': FOLIATION dipping 0° - 10° |
| KING(EASI01)U201464/IBADCREEK | - - RC - 69 | | | 100 | 100 | <u>357.1</u> <u>358.4</u> | quartz- potassium feldspar- hornblende pegmatite, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick QUARTZ-FELDSPAR GNEISS , very light gray (N8) to white (N9), very hard, coarse to very coarse grained, trace biotite and hornblende GRANITIC GNEISS , light gray (N7) to medium light gray (N6), hard, fine to | 356.1 - 356.7': SAMPLE B-21-3-10CM , (UCS/EM), uw= 168, ucs= 19,577 psi, em= 2.93E+06 psi, PR= 0.27 at the low stress range (2,000-7,200 psi) 357.9': Trace fine grained pyrite |
| 8601 - 4/0/27 11:19 - C://WWOK | - - RC - 70 | | | 100 | 100 | | medium grained, thinly to thickly foliated, trace hornblende augen (0.1 - 1.0 cm), trace epidote, trace reddish brown garnets (0.2 - 0.4 cm), trace feldspar augens (0.4 - 1.2 cm), with interlayered quartz- potassium feldspar- hornblende pegmatite, spaced close to moderately close, very light gray (N8), to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick OLIARTZ-FEL DSPAR GNEISS very light | 360.4': FOLIATION dipping 10° - 15° |
| | - - - - 71 | | | 100 | 100 | | gray (N8) to white (N9), very hard, coarse to very coarse grained, trace biotite and hornblende GRANITIC GNEISS, light gray (N7) to medium light gray (N6), hard, fine to medium grained, thinly to thickly foliated, trace hornblende augen (0.1 - 1.2 cm), trace epidote, trace feldspar augens (0.4 - 2.0 cm), with interlayered quartz-potassium feldspar- hornblende pegmatite, spaced close to moderately close very light gray (N8) to white (N9) | 270 4': Slightly bigher bigtite centert |
| | - - RC - 72 | | | 100 | 100 | | very hard, coarse to very coarse grained, 0.1' - 0.4' thick 365.4 - 366.2': Poorly foliated | 370.4': Slightly higher blotte content 370.4': FOLIATION dipping 20° - 30° |



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BORING NUMBER B-21-3

PAGE 16 OF 21



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 17 OF 21

PROJECT NAME BAD CREEK II

| (t) 400 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|-------------------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|--|---|
| dil Geotechnical GINT.GPJ | RC - 78 | | | 100 | 100 | GRANITIC GNEISS , medium light gray (N6), to medium gray (N5), very hard, fine to coarse grained, thinly to thickly foliated, trace hornblende (0.2 - 1.9 cm), trace epidote, trace reddish brown garnets (0.3 - 0.9 cm), trace feldspar augens (0.7 - 2.2 cm), with interlayered quartz- potassium feldspar- hornblende pegmatite, spaced close to moderately close, very light gray (N8) to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | |
| RKING\EAST01\D2014647\BADCREEF | RC - 79 | | | 100 | 100 | | 405.5': FOLIATION dipping 30° - 35° |
| S LAB. GDT - 4/6/22 11:19 - C:/PWWO | RC - 80 | | | 100 | 100 | | 410.5 - 411.35': FOLDING |
| | RC - 81 | | | 100 | 100 | | 416.2 - 418.0': Trace potassium feldspar 418.8': FOLDING |
| | RC - 82 | | | 100 | 100 | | 420.4 - 425.4': Trace potassium feldspar 423.4 - 423.7': FOLDING 424.3 - 428.4': Higher biotite content |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 18 OF 21

PROJECT NAME BAD CREEK II

| | | | | | | | - |
|-----------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|--|
| HLd3D 425 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
| di Geotechnical GINT.GPJ | RC - 83 | | | 100 | 100 | GRANITIC GNEISS, medium light gray (N6), to medium gray (N5), very hard, fine to coarse grained, thinly to thickly foliated, trace hornblende (0.2 - 1.9 cm), trace epidote, trace reddish brown garnets (0.3 - 0.9 cm), trace feldspar augens (0.7 - 2.2 cm), with interlayered quartz- potassium feldspar- hornblende pegmatite, spaced close to moderately close, very light gray (N8) to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick (continued) | 429.3': FOLDING |
| \ST01\D2014647\BADCREEK | RC - 84 | - | | 100 | 100 | 428.4 - 430.4': Light gray (N7) to medium light gray (N6) | 430.8 - 431.4': SAMPLE B-21-3-17T , Splitting Tensile Test, TS= 1,350 psi 432.95 - 433.6': SAMPLE B-21-3-18C , UCS, uw= 168 pcf, ucs= 22,047 psi |
| 11:19 - C:\PWWORKING\EA | RC - | - | | 100 | 100 | | 434.5 - 435.1': SAMPLE B-21-3-19CM , (UCS/EM), uw= 169 pcf, ucs= 20,417 psi, em= 3.74E+06 psi, PR= 0.19 at the low stress range (2,000-7,500 psi) 435.4': FOLIATION dipping 10° - 20° 436.3': FOLDING |
| STD US LAB.GDT - 4/6/22 | 85 | - | | 100 | 100 | | 437.9 - 438.7': FOLDING 440.4': End of day (05/10/2021); Depth to water 147.3' below ground surface, casing at 63.1' below ground surface (05/11/2021) |
| | RC - 86 | | | 100 | 100 | | 444.7': FOLIATION dipping 20° - 30° |
| NORTH CAROLINA BORING LOG-A | RC - 87 | | | 100 | 100 | | 445.0 - 459.2': FOLDING |



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CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 19 OF 21

PROJECT NAME BAD CREEK II

| (1) HLdBD 450 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|---------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|--|--|
| | RC - 88 | - | | 100 | 100 | GRANITIC GNEISS , medium light gray (N6), to medium gray (N5), very hard, fine to coarse grained, thinly to thickly foliated, trace hornblende (0.2 - 1.9 cm), trace epidote, trace reddish brown garnets (0.3 - 0.9 cm), trace feldspar augens (0.7 - 2.2 cm), with interlayered quartz- potassium feldspar- hornblende pegmatite, spaced close to moderately close, very light gray (N8) to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | |
| 460 | RC - 89 | - | | 100 | 100 | | |
| 465 | RC - 90 | _ | | 100 | 100 | | 463.7 - 500.4': FOLDING 465.4': FOLIATION dipping 10° - 20° |
| 470 | RC - 91 | | | 100 | 100 | | |
| | RC - 92 | | | 100 | 100 | 470.7 QUARTZ-FELDSPAR GNEISS , light gray (N7), to pinkish gray (5YR 8/1), very hard, coarse to very coarse grained, with interlayered GRANITIC GNEISS, light gray (N7) to medium light gray (N6), very hard, medium to coarse grained | |
| | | | <u> </u> | I | | Page 69 | 1 |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-3

PAGE 20 OF 21

PROJECT NAME BAD CREEK II

| (1) HLd <u>J</u> 475 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|--|------------------------------|-----------------------------|---|------------|--|---|
| | - RC - 93 | | 100 | 100 | GRANITIC GNEISS, medium light gray (N6), to medium gray (N5), very hard, fine to coarse grained, thinly to thickly foliated, trace hornblende augen (0.1 - 2.7 cm), trace reddish brown garnets (0.3 - 0.9 cm), trace feldspar augens (0.7 - 2.2 cm), with interlayered quartz- potassium feldspar- hornblende pegmatite, spaced close to moderately close, very light gray (N8) to white (N9), very hard, coarse to very coarse grained, 0.1' - 0.4' thick <i>(continued)</i> | 475.4': End of day (05/11/2021); Depth to water 146.55' below ground surface, casing at 63.1' below ground surface (05/12/2021) |
| 485 | RC - 94 | | 100 | 100 | | 480.4': FOLIATION dipping 30° 480.4 - 481.05': SAMPLE B-21-3-20T , Splitting Tensile Test, TS= 1,510 psi 480.8': FOLDING 481.7 - 482.3': SAMPLE B-21-3-21C , UCS, uw=168 pcf, ucs= 18,086 psi 483.55 - 484.2': SAMPLE B-21-3-22CM , (UCS/EM), uw= 169 pcf, ucs= 10,642 psi, em= 3.54E+06, PR= 0.33 at the low stress range (1,100-3,900 psi) |
| 1000 | RC - 95 | | 100 | 100 | | 490 41: EQUATION disping 30° |
| 495 | RC - 96 | | 100 | 100 | | |
| | RC - 97 | | 100 | 100 | | |



Site = Bad Creek Project #= 10270481 Date = 20 April 2021 Geologist: Charles Gruenberg Boring IO = B-21-3 Sample ID : SS-1 Depth: 0.0- 1.5' Blow counts: 2,3,3 N= G Top Bottom 69 7 8 9 10 11

Photograph 51. **B-21-3:** SS-1 **Depth:** 0-1.5 ft **Date:** 04/20/21



Photograph 52. **B-21-3:** SS-2 **Depth:** 2.7-4.2 ft **Date:** 04/20/21



Photograph 53. **B-21-3:** SS-3 **Depth:** 7.7-9.2 ft **Date:** 04/20/21



Photograph 54. **B-21-3:** SS-4 **Depth:** 12.7-13.5 ft **Date:** 04/20/21



Photograph 55. **B-21-3:** Box 1 of 34

Depth: 20.7-35.4 ft

Date: 04/21/21



Photograph 56. **B-21-3:** Box 2 of 34

Depth: 35.4-49.2 ft

Date: 04/21/21

| B-21-3 | 10240481) HDR | 0 | - Contraction | | | |
|--|----------------------------|-----------------------------------|---------------------------|--------------------------------------|--------------------|---------------------------------------|
| Bad Creek (HDR) | | | in the second | RC - 5 = 35.9 - 40 RC - 40.4 - 45 | .4' .4' | |
| Project #= 10270481 | John RC7 405 | RC-8 | Run | Depth (F3) | Receivery (FH / %) | RQD (4/9) |
| Box 3 0134 | | -0- | KC-7 | 45.4-50.4' | 5.0' 100% | 5.0 / 100% |
| Depth= 49.2-63.8 | RC-8 555 | RC-9 | KC-8 | 50.4- 55.4" | 5.01 100% | 5.01 100% |
| Date= 21 April 20210 | | | RC-9 | 55.4'- 60.4' | 50/100% | 4.9' /98% |
| | RC-9 25 | RC-10 | · PL-10 | 60.4-65.4 | 5.01 100% | 4.9'/98% |
| the state of the s | | 1. | 829 | 1 | | |
| Mill Marken and and and and | · | A Martin Contraction of Same Same | 1 . 8 . 8 . 8 . 9 . 8 . 9 | | 2 3 6 9 | |
| The state of the s | | Mar Talkade | ET. MARY | HIRE AN | Same and | 1000 STREET |
| SECTION OF THE CONTRACT OF | The De Contract In and the | Alexandre International | | | 神科世界思维 | |
| A REAL PROPERTY AND A REAL PROPERTY A REAL PROPERTY AND A REAL PROPERTY AND A REAL PRO | The second designed | | 自己自由自己的意思。 | | and the main | L ALC BILLING |
| CONTRACT OF A TRACTAGE OF A DE BUS T | THE SET OF THE SET | THE THE NE THE THE | | | | |
| How was a station of which we a | Contraction of the second | | | | | 1. S. C. M. |
| | | THE REAL PROPERTY AND INCOME. | | | Charles (Alice) | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| | | | and the second second | and the sea | | Contraction of the |
| | | | | | | |
| ank (PH-1022-Mai) !! | | | | | | |

Photograph 57. **B-21-3:** Box 3 of 34

Depth: 49.2-63.8 ft

Date: 04/21/21

| Bad Creek (P#= 10 12-21-2 | 270481) HOR | F | RC-7- 45.4'- 50.4' RC-8: 504'- 554' RC-9- 554'- 60.4 | 10 |
|--|---------------------------------------|---------|--|---|
| Bad Creek (HOR) Project #: 10270481 | RC-10 | | Run Depth (21) RC10 (04-654 | Recency (4/%) RQD (F+/%) |
| B-21-3 Box 4 of 34 | 4 0 0 0 N | | Run (65.4' 70.4' | 5.61 100% 4.91 98% |
| Depth = 63.8'-771 | RC-11 Det | REAL | Ren 70.4'- 75.4' | 5.01 100% 50 / 100% |
| Uate = 21 April 2021 22 April 2021 | RC-12 TE | 0(-12 - | RC-13 75.4'-80.4' | 507 100% 9.8 / 96% |
| | Kirt | RC13 2 | | |
| | | | | A CONTRACTOR OF THE OWNER OWNER OF THE OWNER |
| The William Provident | MELT CARDEN COM CONTRACTOR CONTRACTOR | | | |
| | | PAL | WWW/WWWWW | LA STAN ME |
| EIZ ALL LUID | | | Martin 1 | Philadeline and the second |
| | | | | |
| | | | | Contraction of the second |
| | | | | |

Photograph 58. **B-21-3:** Box 4 of 34

Depth: 63.8-77.1 ft

Date: 04/21/21-4/22/21



Photograph 59. B-21-3: Box 5 of 34

Depth: 77.1-91.6 ft

Date: 04/22/21



Photograph 60. **B-21-3:** Box 6 of 34

Depth: 91.6-105.3 ft **Date:** 04/22/21

| Bed (roux (HDP) | Internet Hole | 0 | | RC-16 = 90.4'- RC-17= 95.4'- | 15.4' 100.4' | 0 |
|--|---------------|--------|--------------|---------------------------------|-----------------|------------|
| Project # = 10270481 | Cipt in a | RL-190 | Run | Depth (Ff) | Recovery (#+/90 | RQD (#1%) |
| B-21-3 | it it | | RL-18 | 1004-105.4 | 5.0 1100% | 49'/100% |
| Depth: 105.5- 119.4' | RC-19 = = = | RC.20 | RC-19 | 105.9-110.4 | 5.01/ 160% | 5.0'1 100% |
| Date = 23 Aprilzozi | RC-20 J - | P() | R(-26 | 110.4- 115.4 | 5.01100% | 5.0'1/00% |
| | | KC- AI | . +211 RL-21 | 115.4- 120.4* | 5.0 / 100% | 4.9' / 98% |
| | | | | | | |
| A CONTRACTOR OF A CONTRACTOR O | (CARLY CALLS | | | | California A | hbl |

Photograph 61. **B-21-3:** Box 7 of 34

Depth: 105.3-119.4 ft **Date:** 04/25/21

| B-21-3 Box 7 of 34 Depth= 1000 - 1194 | | | ec QS QS QS QS QS QS QS QS QS QS QS QS QS | -18 = 100.4-1 -19= 105.4 (-20= 105.4 2(-21= 115.4 | 105.4" - 110.4" - 115.4" - 115.4" | • | |
|---|-----------------------|---------------------|--|--|--|--------------------|-------------|
| Bad Creek (HDR) | 8(-2) 200 | P(-22 | | Run | Depth (ff) | Receivery (FH 9/6) | RQD (++ /%) |
| R-21-3 | nuer al- | AC dia | | RL-21 | 115.4-120.4 | 5.0% 100% | 49'/98% |
| B.2 8 of 34 | 01 121 × 5 | @ RC-23 | 0 | RL-22 | 120.4-125.4 | 5.0 / 100% | 49198% |
| Depth= 119.4' - 1339 | action all | N. A | - | RC-23 | 125.4-130.4' | 5.01 160% | 501 100 |
| Date= 23 April Zoza | R(-13 2) | RC-24 | | RC-24 | 130.4-135.4 | 5.0 / 100% | 50/100% |
| | | 2 | Ţ, | | | | |
| E HOLAN HANNON | 18 I AMERICAN | The second second | Se Sumery by Tes | | tint etcres | | |
| | WIR HELMENERICAN | and Andrew Walkshie | Handander 9 4 | | 2.10.181 | (A.) A Mar Mana | |
| | | | | | 加加州 年十 | ENERGIAN (ROAL) | ANR - |
| | ast contract on | MAH': A TARA | MARKEN | 1817 1 | | | LA DAMANA Y |
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| | | | and the second | | | State Station | 2 |
| | and the second second | | | | | | |

Photograph 62. **B-21-3:** Box 8 of 34

Depth: 119.4-133.9 ft **Date:** 04/25/21

| Bad Creek (P#=1027048 B-21-3 Rox B of 34 | BI) HOR | 1 | · | |
|--|-------------|--|---|---------------------------|
| Bad Greek (HOR) Project #= 16276481 pm | RC-24 195 | RC-25 | Ren Depth (F2) | Reary (F4/9/6) ROD (F4/%) |
| B-21-3 Box 9 0F34 | P1-25 200 | 86-76 | RC-29 .130.4-135.4 RC-25 135.4'.140.4' | 5.0 / 100% 50 / 100% |
| Depth= 133.9-148.3' | | | RL-26 140.4-145.4 | 50'1100% 5.0'1100% |
| Dale = 25 Igni ZOZI | RC-26 2 2 | RC-17 | RC-44 145.4- 150.4 | 5.0710014 5.0710012 - |
| | | | EN CALLAR | |
| | C TRANSPORT | Proved Links of A Database Process With Robert And | | |
| TOTAL STORES | | | and Bridgerich | |
| | | | | Bathball |
| | | | | N STREET |

Photograph 63. **B-21-3:** Box 9 of 34

Depth: 133.9-148.3 ft **Date:** 04/25/21-04/26/21



Photograph 64. **B-21-3:** Box 10 of 34 **Depth:** 148.3- 162.8 ft **Date:** 04/26/21-04/27/21

| Bad Creek (p#= 102704 B-21-3 | 81) HOR | | | RC-27=145.4-1 | 50.Y | 0 | |
|---------------------------------|-----------------------|---------|-------------|---------------|---------------------------|-------------------------------|------------|
| Bad Creek (HDR) | Pier RL- | 20 ·H39 | R(-31 | Rin RC-30 | Depth (++) 160.4-165.4 | Remvery (FH/9%) 5.01/10040 | RQD (F1/4) |
| B-21-3 | de - | | 0/ 72 | R (-3) | 165.4'- 170.4' | 5.0'/100%0 | 50 1100% |
| Depth= 162.8' - 172.3' | ¢ K | | KC-SA | R(-3) | 170.4'- 175.4' | 5.0'/100% | 50'/ 100% |
| Date = 27 April 2021 | 1 | RL-32 | 1-554 RL-33 | Q := K | 125.9 - 100.1 | 5.0710010 | |
| | | | | | | | |
| | | | | | | | |
| | MARINE ZE | ter i i | 》,《释》 | | MENTO) | nel ji | |
| States and the second | and the second second | | | | | | aler - |

Photograph 65. **B-21-3:** Box 11 of 34 **Depth:** 162.8-177.3 ft **Date:** 04/27/21



Photograph 66. **B-21-3:** Box 12 of 34 **Depth:** 117.3-191.7 ft **Date:** 04/27/21-04/28/21

| Depth: 177.3- 1917 | | | | RL-35= | 85.4-190.4 | 1 | 1 |
|---|-------------------------------|----------------------|-------------------|----------------|---------------------|-------------------|---------------|
| Project H= 10270481 55 | R1-71 | .H. | M | Run | Depth (Ft) | Recurry (4/%) | ROD (A/%) |
| B-21-3 | The Jo | 61 | KC-37 1 | R1-36 | 190.4 - 145.4 | 5.0% 100% | 5.0'/100% |
| Box 13 of 34 | RC-37 | | 20 | RC-37 | 195.4' - 200.4 | \$5.0% 100% | 5.0' / 100' . |
| Deptine 1911 + 2024 | | - | KC- 78 | RL-38 | 200.4 - 205.4 | 1.0 1 100 10 | 5.01 100 - |
| Dates and | RC-38 | 25.4 | X | | | | |
| | 7 8 8 3 3 9 8 4 | A 1 1 1 1 | | 8 7 8 | | | |
| SAMARA COMPANY AND A STREET | Republic of the second second | | Int Platetra A 1 | | | | |
| | Sandy Bray Marries Alle Su | | | | south from | | |
| | A BREAK BEAM OF THE A | THE NUMBER OF STREET | New York Williams | 1 1 . 21 | NAME OF DESIGNATION | N TALAN A STATE | |
| CARDENSE CONNERS CANNED FOR ALL OF PROTOCOL | | an an training data | generation (| | STOPP SO | Califord and a | |
| (| | | PHI CONTRACT | | | bellen ve | |
| Contraction of the second s | | | | | | | G.H. |
| | | | | and the second | | a start a start - | A DEST OF |
| | | | | | | | |

Photograph 67. **B-21-3:** Box 13 of 34 **Depth:** 191.7-205.4 ft **Date:** 04/28/21



Photograph 68. **B-21-3:** Box 14 of 34 **Depth:** 205.8-219.3 ft **Date:** 04/28/21



Photograph 69. **B-21-3:** Box 15 of 34 **Depth:** 219.3-23

Depth: 219.3-233.7 ft Date: 04/28/21-04/29/21



Photograph 70. **B-21-3:** Box 16 of 34 **Depth:** 233.7-248.1 ft **Date:** 04/29/21

| Box 16 of 34 Depth= 233.7- 2481" | RC-47= 245.4'- 250.4' |
|--|---|
| Bad Creek (HDR) Rojet # = 102 70 481 B-21-3 Box 17 of 34 Depth= 248.1-261.3' | RC-47 R RC-48 Run OerH(H) Recourt RGO (H1"6) RC-48 Hin RC-48 RC-48 RC-47 2454:425.41 500% 4.5:190% RC-48 Hin RC-49 RC-48 2554:425.41 500% 4.5:190% RC-48 Hin RC-49 RC-49 Z504:2554 5.0% 100% RC-48 Hin RC-49 Z504:2554 5.0% 100% 5.0% |
| | • R(-1) • 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 |
| | |
| | |

Photograph 71. **B-21-3:** Box 17 of 34 **Depth:** 248.1-261.7 ft **Date:** 04/29/21



Photograph 72. **B-21-3:** Box 18 of 34 **Depth:** 261.7-275.4 ft **Date:** 04/30/21



Photograph 73. B-21-3: Box 19 of 34

Depth: 275.4-289.6 ft **Date:** 04/30/21-05/05/21

| Bad Creek (P#= 1027048 B-21-3 Bat 10 - 10 - 34 | 81) HDK | R(-53- R(-54- | 235.4' 280.4' : 280.4' 285.4' | |
|--|-----------------|------------------|----------------------------------|---|
| Der Project #= 10270481 Dr: 221-3 | ert RC-55 inter | R(-56 | Rin Depth RL-55 285.4- | (F1) (F1/9) (F2) (F1/9) (F2) (F1/9) |
| Dati Box 20 of 34 Depth= 284.6-304 | 1 . RC-56 | RL-57 | RC-56 290.4- RC-57 255.4- | 2754 5.0°1 100°6 5.0°1 100°6 300.7 5.0°1 100°6 5.0°1 100°6 |
| Date = 05 may 2021 | RC-57 | RC-58 | RC-58 300.7 | -3654 5.0° / 160°% 5.0' / 100°% |
| | | | | |
| | | | | and Distance |
| Entertainter | | A ANA MAN | all all shirts a line | A Mener Mark |
| A State of the state of the | | | | |

Photograph 74. **B-21-3:** Box 20 of 34 **Depth:** 289.6- 304.1 ft **Date:** 05/05/21



Photograph 75. B-21-3: Box 21 of 34

Depth: 304.1- 318.7ft Date: 05/05/21



Photograph 76. **B-21-3:** Box 22 of 34 **Depth:** 318.7-333.2 ft **Date:** 05/05/21



Photograph 77. B-21-3: Box 23 of 34

Depth: 333.2-347.5 ft Date: 05/05/21-05/06/21



Photograph 78. **B-21-3:** Box 24 of 34 **Depth:** 347.5-361.6 ft **Date:** 05/06/21

| Bad Creek (HDR) Sraject H= 10220481) B-21-3- Bax 25 of 34 | 261.0 261.0 | 2(-70 R(-71 | H, Jerh | Run (14) (4) (4) (4) (4) (4) (4) (4) (4) (4) (| | |
|--|-------------------------|-----------------------|-----------|--|----------------------------|--|
| Depth= 3616-3754 Date= 04.147 2021 | Sar Nore | RC-72 | 3754, 370 | Re-74 370.4-375 | 4, 20, 11002 - 20, 1 10020 | |
| | W. Marker a. K. | | | h sis | | |
| | State State State State | THE REAL PROPERTY AND | | | | |
| | | | | | | |

Photograph 79. **B-21-3:** Box 25 of 34 **Depth:** 361.6-375.4 ft **Date:** 05/06/21



Photograph 80. **B-21-3:** Box 26 of 34 **Depth:** 375.4-388.8 ft **Date:** 05/06/21-05/07/21

| R-21-3 | RC-73 | 3 90 H | RL-76 | Xe | Depth (CA) | Recovery (\$\$/%) | ROD |
|--|---|--|--------------------|---|--------------------------------|--|------------|
| Box 27 of 34 | RC76 | 42.4 | P1 77 | R | 25 385.4-390.4 | 5.6'/160'la | 5.01/1 |
| Depth = 388.8 - 403.2 | | mm (23) | KC- +1_ | R-7 | 390.9-395.9 | 5.0 /100% | 5.0' 11 |
| Date = 07 May 2021 | 8(-71 | 0.4° | 87.70 | RCT RCT | + 395.4-400.4 400.4'-405.4' | 5.0/ 100% | 5.0' / 10 |
| 0 0 | Par II. | 10 | ICC- 18 | e v | | | 3.0 1 100 |
| | 2 1 2 10 1 V | 0. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. | 4 10 8 7 8 8 9 6 | | | 0 | _ |
| and the finite of the participation of the | A A | Constant Process | LED OF REALESS | A REPORT OF A PARTY AND A P | | 3 59 6 | 7 |
| CARLE AGAIN AND AND AND AND AND AND AND AND AND AN | | A CAGIN MACONTRACT AND | | BRE RAMATIL CHILACTA MIL | Televis (Maria) | ANNERS S | |
| White Contraction of the second states in | a della d | Walker Annual A | This Billion Const | PARA AND DAVIS OF DESIGNATION | Will a P | Care and a second | CONTRACTOR |
| Carller Martin Carrow and | | | | | MAX . | S.K. Mar | |
| HALIN BUILDING CONTINUES | and a provide | N State | S Same And | | ANH THE CO | Bar Dell's Const | No ha |
| | Mar P. Delenation | | | ALL ALL ALL AND A | An start | Mental - | |
| 10 DI TRANSVER AND WARRANT PROVINCE | the second se | | | | | the second second second second second | |

Photograph 81. **B-21-3:** Box 27 of 34 **Depth:** 388.8-403.2 ft **Date:** 05/07/21



Photograph 82. **B-21-3:** Box 28 of 34 **Depth:** 403.2-417.2 ft **Date:** 04/21/21

| Depth= 403.2- 417 | .x. | | 1.25 | pt-s | and the second | - | |
|---|------------------------|-------------------------|------|--------------------------------|---|---|--|
| Bad Creek (HOR) Project #= 10276481 B-21-3 Box 29 of 34 Deptin= 412.2 - 430.3 Dogte= 10 may 2021 | 100 1124 69 420.4 HIRA | R(-81 R(-82 R(-83 | rock | Run R(-8) R(-82 R(-83 | Depth (Ft) 4154-420.4 4204-4254- 4254-4304 | Reccray (F4/96) 5.0°/100% 5.0°/100% 5.0°/100% | Kag (H/96) 507/100% 507/100% 5.07/100% |
| | | | | | | | |
| | | | | | | | 3- 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 |

Photograph 83. **B-21-3:** Box 29 of 34

Depth: 417.2-430.3 ft **Date:** 05/10/21

| Bad Creek (PA: B-21-3 0 Box 29 of 34 | INSTOLAD LINK | RC-81-4154-4204 RC-82-4224 4254 RL 83-4254 | - AL |
|--|---|--|------------|
| Bad Cree The (HDR Project #: 102 20481 | C 84 50 F | Ros Depti (4) Recovery (1710) 81-813 425-47-430-47 5 0/10096 |) (F+/4) |
| Box 30 of 34 Dopth= 430.3: 444.7' | RL-85 | RC-84 4324-4554 5.0'hoor | 5.01100% |
| Date: 10 My 2021 11 My 2021 | RL-gs 5 F | in RC-86 440.4'-445.4' 5.0'/100% | 5.0 / 100% |
| | | ALLES CHEVRON & FORMER | |
| | ster se statut (U. C. e. s. a. S. C. C. C. S. | Home to finder ou & allow | |
| The strength of the state of the | lander war bijner of standard drawn an date bill firstlijf in state of the | | |
| | | | |

Photograph 84. **B-21-3:** Box 30 of 34 **Depth:** 430.3-444.7 ft **Date:** 05/10/21-05/11/21



Photograph 85. B-21-3: Box 31 of 34

Depth: 444.7-458.9 ft Date: 05/11/21



Photograph 86. **B-21-3:** Box 32 of 34 **Depth:** 458.9-473.3 ft **Date:** 05/11/21



Photograph 87. B-21-3: Box 33 of 34

Depth: 473.3-487.9 ft **Date:** 05/11/21-05/12/21

| Bad Creek (PH: 10270481) HOR B-21-3 | | |
|---|----------------|----------------------------------|
| Bad (reek (HDR) Project #= 10270481 | 15 212 RC-91 | RI-92= 4704 THE 4' |
| B-21-3 Box 34 of 34 DepH=482.4' R | -96 - 55 BC 77 | RC-8 480.4 5.0/100% 5.0 910 570 |
| Date: 12 May 2021 | @RC-97 | RC-91 495.9' 5.0'/100% 50'/ 100% |
| and the second second | | |
| A CONTRACTOR OF THE OWNER | | |
| | | |
| Contract of | | |

Photograph 88. **B-21-3:** Box 34 of 34 **Depth:** 487.9-500.4 ft **Date:** 05/12/21

| | E |); | 440 S Char Phon hdrin | S. Cl lotte le: 7 | hurch 3 , NC 2 04-338 m/follo | Street 8202- 3-6700 | ., Suit 2075) | e 900 | | BORING NUMBER B-21-4 PAGE 1 OF 7 | | |
|--------------------------|-----------------|--------------------------------|--------------------------------|-------------------------|--|---------------------------|----------------------|---|--|--|--|--|
| | | T DUK | | RGY | | | | | | | | |
| | PROJI | ECT NU | MBER | 102 | 70481 | | | | PROJECT LOC | ATION SALEM, SOUTH CAROLINA | | |
| | DATE | START | - ED 4/5 | /21 | | | со | MPLETED 4/13/21 | GROUND ELE | ATION TBD HOLE SIZE(S) 3.782 inches | | |
| | DRILL | ING CC | NTRAC | TOR | S&N | ИЕ, In | C. | | | | | |
| | DRILL | ING ME | THOD | HSA | A, TW | r, hc | Core |) | GROUND WAT | ER LEVELS: | | |
| | LOGO | GED BY | J. Ruff | ing | | | СН | ECKED BY N. Yacobi | | IE 7.10 ft 4/13/2021 @ 0800 | | |
| | NOTE | s | | | | | | | | E 6.59 ft 4/15/2021 @ 0800 | | |
| | o DEPTH (ft) | - SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | | DESCRIPTION | | REMARKS | | |
| INT.GPJ | | SS - 1 | 2-11-12 (23) | 16 | | | 1.0 | Silty SAND with Gravel (SM) (2.5Y 4/3), medium dense, graded, round to subround, 3") | , olive brown dry, poorly Gravel (up to | 0': Hollow Stem Auger 3.25" 0.0': USCS=SP-SM, LL=NP, PL=NP, PI=NP, NMC=3.9, %200=9.3 | | |
| ECHNICAL_GI | | | | | | | 3.5 | dry, well graded, subangula GRAVEL (up to 0.75") Sandy GRAVEL (GW), grav () | 2.5Y 5/1), ar, fine grained 2.5Y 5/1). | 3': Switch to Tricone Wash Rotary (2'-15/16") 3.5': USCS=SW, LL=NP, PL=NP, PI=NP, NMC=5.9, | | |
| EKIL GEOTE | 5 | SS - 2 | 26-23-35 (58) | 12 | | | 5.7 | very dense, dry, well grade coarse grained SAND, fine grained GRAVEL (up to 1.7 | d, fine to to coarse 75") (PWR) | %200=1.4 | | |
| EAST01\D2014647\BADCRE | | RC - 1 | | | 44 | 24 | | QUARTZ-FELDSPAR GNEIS to very light gray (N8), very coarse grained, thinly foliat mm reddish brown garnets Recovered material only) | S , white (N9) hard, fine to ed, little 1-2 (Boulders; | 5.6': No circulation, added EZ mud polymer 5.7': Start HQ Coring 5.7-10.7': Slight weathering (recovered material only) 5.7-15.7': Very close to close joint spacing (recovered material only) | | |
| /22 11:19 - C:\PWWORKING | | RC - 2 | | | 0 | 0 | | | | HW casing advanced to 10.0' | | |
| NT STD US LAB.GDT - 4/6 | | | | | | | 17.0 | | | | | |
| ELL COLUMN - GI | | | 2-1-4 | | | | | Clay (CL), brown (10YR 5/3), plasticity, moist, contains w | soft, low vood fragments | 18.5': USCS=SM, LL=28, PL=26, PI=2, NMC=23.4, %200=30.5 | | |
| DRING LOG-NO WE | 20 | N 22 - 3 | (5) | 22 | | | 20.0 | Silty GRAVEL (GM), yellowish (10YR 5/4), loose, wet, fine grained SAND, fine to coars GRAVEL | h brown e to coarse se grained | | | |
| NORTH CAROLINA BC | 25 | SS - 4 | 2-3-5 (8) | 24 | | | 24.5 | | | 23.5': USCS=SM, LL=27, PL=26, PI=1, NMC=23.2, %200=33.4 | | |



BORING NUMBER B-21-4

PAGE 2 OF 7

CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

PROJECT NAME BAD CREEK II

PROJECT LOCATION SALEM, SOUTH CAROLINA

SAMPLE TYPE/ NO./CORE RUN BLOW COUNTS (N VALUE) SOIL RECOVERY (in) % % ROCK RECOVERY ROCK RQD DEPTH (ft) REMARKS DESCRIPTION 25 Silty SAND (SM), yellowish brown (10YR 5/3), loose, moist, fine to coarse grained SAND (continued) NORTH CAROLINA BORING LOG-NO WELL COLUMN - GINT STD US LAB.GDT - 4/6/22 11:19 - C.IPWWORKING/EAST01/D20146471BADCREEKII. GEOTECHNICAL GINT.GP. <u>27.0</u> Silty GRAVEL (GM), light gray (10YR 7/1), medium dense, wet, fine grained SAND, coarse grained GRAVEL (up to 1.5") (Saprolite) 28.5': USCS=SM, LL=NP, PL=NP, PI=NP, 10-9-7 (16) NMC=16.6, %200=19.2 SS - 5 7 30 32.0 Silty SAND (SM), yellowish brown (10YR 5/4), loose, moist, fine to coarse grained SAND (Saprolite) HW casing advanced to 32.8' 33.5': USCS=SM, LL=27, PL=25, PI=2, NMC=20.1, 3-3-3 %200=29.6 SS - 6 (6)9 35 38.5 38.51': End of Day (4/6/21) SS - 7 BANDED AUGEN GRANITIC GNEISS, 38.7-55.7': Moderately severe to severe weathering 0 very light gray (N8), soft to medium hard, fine to coarse grained, thinly to thickly foliated, some plagioclase augens (0.2 to 2.5 cm), with interlayered quartz-100 51 RC - 3 40 plagioclase- potassium feldsparhornblende pegmatite; spaced close to moderately close, white (N9) to very light gray (N8), hard, coarse to very coarse grained, 1-4 mm thick (Boulders) 33 8 RC - 4 45 20 0 RC - 5 50



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-4

PAGE 3 OF 7

PROJECT NAME BAD CREEK II

| | - | | | | | |
|------------------|------------------------------|-----------------------------|---|------------|--|---|
| 05 DEPTH (ft) | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
| | | - | | | BANDED AUGEN GRANITIC GNEISS, very light gray (N8), soft to medium hard, | 50.0': Artesian conditions |
| | RC - 6 | | 78 | 55 | fine to coarse grained, thinly to thickly foliated, some plagioclase augens (0.2 to 2.5 cm), with interlayered quartz- plagioclase- potassium feldspar- hornblende pegmatite; spaced close to moderately close, white (N9) to very light gray (N8), hard, coarse to very coarse grained, 1-4 mm thick (Boulders) (continued) | |
| | | | | | 55.7 Sandy SILT (ML), pale brown (10YR 6/3), popplastic, poncohesive (Colluvium) | - |
| | RC - 7 | | 0 | 0 | nonplastic, nonconesive (collaviality) | |
| | RC - 8 | | 30 | 0 | | 60.7-65.7': Grab Sample (GS1) 60.7': USCS=SM, LL=NP, PL=NP, PI=NP, NMC=2.1, %200=27.9 |
| | | | | | | |
| 65 | | | | | 65.4 BANDED AUGEN GRANITIC GNEISS, | 65.4-92.7': Moderately severe to severe weathering |
| | RC - 9 | | 17 | 0 | very light gray (N8) to light gray (N7), medium hard, fine to coarse grained, thinly to thickly foliated, some plagioclase augens (0.2 to 2.5 cm) (Boulders; Recovered material only) | (recovered material only) |
| | RC - 10 | | 0 | 0 | | |



BORING NUMBER B-21-4

PAGE 4 OF 7

CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

PROJECT NAME BAD CREEK II

| DEPTH | (1) | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) ROCK | RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|---|------------------|------------------------------|-----------------------------|-------------------------------|------------|------------|--|---|
| | | | | | | | BANDED AUGEN GRANITIC GNEISS, very light gray (N8) to light gray (N7) | |
| | - - - 0 | RC - 11 | | | 5 | 0 | medium hard, fine to coarse grained, thinly to thickly foliated, some plagioclase augens (0.2 to 2.5 cm) (Boulders; Recovered material only) <i>(continued)</i> | |
| | - | | | | | | Sandy SILT (ML), pale brown (10YR 6/3), | |
| | - - 5 | RC - 12 | | | 0 | 0 | nonplastic, noncohesive (Colluvium) | |
| - LAB.GUI - 4/6/22 11:19 - C:/PWW 66 | - - - 0 | RC - 13 | | | 10 | 0 | | |
| <u>s</u> | _ | | _ | | | | BANDED AUGEN GRANITIC GNEISS, | HW casing advanced to 90.7' |
| | _ _ 5 | RC - 14 | | , | 95 | 52 | very light gray (N8) to light gray (N7), medium hard, fine to coarse grained, thinly to thickly foliated, plagioclase augens (0.2 to 2.5 cm), trace reddish brown garnets, with interlayered quartz- plagioclase- potassium feldspar-hornblende pegmatite, spaced close to moderately close, white (N9) to very light gray (N8), very hard, coarse to very coarse grained, 0.1' to 0.4' thick 93.3 to 111.0': Hard | 90.7-92.7": Heavily jointed, Fe staining, moderate to moderately severe weathering 92.7-121.0": Close to moderately close joint spacing 92.7-141.0": Slight to very slight weathering 92.8": JOINT, 20° dip, open, Fe staining 93.3": JOINT, 20° dip, open, Fe staining 94.0": JOINT, 10° dip, open, Fe staining 94.5": JOINT, 10° dip, open 95.8": JOINT, 10° dip, open, Fe staining |
| | | | | | | | | 96.3': JOINT, 20° dip, open, Fe staining 96.5': JOINT, 30° dip, open, Fe staining |
| | _ | RC - 15 | | | 100 | 82 | | 98.1': JOINT, 30° dip, open |
| 10 I | 00 | | | | | | | 99.4': JOINT, 20° dip, open, minor Fe staining |



CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-4

PAGE 5 OF 7

PROJECT NAME BAD CREEK II

PROJECT LOCATION SALEM, SOUTH CAROLINA

SAMPLE TYPE/ NO./CORE RUN BLOW COUNTS (N VALUE) SOIL RECOVERY (in) % % ROCK RECOVERY ROCK RQD DEPTH (ft) REMARKS DESCRIPTION 100 BANDED AUGEN GRANITIC GNEISS, very light gray (N8) to light gray (N7), medium hard, fine to coarse grained, NORTH CAROLINA BORING LOG-NO WELL COLUMN - GINT STD US LAB. GDT - 4/6/22 11:19 - C;\PWWORKING\EAST01\D2014647\BADCREEKII GEOTECHNICAL GINT. GPJ 101.0-114.6': Slight discoloration of feldspars thinly to thickly foliated, plagioclase augens (0.2 to 2.5 cm), trace reddish 101.8': FOLIATION JOINT, 30° dip, open 102.0': JOINT, 40° dip, open 102.3': JOINT, 0° dip, open brown garnets, with interlayered quartzplagioclase- potassium 102.5': FOLIATION JOINT, 20°v, open, Fe staining feldspar-hornblende pegmatite, spaced RC -100 78 102.9': JOINT, 10° dip, open, Fe staining 103.1': FOLIATION JOINT, 20° dip, open, Fe staining close to moderately close, white (N9) to 16 very light gray (N8), very hard, coarse to 103.3': FOLIATION dipping 20°-30° 103.5': FOLIATION JOINT, 30° dip, open, Fe staining very coarse grained, 0.1' to 0.4' thick 105 (continued) 103.9': JOINT, 0° dip, open, Fe staining 104.9': FOLIATION JOINT, 20° dip, open, Fe staining 105.3': JOINT, 5° dip, open 105.8': JOINT, 0° dip, closed 107.4': FOLIATION JOINT, 30° dip, open, minor Fe staining RC -108.3': JOINT, 0° dip, tight, Fe staining 100 92 17 108.4': FOLIATION dipping 10°-20° 110 109.9': FOLIATION JOINT, 20° dip, tight, Fe staining 111.1': JOINT, 0° dip, open 111 0 to 113 0' Medium hard 111.4': JOINT, 10° dip, open, sand buildup 112.0': FOLIATION JOINT, 20° dip, closed, Fe staining 112.1': JOINT, 30° dip, tight, Fe staining 112.7': JOINT, 20° dip, open, sand and silt buildup 113.0': FOLIATION JOINT, 20° dip, open, sand 113 to 117.7': Hard RC 100 85 18 buildup 113.3': FOLIATION dipping 20°-30° 113.4': FOLIATION JOINT, 20° dip, open 113.8': FOLIATION JOINT, 20° dip, open 115 114.6': FOLIATION JOINT, 25° dip, open 117.3': FOLIATION JOINT, 20° dip 117.6': JOINT, 5° dip, open 117.7 to 118.5': Moderately hard 118.0': JOINT, 10° dip, open, minor Fe staining RC -100 86 118.2': FOLIATION dipping 20°-30° 118.5 to 126.1': Hard to very hard 19 118.3': FOLIATION JOINT, 20° dip, open, minor Fe staining 120 119.95-120.4': SAMPLE B-21-4-1T, Splitting Tensile Test, TS= 1,270 psi 120.5': JOINT, 20° dip, open, Fe staining 121': End of day (4/8/21) 121.0-124.8': Wide joint spacing 122.0-122.6': SAMPLE B-21-4-2C, UCS, uw=168 pcf, UCS= 15,546 psi 122.6-122.8': B-21-4-A, Petrographic Analysis RC 98 89 123.7': FOLIATION dipping 20°-30° 20 124.15-124.65': SAMPLE B-21-4-3CM, (UCS/EM), uw= 168 pcf, ucs= 12,121 psi, em= 1.90E+06 psi,



CLIENT _DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-4

PAGE 6 OF 7

PROJECT NAME BAD CREEK II

| н (II) 125 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|--------------------------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|---|---|
| | RC - 21 | - | | 99 | 75 | 126.1 HARD SHEARED ROCK, very light gray (N8) to light gray (N7), hard, fine to coarse grained, shear planes at 126.2' and 126.8' mylonitic texture, shear zone dips 40°-45° BANDED AUGEN GRANITIC GNEISS, very light gray (N8) to light gray (N7), very | PR=0.21 at the low stress range (1200-4400 psi) 124.8': FOLIATION JOINT, 30° dip, open, Fe staining 124.8-146.0': Close to moderately close JOINT spacing 124.9': FOLIATION JOINT, 30° dip, open, Fe staining 125.7': FOLIATION JOINT, 30° dip, tight, minor Fe staining 126.4': FOLIATION dipping 30°-40° 127.3': JOINT, 20° dip, open |
| 130 | | _ | | | | hard, fine to coarse grained, thinly to thickly foliated, some plagioclase augens (0.2 to 2.5 cm), trace reddish brown garnets, with interlayered Quartz-Plagioclase-Potassium Feldspar-Hornblende Pegmatite, spaced close to moderately close, white (N9) to very light gray (N8) very hard coarse to | 127.6°: JOINT, 20° dip, open, Fe staining 127.9°: JOINT, 20° dip, tight, Fe staining 127.9°: FOLIATION dipping 0°-10° 128.2°: JOINT, 20° dip, open 128.6°: JOINT, 20° dip, open, minor Fe staining 129.9 - 130.4°: SAMPLE B-21-4-4T , Splitting Tensile Test, TS= 1,170 psi 130.4 - 134.95' SAMPLE B-21-4-5C UCS uw=168 |
| 135 | RC - 22 | | | 100 | 100 | very coarse grained, 0.1' to 0.4' wide 128.0 to 129.0': Moderately hard | pcf, ucs= 16,463 psi 133.5': FOLIATION dipping 20°-30° 134.0': JOINT, 60° dip, open, minor Fe staining 135.15-135.70': SAMPLE B-21-4-6CM , (UCS/EM), |
| | RC - 23 | | | 95 | 57 | | uw= 168 pcf, ucs= 20,238 psi, em= 3.13E+06 psi, PR= 0.16 at teh low stress range (2000-7400 psi) 136.0 - 136.6: SAMPLE B-21-4-7T, Splitting Tensile Test, TS= 929 psi 137.4': FOLIATION JOINT, 0° dip, open, Fe staining 138.0': FOLIATION JOINT, 10° dip, open, Fe staining 138.2': FOLIATION JOINT, 0° dip, open 138.3': FOLIATION JOINT, 10° dip, open 138.5': FOLIATION JOINT, 20° dip, open 138.5': FOLIATION JOINT, 20° dip, open 139.1': FOLIATION JOINT, 0° dip, open 139.1': FOLIATION JOINT, 0° dip, open 139.4': FOLIATION JOINT, 0° dip, open |
| 145 | RC - 24 | _ | | 100 | 70 | | 139.4: FOLIATION JOINT, 0' dip, open 139.6: FOLIATION JOINT, 0' dip, open 141.0: FOLIATION JOINT, 10° dip, tight, Fe staining 141.0 - 151.0': Fresh weathering 141.3': JOINT, 5° dip, open 141.5': JOINT, 0° dip, open 141.5 - 141.7': B-21-4-B Petrographic Analysis 141.7': JOINT, 0° dip, open, Fe staining 141.7 - 142.25': SAMPLE B-21-4-8CM (UCS/EM), uw= 168 pcf, ucs= 15,555 psi, em= 2.28E+06 psi, PR= 0.13 at the low stress range (1600-5700 psi) 142.3': FOLIATION dipping 0°-10° 143.5': JOINT, 4° dip. open |
| | RC - 25 | | | 100 | 100 | | 144.4': JOINT, 0° dip, trace potassium feldspar 145.0 - 146.0': JOINT, 80° dip, open 146.0 - 151.0': Wide joint spacing 147.8': FOLIATION dipping 0°-10° |





Photograph 89. **B-21-4:** SS-1 **Depth:** 0.0-1.5 ft **Date:** 04/05/21



Photograph 90. **B-21-4:** SS-3 **Depth:** 18.5-20.0 ft **Date:** 04/06/21



Photograph 91. **B-21-4:** SS-4 **Depth:** 23.5-25.0ft **Date:** 04/06/21



Photograph 92. **B-21-4:** SS-5

Depth: 23.5-25.0 ft

Date: 04/06/21


Photograph 93. **B-21-4:** SS-6 **Depth:** 28.5-30.0 ft **Date:** 04/06/21



Photograph 94. **B-21-4:** SS-7 **Depth:** 38.5-40.0 ft **Date:** 04/06/21



Photograph 95. **B-21-4:** Box 1 of 6

Depth: 5.7-60.7 ft

Date: 04/06/21



Photograph 96. B-21-4: Box 2 of 6

Depth: 60.7-101.0ft **Date:** 04/07/21

Page 101



Photograph 97. B-21-4: Box 3 of 6

Depth: 101.0-116.0 ft Date: 04/08/21



Photograph 98. B-21-4: Box 4 of 6

Depth: 116.0-126.0 ft Date: 04/08/21



Photograph 99. B-21-4: Box 5 of 6

Depth: 126.0-140.5 ft **Date:** 04/13/21



Photograph 100. B-21-4: Box 6 of 6

Depth: 140.5-151.0 ft **Date:** 04/13/21

| CLENT_DUKE ENERGY PROJECT NAME BAD CREEK II PROJECT NUMBER_1027081 PROJECT LOCATION SALEL SUUTH CAROLINA DATE STARTED 62/21 COMPLETED 5/021 PROJECT NUMBER_1027081 FOLDESZE(\$) 3782 inches DRILING CONTRACTOR SAME_Inc. GONOND ELEVAND TBD DRILING METHOD Mult Bolary, Tricone Bollencone, HD Care GROUND WATER LEVELS: LOGGED BY J. Ruffing J. Chemica. CHECKED BY N. Yacobi NOTES Y DATETIME VELSE Starting J. Chemica. Starting J. Chemica. | ┣ | 5 | 440 S Char Phon hdrin | S. Cl lotte ne: 7 c.co | hurch 3 , NC 2 04-338 m/follo | Street 8202- 8-670 ow-us | t, Suite 900 -2075 0 | | BORING NUMBER B-21-5 PAGE 1 OF 5 |
|---|-----------------|------------------------------|--------------------------------|---------------------------------|--|-----------------------------------|--|---|---|
| PROJECT NUMBER_10270481 PROJECT NUMBER_10270481 PROJECT NUMBER_10270481 OUTH CARQUINA DATE STARTED GROUND BLEVATION TDD HOLE SZE(6) 3.782 inches DRULING CONTRACTOR_SBALE_Inc. ORTHING_TBD EASTING_TBD EASTING_TBD DRULING CONTRACTOR_SBALE_Inc. ORTHING_TBD EASTING_TBD EASTING_TBD DRULING CONTRACTOR_SBALE_Inc. ORTHING_TBD EASTING_TBD EASTING_TBD IOGGED BY J_RUING/CONTROL CHECKED BY N_Yacobi Y DATE/TIME_10.50.0.002/02/1.0/2 100 GROUND WATER LEVELS: Y DATE/TIME_10.50.0.002/02/1.0/2 100 Y DATE/TIME_10.50.0.002/02/1.0/2 100 FEMARKS I = 0 I = 0 I = 0.0000 WATER LEVELS: Y DATE/TIME_10.50.0.002/02/1.0/2 100 Y = 0 I = 0 I = 0.0000 WATER LEVELS: Y DATE/TIME_10.50.0.002/02/1.0/2 100 Y = 0 I = 0 I = 0.0000 WATER LEVELS: Y DATE/TIME_10.50.0.002/02/1.0/2 100 Y = 0 I = 0 I = 0.00000 WATER LEVELS: Y DATE/TIME_10.50.0.002/02/1.0/2 100 Y = 0 I = 0 I = 0.000000 WATER LEVELS: Y DATE/TIME_10.50.0.002/02/1.0/2 100 Y = 0 I = 0.0000000000000000000000000000000000 | CLIE | NT DUK | | <u>R</u> GY | | | | PROJECT NAM | E BAD CREEK II |
| DATE STARTED GAULT COMPLETED 6821 GROUND ELEVATION TBD HOLE SUZE(S) 3.762 inches DRILLING CONTRACTOR SAME_Inc. NORTHING TED EASTING TBD GROUND ATTER LEVELS: LOGGED BY J_RUITING MURDING_LOCALITION CHECKED BY N_Yacobi Y DATEFTIME 12.00 ft 6/32021 (g) 1500 TGO NOTES Y DATEFTIME 16.50 ft 6/32021 (g) 1100 REMARKS Y DATE STIME Y DATEFTIME 16.50 ft 6/32021 (g) 1100 REMARKS Y DATE STIME Y DATEFTIME 16.50 ft 6/32021 (g) 1100 REMARKS Y DATE STIME Y DATEFTIME 16.50 ft 6/32021 (g) 1100 REMARKS Y DATE STIME Y DATEFTIME 16.50 ft 6/32021 (g) 1100 REMARKS Y DATE STIME Y DATESTIME 12.01 ft 6/320 (W) | PROJ | | MBER | 102 | 70481 | | | PROJECT LOC | ATION SALEM, SOUTH CAROLINA |
| PRILING CONTRACTOR SAME_Inc NORTHING TED EASTING TED DRILLING METHOD Multiple Moduly Chartenia GROUND WATER LEVELS: LOGGED PY J. Rolfnold J. Chartenia Chartenia 2.0 R 03/3021 (§ 1930) NORT IS 60 R 08/2021 (§ 1930) IS 60 R 08/2021 (§ 1930) IS 60 R 08/2021 (§ 1930) V Artenia IS 60 R 08/2021 (§ 1930) IS 60 R 08/2021 (§ 1930) V Artenia IS 60 R 08/2021 (§ 1930) IS 60 R 08/2021 (§ 1930) V Artenia IS 60 R 08/2021 (§ 1930) IS 60 R 08/2021 (§ 1930) V Artenia IS 60 R 08/2021 (§ 1930) IS 60 R 08/2021 (§ 1930) V Artenia IS 60 R 08/2021 (§ 1930) IS 60 R 08/2021 (§ 1930) V Artenia IS 60 R 08/2021 (§ 1900) IS 60 R 08/2021 (§ 1900) V Artenia IS 60 R 08/2021 (§ 1000) IS 60 R 08/2021 (§ 1000) V Artenia IS 60 R 08/2021 (§ 1000) IS 60 R 08/2021 (§ 1000) V IS 60 R 08/2000 | DAT | E START | ED <u>6/2</u> | 2/21 | | | COMPLETED _6/8/21 | GROUND ELE | ATION TBD HOLE SIZE(S) 3.782 inches |
| DelLING METHOD Multical Rolenzone. H0 Czer. GROUND WATER LEVELS: LOGGED BY J. Ruffind/J. Chartion CHECKED BY Naces NOTES V DATE/TIME 12.40 fb 03/2021 @ 1630 VIDES V DATE/TIME 12.40 fb 03/2021 @ 1100 Image: I | DRIL | LING CO | NTRAC | TOR | S&N | ME, In | IC. | NORTHING T | BD EASTING TBD |
| LOGED BY J. Buffind/ J. Charlon CHECKED BY N. Yacobi If DATE/TIME 12.40 ft 6/3/021 (§) 1630 NOTES Image: State of the | DRIL | LING ME | THOD _ | Mud | d Rota | ry, Tr | icone Rollercone, HQ Core | GROUND WAT | ER LEVELS: |
| NOTES ▼ DATE/TIME_16 50 R 68/2021 @ 1100 Image: Barborn Stress St | LOG | GED BY | J. Ruff | ing/ | J. Cha | arlton | CHECKED BY N. Yacobi | | IE _12.40 ft 6/3/2021 @ 1630 |
| Lage Image: State of the second | NOT | ES | | | | | | | E 16.50 ft 6/8/2021 @ 1100 |
| Poorly Graded GRAPLE, with Sand (GP), Ill thrownis ray of UYR 62, very dense, dry, contains boulders (FILL) 2.6°: USCS=SM, LL=NP, PL=NP, PI=NP, NMC=14.5, %200=20.1 5 5 5 5 5 5 5 5 5 5 6 50 50 50 50 7.6°: Brown (10YR 42), wery dense, dry, time to coarse SAND (PWR) 7.6°: USCS=SM, LL=NP, PL=NP, PL=NP, PL=NP, NMC=15.1, %200=27.8 10 7.6°: Brown (10YR 42), medium dense, wet. Fe staining, (SOIL/SAPROLITE) 7.6°: USCS=SM, LL=NP, PL=NP, PL=NP, PL=NP, NMC=15.1, %200=27.8 11 12.6°: Grayish brown (10YR 5/2), very dense, dryth trace coarse Gravel (up to 2.0) 12.6°: USCS=SM, LL=NP, PL=NP, PL= | o DEPTH (ft) | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | DESCRIPTION | | REMARKS |
| Image: Second State Sta | | - X <u>ss - 1</u> | 50/4" | 3 | | | 5.0 Silty SAND (SM), grayish bro 5/2), very dense, dry, fine t | n Sand (GP), 6/2), very ers (FILL) wn (10YR o coarse SAND | 2.6': USCS=SM, LL=NP, PL=NP, PI=NP, NMC=14.5, %200=20.1 |
| 15 12.6': Grayish brown (10YR 5/2), very dense, with trace coarse Gravel (up to 2.0 inches) 12.6': USCS=SM, LL=NP, PL=NP, PI=NP, NMC=13.7, %200=24.3 15 - <td< td=""><td></td><td>SS - 2</td><td>12-12-14 (26)</td><td>14</td><td></td><td></td><td>(PWR) 7.6': Brown (10YR 4/3), medi Fe staining, (SOIL/SAPRO</td><td>ium dense, wet, LITE)</td><td>7.6¹: USCS=SM, LL=NP, PL=NP, PI=NP, NMC=15.1, %200=27.8</td></td<> | | SS - 2 | 12-12-14 (26) | 14 | | | (PWR) 7.6': Brown (10YR 4/3), medi Fe staining, (SOIL/SAPRO | ium dense, wet, LITE) | 7.6 ¹ : USCS=SM, LL=NP, PL=NP, PI=NP, NMC=15.1, %200=27.8 |
| 30 30 17.6': (PWR) 17.6': (PWR) 17.6': USCS=SM, LL=NP, PL=NP, PI=NP, NMC=12.5, %200=16.1 | - 07:11 77/0/+ | | 14-22-40 (62) | 11 | | | 12.6': Grayish brown (10YR dense, with trace coarse G inches) | 5/2), very ravel (up to 2.0 | 12.6': USCS=SM, LL=NP, PL=NP, PI=NP, NMC=13.7, %200=24.3 |
| | | × <u>SS-4</u> | 50/3" | 0 | | | 17.6': (PWR) | | 17.6': USCS=SM, LL=NP, PL=NP, PI=NP, NMC=12.5, %200=16.1 |
| | | - | | | | | | | |
| | 25 | | | | | | | | |



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BORING NUMBER B-21-5

PAGE 2 OF 5

CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

PROJECT NAME BAD CREEK II

PROJECT LOCATION _SALEM, SOUTH CAROLINA

| HLdED 25 | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | RECOVERY % | ROCK RQD % | DESCRIPTION | REMARKS |
|-----------------------|---------------------------------|-----------------------------|-----------------------|------------|------------|---|---|
| | | | | | | 17.6': (PWR) (continued) | |
| | - | 23-24-30 (54) | - | | | 27.6': Very dense, (SOIL/SAPROLTE) 28.7': White (10YR 8/1), 0.3' quartz-feldspar vein | 27.6': USCS=SM, LL=NP, PL=NP, PI=NP, NMC=21.3, %200=27.3 |
| <u>35</u> | - - - <u>Xss - 7</u> - | 32-50/3" | 9 | | | 33.1': (PWR) | 32.6': USCS=SM, LL=27, PL=NP, PI=NP, NMC=19.3, %200=29.8 |
| <u>40</u> | - - -X SS - 8 - | 48-50/3" | 9, | | | | 37.6': USCS=SM, LL=27, PL=NP, PI=NP, NMC=18.7, %200=29.7 |
| 45 | - - - - - - - | 50/1" | 0 | | | | |
| 50 | SS - 10 | 50/2" | 2 | | | | 47.6': USCS=SM, LL=NP, PL=NP, PI=NP, NMC=14.4, %200=26.1 |



BORING NUMBER B-21-5

PAGE 3 OF 5

CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

PROJECT NAME BAD CREEK II

PROJECT LOCATION SALEM, SOUTH CAROLINA

SAMPLE TYPE/ NO./CORE RUN BLOW COUNTS (N VALUE) SOIL RECOVERY (in) % % ROCK RECOVERY ROCK RQD DEPTH (ft) REMARKS DESCRIPTION 50 33.1': (PWR) (continued) NORTH CAROLINA BORING LOG-NO WELL COLUMN - GINT STD US LAB. GDT - 4/6/22 11:20 - C;\PWWORKING\EAST01\D2014647\BADCREEKII GEOTECHNICAL GINT.GPJ 52.6': USCS=SC-SM, LL=27, PL=22, PI=5, 52.6': (SOIL/SAPROLITE) NMC=11.8, %200=19.6 22-45-48 SS (93) 18 11 53.5': White (10YR 8/1) 53.6': Strong brown (7.5YR 5/6) 55 50/1" SS 0 58.1': End of day (06/02/2021); depth to water 12.1' 12 below ground surface (06/03/2021) HW casing advanced to 59.2' GRANITIC GNEISS, medium light gray 59.2': Start HQ coring 100 91 60 RC - ⁻ (N6), very hard, medium to coarse 59.5': FOLIATION dipping 30°-40° grained, very thinly to thinly banded, some 60.1': JOINT, healed, 40° dip, Fe staining feldspar augens, some hornblende, trace garnets, with interlayered quartz-plagioclase-potassium felspar-hornblende pegmatite, spaced close to moderately close, very light gray 62.8 62.5 - 68.0': PACKER TEST 2: K=5.7E-06 cm/sec 100 100 RC - 2 (N8), very hard, coarse to very coarse 63.4 grained, very thinly foliated, 0.1'-0.3' thick QUARTZ-FELDSPAR GNEISS, very light gray (N8), very hard, coarse to very 64.4': 0.1' epidote vein, 50° coarse grained 65 64.8': FOLIATION dipping 20°-30° GRANITIC GNEISS, medium light gray 65.4': FOLIATION JOINT, 30° dip, trace Fe staining (N6), very hard, medium to coarse grained, very thinly to thinly foliated, some and clay augens, some hornblende, trace garnets, with interlayered guartz- potassium feldspar- hornblende pegmatite, spaced close to moderately close, very light gray 67.5 - 73.0': PACKER TEST 1: NO take at 60 psi 100 100 RC - 3 (N8), very hard, coarse to very coarse grained, 0.1'-0.3' thick 68.7': FOLIATION dipping 20°-30° 69.5 QUARTZ-FELDSPAR GNEISS, very light 70 70.0 gray (N8), very hard, coarse to very coarse grained GRANITIC GNEISS, medium light gray (N6), very hard, medium to coarse 71.9 72.3 grained, very thinly to thinly banded, some feldspar augens, trace garnets, with 100 100 interlayered quartz- potassium feldspar-RC - 4 72.9': FOLIATION dipping 15° hornblende pegmatite, spaced close to moderately close, very light gray (N8), very hard, coarse to very coarse grained, 74.1': FOLIATION dipping 10° 0.1' -0.3' thick 74.5': FOLIATION dipping 20° 75



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CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-5

PAGE 4 OF 5

PROJECT NAME BAD CREEK II

PROJECT LOCATION SALEM, SOUTH CAROLINA

SAMPLE TYPE/ NO./CORE RUN BLOW COUNTS (N VALUE) SOIL RECOVERY (in) % % ROCK RECOVERY ROCK RQD DEPTH (ft) REMARKS DESCRIPTION 75 75.0': End of day (06/03/2021); depth to water 12.4' QUARTZ-FELDSPAR GNEISS, very light gray (N8), very hard, coarse to very coarse grained GRANITIC GNEISS, medium light gray NORTH CAROLINA BORING LOG-NO WELL COLUMN - GINT STD US LAB. GDT - 4/6/22 11:20 - C;\PWWORKING\EAST01\D2014647\BADCREEKII GEOTECHNICAL GINT.GPJ (N6), very hard, medium to coarse grained, very thinly to thinly banded, some RC - 5 100 100 feldspar augens, trace garnets, with interlayered quartz-potassium-feldspar-hornblende 78.8 - 79.2': JOINT, healed with chlorite, 70°, Fe pegmatitie, spaced close to moderately staining close, very light gray (N8), very hard, coarse to very coarse grained, very thinly 80 foliated, 0.1-0.3' thick (continued) 80.3': FOLDING 80.9': FOLIATION dipping 20° 100 100 82.6 - 84.3': JOINT, healed with chlorite, 70°-90° dip RC - 6 85 85.4': FOLIATION dipping 20°-30° 86.3': JOINT with chlorite, 70° dip 100 100 RC - 7 88.6-88.9': JOINT, healed with chlorite, 60° dip 88.7-89.4': FOLDING 90 90.7 - 92.4': Thinly to thickly laminated 90.8': JOINT with chlorite and calcite, 70° dip, tight 91.5-92.1': OPEN FOLDING 100 100 RC - 8 92.9': FOLIATION dipping 30°-40° 93.6': JOINT, healed with chlorite and epidote (1-2 mm wide), 60° dip 95 100 RC - 9 100 98.7 98.8': FOLIATION dipping 30° GRANITIC GNEISS, light gray (N7), medium to coarse grained, with 99.5 - 99.75': B-21-5-A Petrographic Analysis interlavered quartz-feldspar pegmatite 100.0 100



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CLIENT DUKE ENERGY

PROJECT NUMBER 10270481

BORING NUMBER B-21-5

PAGE 5 OF 5

PROJECT NAME BAD CREEK II

PROJECT LOCATION _SALEM, SOUTH CAROLINA

| HLDIN 1 | 00 (ff) | SAMPLE TYPE/ NO./CORE RUN | BLOW COUNTS (N VALUE) | SOIL RECOVERY (in) | ROCK RECOVERY % | ROCK RQD % | | DESCRIPTION | REMARKS |
|----------------------------------|---------------------|------------------------------|-----------------------------|-----------------------|--------------------|------------|----------------|--|---|
| KII_GEOTECHNICAL_GINT.GPJ | 05 | RC - 10 | | | 100 | 100 | 103.0 103.6 | pinkish gray (5YR 8/1), to light gray (N7), very hard, coarse to very coarse grained, spaced very close to close, well-foliated but no indications of GRANIFRO (N6), hard to very hard, medium to coarse grained, very thinly to thinly banded, some feldspar augens, trace garnets, with interlayered quartz- potassium feldspar-hornblende pegmatite, spaced close to moderately close, very light gray (N8), very hard, coarse to very coarse | 100.3 - 106.0': Fresh weathering 100.3 - 107.0': JOINT, healed with quartz and chlorite (2-3 mm wide), 90° dip 100.3': End of day (06/04/2021) 100.3': FOLIATION dipping 10°-15° 100.3': Trace hornblende crystals (1-4 mm diameter) |
| DRKING\EAST01\D2014647\BADCREE | - | RC - 11 | - | | 100 | 100 | | grained, 0.1'-0.3' thick 103.3': Hard sheared rock, light gray (N7), very hard, fine to medium grained GRANITIC GNEISS , medium light gray (N6), hard to very hard, medium to coarse grained, very thinly to thinly banded, some feldspar augens, trace garnets, with interlayered quartz- potassium feldspar-hornblende pegmatite, spaced close to moderatel | 106.0 - 120.3': Fresh to slight weathering 106.0': FOLIATION dipping 30° 108.0 - 109.0': JOINT, healed with quartz (1-2 mm wide), 80° dip 109.8': FOLIATION dipping at 30° |
| .GDT - 4/6/22 11:20 - C:\PWWC | | RC - 12 | | | 100 | 100 | | | 111.3': FOLIATION dipping 10°-20° 111.7 - 112.1': JOINT, with chlorite and calcite, 80° dip, open |
| NO WELL COLUMN - GINT STD US LAB | <u>-</u> - 20 | RC - 13 | _ | | 100 | 100 | 115.3 116.1 | QUARTZ-FELDSPAR GNEISS, very light gray (N8), very hard, coarse to very coarse grained, very thinly foliated GRANITIC GNEISS, medium light gray (N6), very hard, medium to coarse grained, very thinly to thinly banded, some feldspar augens, trace garnets, with interlayered quartz- potassium feldspar- hornblende pegmatite | 118.7': FOLIATION dipping 0°-10° |
| NORTH CAROLINA BORING LOG- | | | | | | | | Coring termianted at 120.3 feet below ground surface Bottom of borehole at 120.3 feet. | |



Photograph 101. **B-21-5:** SS-1 **Depth:** 2.6-4.1 ft **Date:** 06/02/21



Photograph 102. **B-21-5:** SS-2 **Depth:** 7.6-9.1 ft

Date: 06/02/21



Photograph 103. **B-21-5:** SS-3 **Depth:** 12.6-14.1 ft **Date:** 06/02/21



Photograph 104. **B-21-5:** SS-4 **Depth:** 17.6-19.1 ft **Date:** 06/02/21



Photograph 105. **B-21-5:** SS-5 **Depth:** 22.6-241. ft **Date:** 06/02/21



Photograph 106. **B-21-5:** SS-6 **Depth:** 27.6-29.1 ft **Date:** 06/02/21



Photograph 107. **B-21-5:** SS-7 **Depth:** 32.6-34.1 ft **Date:** 06/02/21



Photograph 108. **B-21-5:** SS-8 **Depth:** 37.6-39.1 ft **Date:** 06/02/21

| $\begin{array}{c} \begin{array}{c} \begin{array}{c} \begin{array}{c} \begin{array}{c} \begin{array}{c} \\ \end{array} \end{array} \end{array} \end{array} \end{array} \\ \begin{array}{c} \begin{array}{c} \end{array} \end{array} \end{array} \\ \begin{array}{c} \begin{array}{c} \end{array} \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \end{array} \\ \begin{array}{c} \begin{array}{c} \end{array} \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \end{array} \end{array} \\ \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \end{array} \\ \end{array} \end{array} \\ \end{array} \end{array} \\ \begin{array}{c} \end{array} \end{array} \\ \end{array} \\ \end{array} \end{array} \\ \end{array} \\ \end{array} \\ \end{array} \\ \end{array} \end{array} \\ \\ \end{array} \\ \\ \end{array} \\ \end{array} \\ \\ \\ \end{array} \\ \\ \\ \end{array} \\ \\ \\ \\ \end{array} \\ \\ \end{array} \\ \\ \\ \end{array} \\ \\ \\ \end{array} \\ \\ \\ \\ \\ \\ \\ \\ \end{array} \\$ | |
|--|--|
| Geologist: Jacob Ruffing Boring 1D: B-21-5 Sample ID: SS - 9 | |
| Depth: 42.6 - 44.1 Blows: 50 No Recovery | |
| | |

Photograph 109. **B-21-5:** SS-9 **Depth:** 42.6-44.1 ft **Date:** 06/02/21



Photograph 110. **B-21-5:** SS-10 **Depth:** 47.6-49.1 ft **Date:** 06/02/21



Photograph 111. **B-21-5:** SS-11 **Depth:** 52.6-54.1 ft **Date:** 06/02/21



Photograph 112. **B-21-5:** SS-12 **Depth:** 57.6-59.1 ft **Date:** 06/02/21



Photograph 113. B-21-5: Box 1 of 4

Depth: 59.2-70.3 ft

Date: 06/03/21



Photograph 114. B-21-5: Box 2 of 4

Depth: 70.3-80.3 ft

Date: 06/03/21



Photograph 115. **B-21-5:** Box 3 of 4

Depth: 80.3-90.3 ft

Date: 06/04/21



Photograph 116. B-21-5: Box 4 of 4

Depth: 90.3-100.3 ft Date: 06/04/21

| BAD CREEK II (PW: 102 B-21-5 Box Sof 6 DEPTH: 100.3-110.3 DATE: 07-JUNE 2021 | RC-11 (1) (1) (1) (1) (1) (1) (1) (1) (1) (| $\frac{ R_{UN} }{ R_{C}-10 } \xrightarrow{D=pm(3)}{ R_{C}-1$ | C) Rec(Ft/3) 3.3 50/10070 0.3 50/10070 | Fe)-72 5-9/1007 2-0/1007 |
|--|---|--|--|--------------------------------|
| | | | | |

Photograph 117. **B-21-5:** Box 5 of 6

Depth: 100.3-110.3 ft Date: 06/04/21

0 01-5 BAD CREEK II (PN: 10270481) HDR RUN DEPTHYTC B-21-5 RC-12 RC-12 110.3-Box 6 of 6 RC-13 115.3-103 RC-13 DEPTH: 110.3-120.3 5.0/1007 20/100% DATE: OT JUNE 2021 20.3

Photograph 118. **B-21-5:** Box 6 of 6 **Depth:** 110.3-120.3 ft **Date:** 06/04/21

Appendix C

Water Pressure Test Results and Data Sheets

Not Included - Available Upon Request



Appendix D

SCDHEC Monitoring Well Approval Letter

Not Included - Available Upon Request

Appendix E

GEL Solutions Surface Geophysical Report

Not Included - Available Upon Request



Appendix F

GEL Solutions Downhole Geophysical Survey Report

Not Included - Available Upon Request

Appendix G

Soil Sample Laboratory Testing Report



September 7, 2021

HDR Engineering, Inc. 1122 Lady Street, Suite 1100 Columbia, South Carolina 29201

Attention: Mr. John Charlton via email: cjohn.charlton@hdrinc.com

Reference: Laboratory Testing Results Bad Creek Phase 2 Feasibility Study Project Salem, Oconee County, South Carolina S&ME Project No. 213045

Dear Mr. Charlton:

S&ME, Inc. (S&ME) has completed the laboratory testing as it pertains to the Bad Creek Phase 2 Feasibility Study Project in Salem, Oconee County, South Carolina. Our work was performed in general accordance with the Task Order: SME-10270481-2021-001 dated March 25, 2021. The purpose of this letter is to provide the laboratory test results.

S&ME performed the requested laboratory testing of 34 soil samples provided by HDR Engineering, Inc (HDR) on July 27, 2021 via mail. The laboratory testing program consisted of natural moisture content, grain-size analysis with #200 wash, and Atterberg Limits testing (plasticity). Note that S&ME did not test rock cores collected during the exploration. A Summary of Laboratory Test Data and individual laboratory test sheets are provided in Attachment I.

S&ME appreciates the opportunity to offer our engineering assistance to this project. If you have any questions concerning the information presented or if we can be of further assistance, please feel free to contact us.

Sincerely, S&ME, Inc.

Khiya Urmstrong

Khiya Armstrong Staff Professional I <u>karmstrong@smeinc.com</u>

Enclosure: Attachment I – Laboratory Test Data

FRANKP.MORTSR.

Frank P. Morris, P.E. Project Engineer-Manager <u>fmorris@smeinc.com</u>

Attachments

Attachment I – Summary of Laboratory Test Data & Laboratory Test Data



SUMMARY OF LABORATORY TEST DATA

Geotechnical Exploration and Evaluation - Bad Creek Phase II Feasibility Study Project Salem, Oconee County, South Carolina S&ME Project No. 213045

| | | Sample | LICOC | | Natural | Percent | Atterber | rg Limits |
|----------|-----------|--------|--------|---------|----------|------------|----------|-----------|
| Borehole | Sample ID | Denth | USCS | SPT (N) | Moisture | Finer #200 | 11 | PI |
| Derenere | oumpro in | (feet) | Symbol | (bpf) | (%) | (%) | (%) | (%) |
| B-21-1 | SS-1 | 0.3 | SP-SM | 81 | 3.0 | 10.0 | | NP |
| B-21-1 | SS-2 | 3.1 | SP-SM | - | 8.6 | 11.4 | | NP |
| B-21-1 | SS-3 | 8.1 | SM | 50/6" | 12.0 | 16.2 | | NP |
| B-21-2 | SS-1 | 0 | SW-SM | 23 | 2.9 | 10.8 | | NP |
| B-21-2 | SS-2 | 5 | SP-SM | 40 | 4.3 | 8.6 | | NP |
| B-21-2 | SS-3 | 8.5 | SC | 9 | 19.2 | 46.5 | 33 | 11 |
| B-21-2 | SS-4 | 13.5 | SM | 5 | 16.7 | 33.3 | 30 | 5 |
| B-21-2 | SS-5 | 18.5 | SM | 7 | 15.1 | 23.0 | | NP |
| B-21-2 | SS-6 | 23.5 | SM | 9 | 20.9 | 35.8 | 32 | 5 |
| B-21-2 | SS-7 | 28.5 | SM | 11 | 14.4 | 22.8 | | NP |
| B-21-2 | SS-8 | 33.5 | SM | 22 | 22.5 | 20.7 | | NP |
| B-21-2 | SS-11 | 48.5 | SM | 15 | 26.4 | 22.9 | | NP |
| B-21-2 | SS-12 | 53.5 | SM | 42 | 20.4 | 25.6 | | NP |
| B-21-2 | SS-13 | 58.5 | SM | - | 17.5 | 24.0 | | NP |
| B-21-3 | SS-1 | 0 | SM | 6 | 16.3 | 46.8 | 33 | 8 |
| B-21-3 | SS-2 | 2.7 | SM | 21 | 13.6 | 22.3 | | NP |
| B-21-3 | SS-3 | 7.7 | SM | 13 | 18.0 | 20.6 | | NP |
| B-21-3 | SS-4 | 12.7 | SM | 50/6" | 13.9 | 17.6 | | NP |
| B-21-4 | SS-1 | 0 | SP-SM | 23 | 3.9 | 9.3 | | NP |
| B-21-4 | SS-2 | 3.5 | SW | 58 | 5.9 | 1.4 | | NP |
| B-21-4 | SS-3 | 18.5 | SM | 5 | 23.4 | 30.5 | 28 | 2 |
| B-21-4 | SS-4 | 23.5 | SM | 8 | 23.2 | 33.4 | 27 | 1 |
| B-21-4 | SS-5 | 28.5 | SM | 16 | 16.6 | 19.2 | | NP |
| B-21-4 | SS-6 | 33.5 | SM | 6 | 20.1 | 29.6 | 27 | 2 |
| B-21-4 | RC-1 | 60.7 | SM | - | 2.1 | 27.9 | | NP |
| B-21-5 | SS-1 | 2.6 | SM | - | 14.5 | 20.1 | | NP |
| B-21-5 | SS-2 | 7.6 | SM | 26 | 15.1 | 27.8 | | NP |
| B-21-5 | SS-3 | 12.6 | SM | 62 | 13.7 | 24.3 | | NP |
| B-21-5 | SS-4 | 17.6 | SM | - | 12.5 | 16.1 | | NP |
| B-21-5 | SS-6 | 27.6 | SM | - | 21.3 | 27.3 | | NP |
| B-21-5 | SS-10 | 47.6 | SM | - | 14.4 | 26.1 | | NP |
| B-21-5 | SS-17 | 32.6 | SM | 50/6" | 19.3 | 29.8 | 27 | NP |
| B-21-5 | SS-18 | 37.6 | SM | 50/6" | 18.7 | 29.7 | 27 | NP |
| B-21-5 | SS-21 | 52.6 | SC-SM | 93 | 17.6 | 36.0 | 27 | 5 |

Notes:

USCS = Unified Soil Classification System SPT = Standard Penetration Test bpf = blows per foot LL = Liquid Limit PI = Plasticity Index Form No TR-D6913-GR-01 Revision No. 1 Revision Date: 9/5/17

SIEVE ANALYSIS OF SOIL



| Single sieve set | ingle sieve set ASTM D 6913 S&ME, Inc Greenville: 48 Brookfield Oaks Dr., Suite F Greenville, SC 29607 | | | | | | | | | | | | | | | | | | |
|----------------------------|---|------------------------|-------------------|-------------------|---------------------|---|-------------------|------------|---------------|----------------|----------|----------------------------------|----------------|--------|--------|----------------|--------------|-----------------------|----------|
| | S | &ME, | Inc (| Green | ville: | 48 E | Brookfi | ield Oa | aks D | r., Si | uite F | Gre | enville | e, SC | 296 | 07 | | | |
| Project #: | 213 | 045 | | | | | | | | | | | | | Re | port | Date: | 8/30 |)/21 |
| Project Name: | Bad | Creek | Phase | e 2 Fea | sibilit | y Stu | dy Pro | ject | | | | | | | | Test | Date: | 8/10 - 8 | 8/24/21 |
| Client Name: | HDR | | | | | | | | | | | | | | | | | | |
| Client Address: | 1122 | 2 Lady | Street | t, Suite | e 1100 |) Col | umbia | , Soutl | n Car | olina | a 292 | 201 | | | | | | | |
| Boring #: | B-21 | -1 | | | | | | Log | #: | | | 96g | | | Sar | nple | Date: | 4/06 | 5/21 |
| Sample ID: | SS-1 | | | | | | | Тур | e: | | Spli | it-spo | on | | | D | epth: | 0. | 3' |
| Sample Descrip | tion: | poorl | y grad | ed SA | ND w | ith sil | lt and | gravel | (SP-S | 5M) | - gra | ıy whi [.] | te, coa | arse 1 | to fir | ne | | | |
| 100% 90% | 3" 2 | . 1.5" | 1" 3/4" | | 3/8" | #4 | | #10 | #2 | | #40 | #60 | #100 | #140 | #200 | | | | |
| 80% | | | | | | | | | | | | | | | | | | | |
| assing 0% | | | | | | | | | | | | | | | | | | | |
| Eent H 50% | | | | | | | | | | | | _ | | | | | | | |
| 40% | | | | | | | | | | | | | | | | | | | |
| 30% | | | | | | | | | | | | $\overline{}$ | | | | | | | |
| 20% | | | | | | | | | | | | | | | | | | | |
| 10% | ┝┼┼┼ | | | | | | | | | | | _ | | | ┝ | | | | - |
| 0% | | | | 10 | 00 | Mi | llimator | | 1 00 | | | | | 0 10 | | | | | 0.01 |
| | | | | 10 | | IVII | mineter | .5 | 1.00 | | | | | 0110 | | | | | |
| Cobbles | | < 3 | 800 mn | n (12") | and > | • 75 m | ım (3") | | | Fir | ne Sar | nd | | < | 0.42 | 25 mn | n and | > 0.075 | mm |
| Gravel | | | < 75 m | m and | > 4.7 | 5 mm | (#4) | | | | Silt | | | | < 0. | .075 a | and > (| 0.005 m | m |
| Coarse Sar | nd | < | 4.75 m | nm and | 1 > 2.0 | 0 mm | (#10) | | | | Clay | 1. | | | | < | 0.005 r | nm | |
| Method: B | na | < 2 | 2.00 mi Proced | m and lure foi | > 0.42 | ining (| 1 (#40) Snecim | en: | Moi | <u>ر</u> در | .011010 | is Die | nersio | n Pro | | < (| Dis | nm nersant | |
| Maxir | num Par | ticle S Gra | ize : vel | 37.50 47.0 | mm % | , in the second s | opeenin | C Me | oarse dium | Sar Sar | nd nd | 9.99 12.3 | % % | | | Fine Silt & | Sand Clay | 20. 20. | 9% 0% |
| | Liq | luid Li | mit | | | | | P | lastic | : Lin | nit | NF | þ | | Pla | stic | Index | Ν | Р |
| | | | | | | | | Natura | al Mo | istu | re | 3.09 | % | | | | | | |
| | | | Cc | $= D_{30}^{2}$ | /(D ₁₀ : | к D ₆₀) | (| 0.3 | | C | Cu = C | D ₆₀ /D ₁₀ | | | 100. | 0 | | | |
| D10 = Notes / Deviation | 0.075 ns / Refere | ences: | D30 | = 0 | .40 | | D6 | 0 = | 7.50 | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| <u>Frank</u> Technico | <u>Morris,</u> al Respons | <u>P.E.</u> ibility | | | FRAM | Signe | ture | R. | | | <u>P</u> | Project Po | Mana Sition | ager | | | | <u>8/30/2</u> Date | <u>1</u> |
| | | This r | eport sh | nall not | be repr | oduced | l, except | t in full, | withou | t the | writte | n appro | oval of S | S&ME, | Inc. | | | | |

Form No. TR-D4318-T89-90 Revision No. 1 Revision Date: 7/26/17

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | | ASTM | D 4318 | X | AASH | ITO T 8 | 9 🗆 |] A | ASHTO T | - 90 | | | | | |
|--|--|--|------------|-------------|-------------|-----------|-------------|-------------|-------------|----------|----------------|--------------|---------------|------------------|--|
| | | S&ME, Ir | nc Gre | enville | 48 Br | ookfie | ld Oaks | Dr., Su | uite F | Gree | enville, S | C 29607 | | | |
| Project # | #: | 213045 | | | | | | | | | Report | Date: | 8/30/ | 21 | |
| Project I | Name: | Bad Creek | Phase 2 | 2 Feasibil | ity Stu | dy Pro | ject | | | | Test | Date: | 8/19/ | 21 | |
| Client N | ame: | HDR | | | | | - | | | | | | | | |
| Client A | ddress: | 1122 Lady | Street, | Suite 11 | 00 Col | umbia | , South | Caroli | na 2920 |)1 | | | | | |
| Boring # | ŧ: B-21 | -1 | | L | og #: | | 96g | | S | Samp | ple Date: | : | 4/06/21 | | |
| Sample | ID: SS-1 | | | | Туре: | S | plit-spc | on | | | Depth: | : | 0.3' | | |
| Sample | Descriptio | n: p | oorly g | raded SA | ND wi | th silt a | and gra | ivel (SP | P-SM) - (| gray | white, c | oarse to fi | ne | | |
| Type and | Specificatio | n | S&ME IL | D # | Cal D | ate: | Туре | and Spe | ecificatio | n | S8 | RME ID # | Cal | Date: | |
| Balance | (0.01 g) | | 1394 | 2 | 10/19/ | 2020 | Groov | ving too | ol | | | 23119 | 10/1 | 5/2020 | |
| LL Appara | atus | | 2315 | 8 | 2/1/2 | 021 | | | | | | | | | |
| Oven Pan t | # | | 1397 | 8 | 10/7/2 | 2020 | Liquid | Limit | | | | ſ | Plastic Lim | it. | |
| r un + | n r | - | Fare #: | | | | Liquid | Liiiit | | <u> </u> | | | | | |
| Α | Tare Weig | ht | | | | | | | | | | | | | |
| B | Wet Soil V | Veight + A | | | | | | | | | | | | | |
| C C | Dry Soil W | /eight + A | | | | | | | | | | | | | |
| D | Water We | iaht (B-C) | | | | | | | | | | | | | |
| F | Dry Soil W | $\frac{1}{2} = \frac{1}{2} $ | | | | | | | - | | | | | | |
| | % Moistur | P(D/F) * 100 | | | | | | | - | | | | | | |
| N | | | | | | | | | | | | Maiatura C | ovetoveto dov | a main a d hu | |
| | | - E * EACTO | D | | | | | | | | | Moisture Co | STM D 22 | erminea by 16 | |
| Ave | LL LL = F * FACTOR ASTM D 2216 Ave Average Average | | | | | | | | | | | | | | |
| 7176. | | Tweruge | | | | | | | | | | One Point I | iquid Lin | nit | |
| 4 | 10.0 | | | | | | | | | | N | Factor | N | Factor | |
| | | | | | | | | | | | 20 | 0.974 | 26 | 1.005 | |
| <u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u></u> | 5.0 | | | | | | | | | | 21 | 0.979 | 27 | 1.009 | |
| uten | | | | | | | | | | | 22 | 0.985 | 28 | 1.014 | |
| Co | | | | | | | | | | | 23 | 0.99 | 29 | 1.018 | |
| an 3 | 30.0 | | | | | | | | | | 24 | 1.000 | 50 | 1.022 | |
| loist | | | | | | | | | | Ľ | N | IP, Non-Pla | astic | X | |
| | 25.0 | | | | | | | | | | | Liquid L | .imit · | | |
| | | | | | | | | | | | | Plastic L | .imit I | NP | |
| | | | | | | | | | | | | Plastic Ir | ndex I | NP | |
| 2 | 20.0 | | - | | | ļ | | | | | (| Group Syn | nbol SP | -SM | |
| | 10 | 15 | 20 | 25 30 | 35 4 | 10 | # of D | rops | 100 | | Ν | Aultipoint N | /lethod | 1 | |
| | | | | | | | | | | | C | Dne-point N | /lethod | | |
| Wet Pre | eparation | Dry | Preparat | ion 🗸 | Air | Dried | 1 | | | % | 6 Passing | the #200 S | ieve: | 10.0% | |
| Notes / D | Deviations / | References: | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| ASTM D 4 | 4318: Liauid | Limit, Plast | ic Limit. | & Plastic | ndex of | f Soils | | | | | | | | | |
| B | enjamin J | . Kovalesk | <u>i</u> | | <u>8/30</u> | /21 | | <u>Bria</u> | an Vaug | ghar | <u>η, Ρ.Ε.</u> | | <u>8/3</u> | <u>0/21</u> | |
| | Technicia | n Name | | | Dat | e | | Тес | chnical Res | spons | ibility | | D | ate | |
| | | This rep | oort shall | not be repi | oduced, | except i | n full, wit | hout the | e written a | pprov | val of S&M | E, Inc. | | | |

3201 Spring Forest Road Raleigh, NC. 27616 Form No TR-D6913-GR-01 Revision No. 1 Revision Date: 9/5/17

SIEVE ANALYSIS OF SOIL



| Single sieve set | | A | STM D 6913 | | | | | | | | |
|--|--|--|---|---|---|----------------------------|--|--|--|--|--|
| | S&ME, Inc G | ireenville: 48 Brool | rfield Oaks Dr., S | uite F Greenville | e, SC 29607 | | | | | | |
| Project #: | 213045 | | | | Report Date: | 8/30/21 | | | | | |
| Project Name: | Bad Creek Phase | 2 Feasibility Study P | roject | | Test Date: | 8/10 - 8/24/21 | | | | | |
| Client Name: | HDR | | | | | | | | | | |
| Client Address: | 1122 Lady Street, | Suite 1100 Columb | ia, South Carolir | ia 29201 | | | | | | | |
| Boring #: | B-21-1 | | Log #: | 96g | Sample Date: | 4/06/21 | | | | | |
| Sample ID: | SS-2 | | Туре: | Split-spoon | Depth | 3.1' | | | | | |
| Sample Description | : poorly grade | d SAND with silt and | d gravel (SP-SM) | - gray white, coa | arse to fine | | | | | | |
| Leccent Passing (%) 90% 80% 60% 40% 40% 30% 20% | " 2" 1.5" 1" 3/4" | 3/8" #4 | #10 #20 | | #140 #200 | | | | | | |
| 10% 0% 100.00 | 200 mm | 10.00 Millimet | ers 1.00 | no Cond | 0.10 | 0.01 | | | | | |
| Gravel | < 300 mm | (12) and > 4.75 mm (3) |) Fi | Silt | < 0.425 mm and | > 0.075 mm | | | | | |
| Coarse Sand | < 4.75 mr | m and >2.00 mm (#10 |) | Clay | < 0.005 | mm | | | | | |
| Medium Sand | < 2.00 mm | and > 0.425 mm (#4 | D) (| Colloids | < 0.001 | mm | | | | | |
| Method: B Maximum | Procedu n Particle Size 2 Gravel Liquid Limit | ire for obtaining Speci 5.00 mm 37.6% | men: Moist Coarse Sa Medium Sa Plastic Lir Natural Moistu | Dispersic nd 11.9% nd 15.1% nit NP ure 8.6% | on Process: Di Fine Sand Silt & Clay Plastic Index | spersant 23.9% 11.4% | | | | | |
| | Cc = | = D ₃₀ ² /(D ₁₀ x D ₆₀) | 0.3 | $Cu = D_{60}/D_{10}$ | 63.1 | | | | | | |
| D10 = 0.07 D30 = 0.29 D60 = 4.10 Notes / Deviations / References: < | | | | | | | | | | | |
| | orris, P.E. | FRANKPAUER | -512. | Project Mana | ager | <u>8/30/21</u> | | | | | |
| Technical Re | sponsibility This report sha | Signature Ill not be reproduced. exce | ept in full, without the | Position e written approval of S | S&ME, Inc. | Date | | | | | |

Form No. TR-D4318-T89-90 Revision No. 1 Revision Date: 7/26/17

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | | AST | M D 4318 | \mathbf{X} | AASHTO | Т 89 | | АЅНТО Т | 90 🗆 | | | | | |
|---|-----------------------|--------------------|---------------|--------------|----------------|----------------|-------------|-------------|-------------------|---------------------|-------------------|--------------|--|--|
| | | S&ME, | Inc Gre | enville | 48 Brool | kfield Oa | ks Dr., Su | uite F (| Greenville, S | SC 29607 | | | | |
| Project # | #: | 213045 | | | | | | | Report | Date: | 8/30/2 | 21 | | |
| Project I | Name: | Bad Cree | k Phase 2 | 2 Feasibil | ity Study | Project | | | Test | Date: | 8/19/2 | 21 | | |
| Client N | ame: | HDR | | | , , | 5 | | | | | | | | |
| Client A | ddress: | 1122 Lad | y Street, | Suite 110 | 0 Colum | bia, Sout | h Carolii | na 2920 | 1 | | | | | |
| Boring # | ≠: B-2 | 1-1 | | L | og #: | 960 | 3 | S | ample Date | e: | 4/06/21 | | | |
| Sample | ID: SS-2 | 2 | | - | Туре: | Split-sp | boon | | Dept | ו: | 3.1' | | | |
| Sample | Descriptic | on: | poorly g | raded SA | ND with s | silt and g | ravel (SP | -SM) - c | gray white, | coarse to f | ine | | | |
| Type and | Specificati | on | S&ME IE |) # | Cal Date: | Тур | e and Spe | ecification | n S | &ME ID # | Cal | Date: | | |
| Balance | (0.01 g) | | 13942 | 2 | 10/19/202 | 0 Gro | oving too | Ы | | 23119 | 10/15 | 5/2020 | | |
| LL Appara | atus | | 23158 | 3 | 2/1/2021 | | | | | | | | | |
| Oven | | | 13978 | 3 | 10/7/2020 | 0 | | | | | | | | |
| Pan ‡ | # | | Tara #1 | | T | Liqu | id Limit | | | | Plastic Limi | t | | |
| | Tara Mai | abt | Tale #. | | | | | | | | | | | |
| A | | Jiii Maimht I A | | | | | | | | | | | | |
| В | Wet Soll | weight + A | | | | | | | | | | | | |
| | Dry Soll V | | | | | | | | | | | | | |
| D | Water We | eight (B-C) | | | | | | | | | | | | |
| E | Dry Soil V | Veight (C-A | N) | | | | | | | | | | | |
| F | % Moistu | re (D/E)*10 | 0 | | | | | | | | | | | |
| N # OF DROPS Moisture Contents determined | | | | | | | | | | | | | | |
| LL LL = F * FACTOR ASTM D 2216 | | | | | | | | | | | | | | |
| Ave. Average | | | | | | | | | | | | | | |
| 4 | 10.0 T | | | F | | | | | | One Point | Liquid Lim | it Easter | | |
| | | | | | | | | | 20 | 0.974 | 26 | 1 005 | | |
| | | | | | | | | | 21 | 0.979 | 27 | 1.009 | | |
| tent 3 | 35.0 | | | | | | | | 22 | 0.985 | 28 | 1.014 | | |
| Ont | | | | | | | | | 23 | 0.99 | 29 | 1.018 | | |
| le 3 | 30.0 | | | | | | | | 24 | 0.995 | 30 | 1.022 | | |
| istu | | | | | | | | | 25 | 1.000 | | | | |
| Mo | | | | | | | | | | NP, Non-Pl | | XI | | |
| 8 2 | 25.0 | | | | | | | | | | -imit - | | | |
| | | | | | | | | | | Plastic L | limit r | | | |
| 2 | | | | | | | | | | Plastic Ir | ndex r | | | |
| - | 10 | 15 | 20 | 25 30 | 35 40 | # of | Drong | 100 | _ | Group Syr | | | | |
| | | | | | | # 01 | Drops | | | | vietnou Aathad | ~ | | |
| Wet Br | oparation | Da | (Proparati | ion (| Air Dri | ind (| | | Passing | one-point r | ieuro: | 11 /0/ | | |
| Notes / D | | References | | | | eu 🔄 | | | 70 Fussing | <i>j</i> the #200 S | leve. | 11.4 /0 | | |
| Notes / D | veviations / | References | • | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| ASTM D 4 | 4318: Liqui | d Limit, Pla | stic Limit, a | & Plastic I | ndex of Sol | ils | | | | | | | | |
| | | | | | 0 / 20 / 21 | | | | | | 0./2 | 0/21 | | |
| <u>B</u> | enjamin . Technici | J. KOVales | <u>SKI</u> | | <u>8/30/21</u> | <u> </u> | <u>Bria</u> | an Vaug | nan, P.E. | | 8/3 | <u>U/21</u> | | |
| | recrimen | This i | eport shall | not be reni | oduced. exc | ept in full. v | vithout the | e written a | porisional of S&I | ME. Inc. | D | | | |

3201 Spring Forest Road Raleigh, NC. 27616 Form No TR-D6913-GR-01 Revision No. 1 Revision Date: 9/5/17

SIEVE ANALYSIS OF SOIL



| Single sieve set | | | | | | | | AS | STM | D 69 | 13 | | | | | | | | | | | | | |
|---------------------------------------|------------------------------|------------------------|---------|---------------|--------|-------|-------|--------|----------|--------|------------|--------------|----------|--------------|-------------|---------------------|-------------|------|------|-------|-------|-----------|------------------------|-----|
| | S | &ME, | Inc | Greer | nville | e: - | 48 B | Brook | cfielc | l Oak | s Di | r., Si | uite | F | Gree | envill | e, SC | 29 | 9607 | 7 | | | | |
| Project #: | 213 | 045 | | | | | | | | | | | | | | | | F | Repo | ort l | Date: | | 8/30/2 | 1 |
| Project Name: | Bad | Creek | Phas | e 2 Fe | asib | ility | Stu | dy Pı | rojec | t | | | | | | | | | Te | est l | Date: | : 8/ | /10 - 8/24 | /21 |
| Client Name: | HDR | | | | | | | | | | | | | | | | | | | | | | | |
| Client Address: | 1122 | Lady | ' Stree | et, Suit | te 11 | 100 | Col | umb | ia, So | outh | Care | olina | a 29 | 201 | | | | | | | | | | |
| Boring #: | B-21 | -1 | | | | | | | ļ | _og # | # : | | | 96 | ōg | | | S | amp | ole I | Date: | | 4/06/2 | 1 |
| Sample ID: | SS-3 | | | | | | | | | Туре | e: | | Sp | lit-s | spoc | n | | | | D | epth: | | 8.1' | |
| Sample Descript | tion: | silty S | SAND | with g | grav | el (S | SM) · | - gra | ıy wł | ite, r | ned | ium | to f | fine | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| 100% | 3" 2 | 1.5" | 1" 3/4 | 4" | 3/8 | | #4 | | #10 | | #2(|) | #4 | 0 | #60 | #100 | #140 | #2 | 200 | | | | | |
| | | ⊢┼─ | | \rightarrow | | | | | | | | | _ | | | | | | | | _ | _ | | |
| 90% | | | | | | | | | | | | | | | | | | | | | | | - | |
| 80% | | | | | | | | | | | | | | | | | | | | | | | | |
| (%) | | | | | | | | | | | | | | | | | | | | | _ | _ | | |
| ം 70% | | | | | | | | | | | | | | | | | | | | | | | | |
| assi 40% | | \vdash | | | | | + | | | | | \checkmark | | | | | | | | | | _ | _ | |
| I I I I I I I I I I I I I I I I I I I | | | | | | | | | | | | | | | | | | | | | | | _ | |
| 50% | | | | | | | | | | | | | | \mathbb{N} | | | | | | | | | | |
| 40% | | \vdash | | | | | | | | | _ | | _ | | X | | | | | | | | | |
| 20% | | | | | | | | | | | ++- | | - | | | | - | | | | | | | |
| 30% | | | | | | | | | | | | | | | | | | | | | | | | |
| 20% | | | | | | | | | | | | | _ | | | | <u> </u> | | | | _ | _ | _ | |
| 10% | | | | | | | | | | | | | | | | | | | | | | | | |
| 10% | | | | | | | | | | | | | | | | | | | | | | | | |
| 0% | | <u> </u> | | 1 | | | | | <u> </u> | | 1 00 | | | | | | 0.14 | | | | | | | |
| 100 | .00 | | | 1 | 0.00 | | Mil | limet | ters | | 1.00 | | | | | | 0.10 | J | | | | | 0.0. |) |
| Cobbles | | < | 300 m | m (12" | ') and | d > 7 | 75 m | nm (3 | ") | | | Fir | ne Sa | and | | | | < 0. | 425 | mm | n and | > (| .075 mn | n |
| Gravel | | _ | < 75 r | nm and | d > 4 | 1.75 | mm | (#4) | / | | | | Silt | | | | | < | 0.0 | 75 a | nd > | 0.0 | 05 mm | |
| Coarse San | d | < | 4.75 | mm an | id >2 | 2.00 | mm | (#10) |) | | | | Clay | / | | | | | | < (| .005 | mm | I | |
| Medium Sar | nd | < | 2.00 n | nm and | d > 0 | .425 | mm | า (#4(| 0) | | | C | olloi | ids | | | | | | < (| .001 | mm | I | |
| Method: B | | | Proce | dure fo | or ob | otain | ing S | Speci | men: | | Moi | st | | | Dis | persi | on Pr | oce | ss: | | Di | spe | rsant | |
| Maxim | num Par | ticle S | Size | 19.00 | mm | ۱ | | | | Co | arse | Sar | nd | | 8.9% | 0 | | | Fi | ne | Sand | | 35.6% | 1 |
| | | Gra | avel | 18.4 | 4% | | | | | Med | ium | Sar | nd | 2 | 21.09 | % | | | Sil | t & | Clay | ' | 16.2% |) |
| | Liq | uid Li | imit | | - | | | | | Pla | astic | Lin | nit | | NP | | | F | Plas | tic I | ndex | (| NP | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | Na | tural | Мо | istu | re | 1 | 12.09 | % | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| Notes / Deviation | s / Refere | ences: | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | | | | - | | - | - | | | | | | | | | | | | | | | | |
| | | | | | TP | ANV | (PA | DOT | 50 | | | | | | | | | | | | | | | |
| <u>Frank</u> | Morris, | <u>P.E.</u> | | | TR | ANN | cp.n | 14947 | -21S | -+ | | | | Pro | ject | Man | <u>ager</u> | | | | | <u>8/</u> | 30/21 | |
| <u>Frank</u> Technica | <u>Morris,</u> Il Respons | <u>P.E.</u> ibility | | | TR | ANN | Signa | ture | -215 | -* | | | <u> </u> | Proj | ject Pos | <u>Man</u> ition | <u>ager</u> | | | | | <u>8/</u> | ' <u>30/21</u> Date | |

Form No. TR-D4318-T89-90 Revision No. 1 Revision Date: 7/26/17

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | | AS | TM D 4318 | \mathbf{X} | AASI | нто т 8 | 9 E | | ASHTC |) T 90 | | | | |
|--|-------------------|--------------|----------------|--------------|-------------|--------------|-----------|-------------|--------------|---------|-------------|-----------------|---------------|-------------|
| | | S&ME | , Inc Gre | enville | 48 Bi | rookfie | ld Oak | s Dr., Si | uite F | Gre | enville, So | C 29607 | | |
| Project | #: | 213045 | | | | | | | | | Report I | Date: | 8/30/2 | 21 |
| Project | Name: | Bad Cre | ek Phase 2 | 2 Feasibi | lity Stu | udy Pro | ject | | | | Test l | Date: | 8/19/2 | 21 |
| Client N | lame: | HDR | | | | | - | | | | | | | |
| Client A | ddress: | 1122 La | dy Street, | Suite 11 | 00 Co | lumbia | , South | n Caroli | na 29 | 201 | | | | |
| Boring # | #: B-2 | 21-1 | - | l | _og #: | | 96g | | | Sam | ple Date: | | 4/06/21 | |
| Sample | ID: SS- | -3 | | | Type: | S | plit-sp | oon | | | Depth: | | 8.1' | |
| Sample | Descripti | on: | silty SAN | D with g | gravel (| (SM) - (| gray w | hite, me | edium | to fir | ie . | | | |
| Type and | l Specificat | ion | S&ME IL |) # | Cal D | Date: | Туре | and Spe | ecificat | ion | S8 | ME ID # | Cal | Date: |
| Balance | (0.01 g) | | 13942 | 2 | 10/19, | /2020 | Groo | oving too | ol | | | 23119 | 10/15 | 5/2020 |
| LL Appar | ratus | | 23158 | 3 | 2/1/2 | 2021 | | | | | | | | |
| Oven | " | | 13978 | 3 | 10/7/ | 2020 | | | | | | | | |
| Pan | # | | Taro #: | | - | | Liquid | Limit | | | | | Plastic Limi | t |
| | Tare We | iaht | | | | | | | | | | | | |
| | Wot Soil | | ٨ | | | | | | | | | | | |
| | | | ^ | | | | | | _ | | | | | |
| | Dry Soli | Velgint + / | 4 \ | | | | | | | | | | | |
| | water w | |) | | _ | | | | _ | | | | | |
| | | | -A) | | | | | | _ | | | | | |
| | % Moist | ure (D/E)^ I | 00 | | _ | | | | | | | | | |
| N # OF DROPS Moisture Contents determined LL LL = F * FACTOR ASTM D 2216 | | | | | | | | | | | | | | |
| LL LL = F * FACTOR ASTM D 2216 | | | | | | | | | | | | | | |
| Ave. Average One Point Liquid Limit | | | | | | | | | | | | | | |
| 4 | ^{40.0} T | | | | | 1 | | | | 1) | N | | | Factor |
| | | | | | | | | | | | 20 | 0.974 | 26 | 1.005 |
| | | | | | | | | | | | 21 | 0.979 | 27 | 1.009 |
| iteni | ^{35.0} | | | _ | | | | | | | 22 | 0.985 | 28 | 1.014 |
| Con | | | | | | | | | | | 23 | 0.99 | 29 | 1.018 |
| nre | 30.0 | | | | | | | | | | 24 | 0.995 | 30 | 1.022 |
| oist | | | | | | | | | | | N | P. Non-Pla | astic | X |
| W % | | | | | | | | | | | | Liquid L | .imit - | |
| | 23.0 | | | | | | | | | | | Plastic L | .imit N | IP |
| | | | | | | | | | | | | Plastic Ir | ndex N | IP |
| 2 | 20.0 | | | | | - | | | | | (| Group Syn | nbol S | м |
| | 10 | 15 | 20 | 25 30 | 35 | 40 | # of 1 | Drops | 1 | 00 | N | Aultipoint N | /lethod | 1 |
| | | | | | | | | | | | C |) ne-point N | /lethod | |
| Wet Pr | eparation | | ry Preparat | ion 🗸 | Ai | r Dried | ~ | | | (| % Passing | the #200 S | ieve: | 16.2% |
| Notes / E | Deviations | / Reference | es: | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| ACT:4 5 | 1210 1 | | | | | (c '' | | | | | | | | |
| ASIMD | 43 I 8: Liqu | ıa Limit, Pl | astic Limit, a | x Plastic | index o | T Soils | | | | | | | | |
| <u>B</u> | Benjamin | J. Kovale | <u>eski</u> | | <u>8/30</u> |)/2 <u>1</u> | | <u>Bria</u> | an Va | ugha | n, P.E. | | <u>8/3</u> | <u>0/21</u> |
| _ | Technic | tian Name | | | Da | te | | Tec | hnical I | Respons | sibility | | D | ate |
| | | Thi | s report shall | not be ren | roduced | . except i | n full. w | ithout the | , writter | n appro | val of S&M | E. Inc. | | |

3201 Spring Forest Road Raleigh, NC. 27616 Form No TR-D6913-GR-01 Revision No. 1 Revision Date: 9/5/17

SIEVE ANALYSIS OF SOIL



| Single sieve set ASTM D 6913 | | | | | | | | | | | | | | | | | |
|--|------------|---------------------------|---------------------|---------------------|---------|----------|-------|--|--------------------------------|------------------------------|---------------------------|------------------------|---------|------------------------|--------------------------------|-------|--|
| | S&ME | E, Inc Gree | enville: | 48 Broo | okfield | Oaks Dr | ., Sı | uite F | Gre | enville | , SC 2 | 2960 | 7 | | | | |
| Project #: | 213045 | | | | | | | | | | | | ort Dat | e: | 8/30/21 | | |
| Project Name: | Bad Cree | k Phase 2 F | easibilit | ty Study | Project | t | | | | | | | est Dat | e: | 8/10 - 8/2 | 24/21 | |
| Client Name: | HDR | | | | | | | | | | | | | | | | |
| Client Address: | 1122 Lad | y Street, Su | ite 1100 |) Colum | bia, So | uth Carc | olina | a 2920 |)1 | | | | | | | | |
| Boring #: | B-21-2 | | | | Lo | og #: | | ç | 96g | | | Sam | ple Dat | e: | 4/20/ | 21 | |
| Sample ID: | SS-1 | | | | ype: | | Split | -spoo | on | | Depth: | | | 0' | | | |
| Sample Descrip | tion: well | -graded SA | ND with | n silt and | gravel | (SW-SN | 1) - | gray v | white | , coars | e to | fine | | | | | |
| 100% 90% (%) guiss 70% | 3" 2" 1.5" | 1" 3/4" | 3/8" | #4 | #10 | #20 | | #40 | #60 | #100 * | *140 | #200 | | | | | |
| 60% 50% 40% 30% 20% 10% | | | | | | | | | | | | | | | | | |
| 100 |).00 | | 10.00 | Millim | eters | 1.00 | | | | | 0.10 | | | | 0 | .01 | |
| Cobbles | < | 300 mm (12 | 2") and > | > 75 mm (| (3") | | Fin | e San | d | | < 0.425 mm and > 0.075 mm | | | | | | |
| Gravel | d | < 15 mm ai | nd > 4.7 | 5 mm (#4 |) | Silt | | | | | | < 0.075 and > 0.005 mm | | | | | |
| Medium Sa | nd < | < 4.75 mm a 2 00 mm ar | 100 > 2.0 | 25 mm (#1 | 40) | Colloids | | | | | | < 0.005 mm | | | | | |
| Method: B Procedure for obtaining Specimen: Maximum Particle Size 25.00 mm 0 Gravel 44.8% M Liquid Limit | | | | | | | | Moist Dispersion Coarse Sand 13.6% Medium Sand 15.1% Plastic Limit NP | | | | | | Disp id ay ex | ersant 15.6' 10.8' NP | % | |
| | | Cc = D | $D_{30}^2/(D_{10})$ | x D ₆₀) | 1.1 | | C | u = D _f | ₅₀ /D ₁₀ | 0 | | 96.9 | | | | | |
| D10 = 0.07 D30 = 0.68 D60 = 6.30 Notes / Deviations / References: | | | | | | | | | | | | | | | | | |
| Frank Morris, P.E. Technical Responsibility Signature This report shall not be reproduced, except in | | | | | | | the | <u>Pr</u> written | oject Pos | Manag sition val of S& | ger &ME, I | Inc. | | <u>.</u> | <u>8/30/21</u> Date | | |

Form No. TR-D4318-T89-90 Revision No. 1 Revision Date: 7/26/17

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | | AST | M D 4318 | \mathbf{X} | AASH | нто т 8 | 9 [| _ <i>,</i> | AASHI | то т 90 | | | | | | |
|--|--|--------------------|---------------|--------------|--------------------|--|-------------------|-----------------|----------|--------------------|----------------------|--------------|--------------|----------------------|--|--|
| | | S&ME, | Inc Gre | enville | 48 Br | ookfie | ld Oak | s Dr., S | Suite | F Gre | enville, So | C 29607 | | | | |
| Project # | <i>‡</i> : | 213045 | | | | | | | | | | Date: | 8/30/21 | | | |
| Project N | ame: Bad Creek Phase 2 Feasibility Study Project | | | | | | | | | | Test l | Date: | 8/19/21 | | | |
| Client Na | | | | | | | | | | | | | | | | |
| Client Ac | ddress: | 1122 Lac | ly Street, | Suite 11 | 00 Co | lumbia | , South | n Carol | lina 2 | 29201 | | | | | | |
| Boring # | Boring #: B-21-2 Log #: 96g Sam | | | | | | | | | ple Date: | | 4/20/21 | | | | |
| Sample I | ID: SS-1 | | | | Type: | S | plit-sp | oon | Depth: | | | | | | | |
| Sample Description: well-graded SAND with silt and gravel (SW-SM) - gray white, coarse to fine | | | | | | | | | | | | | | | | |
| Type and Specification S&ME ID | | | |) # | Cal D | ate: | Туре | and Sp | oecific | ation | S8 | xME ID # | Cal I | Date: | | |
| Balance (| (0.01 g) | | 13942 | 2 | 10/19/ | 2020 | Groo | oving to | loc | | | 23119 | 10/15/2020 | | | |
| LL Appara | atus | | 2315 | 8 | 2/1/2 | 021 | | | | | | | | | | |
| Oven | | | 13978 | 3 | 10/7/2 | 2020 | | | | | | | | | | |
| Pan # | ŧ | | T | | 1 | | Liquio | d Limit | - | | | | Plastic Limi | t | | |
| | Tara Maia | . b. t | Tare #: | | | | | | | | | | | | | |
| A | | jiil Maiakt : 1 | | | | | | | | | | | | | | |
| B | Wet Soil V | $\frac{1}{1}$ | 4 | | | | | | | | | | | | | |
| C | Dry Soil V | /eight + A | | | | | | | | | | | | | | |
| D | Water We | eight (B-C) | | | | | | | | | | | | | | |
| E | Dry Soil V | /eight (C-/ | 4) | | | | | | | | | | | | | |
| F | % Moistu | re (D/E)*1(| 00 | | | | | | | | | | | | | |
| N # OF DROPS | | | | | | | | | | | Moisture C | ontents det | ermined by | | | |
| LL | LL | = F * FAC1 | FOR | | | | | | | | | A | STM D 221 | 6 | | |
| Ave. | | Average | | | | | | | | | | | | | | |
| 4 | 0.0 T | | | | _ | | 1 1 | | 1 1 | | | One Point | Liquid Lim | it 🖉 | | |
| | | | | | | | | | | | N 20 | Factor | N | 1 005 | | |
| | | | | | | | | | | | 20 | 0.974 | 20 | 1.003 | | |
| ent 3 | 5.0 | | | | | | | | | | 22 | 0.985 | 28 | 1.014 | | |
| ont | | | | | | | | | | | 23 | 0.99 | 29 | 1.018 | | |
| er 3 | 0.0 | | | | | | | | | | 24 | 0.995 | 30 | 1.022 | | |
| istu | | | | | | | | | | | 25 | 1.000 | | | | |
| Mo | | | | | | | | | | | n | IP, Non-Pl | astic L | XI XI | | |
| ≥° 2: | 5.0 | | | | | | | | | | | | insit N | | | |
| | | | | | | | | | | | | Plastic L | | | | |
| 20 | 0.0 | | | | | | | | | | | Plastic II | | SM | | |
| | 10 | 15 | 20 | 25 30 | 35 4 | 40 | # of] | Drops | | 100 | | Aultinoint N | Aethod | | | |
| | | | | | | | <i>"</i> O | JIOPS | | | C C |)ne-noint M | /ethod | - | | |
| Wet Pre | enaration | Dr | v Prenarat | ion 🗸 | Δir | Dried | 1 | | | | % Passina | the #200 S | ieve. | 10.8% | | |
| Notes / D | eviations / | Reference | <u>s:</u> | | 7.01 | Drica | | | | | or assing | 110 | | 10.070 | | |
| | , | -1 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| ASTM D 4 | 1318: Liquic | l Limit, Pla | stic Limit, o | & Plastic | ndex of | f Soils | | | | | | | | | | |
| D. | oniamin | Kovala | cki | | Q /20 | /21 | | Dr | ian V | Jugha | | | 0 / 2 | 0/21 | | |
| <u>B6</u> | Technicia Technicia | <u>n Name</u> | <u>5KI</u> | | <u>0/30</u> Dat | <u>7 </u> | | <u>Dſ</u> Te | chnice | augna al Resnon | ii, r.c. sibility | | <u>ס /ס</u> | <u>0/ 2 1</u> ate | | |
| | | This | report shall | not be repl | roduced. | except i | n full, w | ithout th | he writi | ten appro | val of S&M | E, Inc. | | | | |

3201 Spring Forest Road Raleigh, NC. 27616 Form No TR-D6913-GR-01 Revision No. 1 Revision Date: 9/5/17

SIEVE ANALYSIS OF SOIL



| Single sieve set ASTM D 6913 | | | | | | | | | | | | | | | | | | | | | |
|--|---|---------|-----------|------------------------------------|-------------------|-------------------|-----------------|--------------------------|-----------|-------------------|------------------|--------------------------------|-----------|---------------------------|------------------------|---------------------------|--------|-----------------------|-----------|--|--|
| | Sa | &ME, | nc G | reenvil | le: | 48 Br | ookfie | ld Oak | s Dr., | Sui | ite F | Gre | enville, | SC | 2960 |)7 | | | | | |
| Project #: | 213045 | | | | | | | | | | | | | Rej | oort [| 8/30 |)/21 | | | | |
| Project Name: | Bad | Creek | Phase 2 | 2 Feasil | bility | Stud | y Proje | ect | | | | | | Test Date: 8/10 - 8/2 | | | | | 8/25/21 | | |
| Client Name: | HDR | | | | | | | | | | | | | | | | | | | | |
| Client Address: | 1122 | Lady | Street, | Suite 1 | 100 | Colu | mbia, S | South | Carol | ina | 2920 |)1 | | | | | | | | | |
| Boring #: | B-21 | -2 | | | | | | Log # | ±: | | ç | 96g | | | San | nple [| Date: | 4/20 |)/21 | | |
| Sample ID: | SS-2 T | | | | | | | | | Type: Split-spoon | | | | | | | Depth: | | | | |
| Sample Descript | ion: | poorly | ′ grade | d SANI | D wit | h silt | and g | ravel (| SP-SN | 1) - | gray | / whit | e, coai | rse t | o fin | e | | | | | |
| 100% | 3" 2 | 1.5" | 1" 3/4" | 3/ | 8" | #4 | #1 | 0 | #20 | | #40 • | #60 | #100 # | ¢140 | #200 | | | | | | |
| 90% | | | | | | | | | | | | | | | | | | | | | |
| 80% | • | | | | | | | | | + | | + | | | +++ | ++ | | | | | |
| <u>ຈັ</u> ສ 70% | | | | | | | | | | | | | | | | | | | | | |
| ssi | | | | | \mathbb{N} | | | | | + | | | | | +++ | | | | | | |
| 809 Ba | | | | | | N | | | | | | | | | | | | | | | |
| 50% | • | | | | | | | | | + | | | | | +++ | | | | - | | |
| Jel 40% | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | - | | | | | +++ | | | | | | |
| 30% | | | | | | | | | | | | | | | | | | | | | |
| 20% | | | | | | | | | | + | | | | | $\left \right $ | + | | | | | |
| 10% | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | + | | | | | ┣ | ++ | | _ | - | | |
| 0% 100. | .00 | | 1 | 10.00 |) | Milli | meters | 1 | 1.00 | | • | | <u> </u> | 0.10 | <u> </u> | | | | 0.01 | | |
| | | | | | | | | | | | | | | | | | | | | | |
| Cobbles | | < 3 | 00 mm | (12") ar | nd > ' | 75 mn | n (3") | | Fine Sand | | | | | | | < 0.425 mm and > 0.075 mm | | | | | |
| Gravel | | < | 75 mm | n and > | 4.75 | mm (‡ | #4) | _ | Silt | | | | | | < 0.075 and > 0.005 mm | | | | | | |
| Coarse Sand Medium San | a d | < | 4.75 mr | n and > | 0.425 | mm (/ | ≠10) (#40) | - | Colloids | | | | | | < 0.005 mm | | | | | | |
| Method: B | iu | | Procedu | re for o | btain | ina Sr | (#40) Decime | <u>ו</u> ו: | Moist | CO | noius | Dis | persior | n Pro | cess: | < 0 | Dis | persant | | | |
| Maxim | um Par | ticle S | ize 3 | 7.50 mi | m | 5 -1 | | Coa | arse S | anc | t | 14.3 | % | | | Fine S | Sand | 18. | 0% | | |
| Gravel 40.9% Mec | | | | | | | Med | Vedium Sand 18.2% | | | | | | S | ilt & | 8.6% | | | | | |
| | Liq | uid Lir | nit | | | | | Pla | stic L | imit | t | NP | | | Pla | stic lı | NP | | | | |
| | | | | | | | N | atural | Mois | ture | 9 | 4.3% | 6 | | | | | | | | |
| | | | Cc = | = D ₃₀ ² /([| D ₁₀ x | D ₆₀) | 0. | 3 | | Cu | = D ₆ | ₅₀ /D ₁₀ | | | 55.6 | | | | | | |
| $D10 = 0.09 \qquad D30 = 0.60 \qquad D60 = 5.00$ | | | | | | | | | | | | | | | | | | | | | |
| Notes / Deviations | / Refere | ences: | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | | | | T | P A A | D | 77 00 | _ | | | | | | | | | | | | | |
| Frank Morris, P.E. | | | | | KAN | Signatu | ure | Project Mana Position | | | | | | l <u>ger 8/30/</u> Dat | | | | <u>8/30/2</u> Date | <u>.1</u> | | |
| | | This r | eport sha | ll not be | repro | duced, | except ii | n full, wi | thout t | he w | ritten/ | appro | val of S& | èМЕ, | Inc. | | | | | | |
LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | | AST | M D 4318 | \mathbf{X} | AASH | нто т 8 | 9 [| | AASH | то т 90 | | | | |
|------------|------------------|--------------------|-----------------|--------------|-------------|--------------------|---------------|---------------|---------|--------------------|-----------------------------|---------------|-----------------|----------------------|
| | | S&ME, | Inc Gre | enville | 48 Br | ookfie | ld Oak | s Dr., | Suite | F Gre | enville, S | C 29607 | | |
| Project # | <i>‡</i> : | 213045 | | | | | | | | | Report | Date: | 8/30/2 | 21 |
| Project N | Name: | Bad Cree | ek Phase 2 | 2 Feasibil | itv Stu | dv Pro | iect | | | | Test | Date: | 8/19/2 | 21 |
| Client Na | ame: | HDR | | | , | , | 5 | | | | | | | |
| Client Ac | ddress: | 1122 Lac | ly Street, | Suite 11 | 00 Co | lumbia | , South | n Caro | lina 2 | 29201 | - | | | |
| Boring # | : B-2 | 1-2 | | L | og #: | | 96g | | | Sam | ple Date: | | 4/20/21 | |
| Sample I | ID: SS-2 | <u>,</u> | | | Type: | S | plit-sp | oon | | | Depth: | | 5' | |
| Sample I | Descriptio | n: | poorly gr | raded SA | ND wi | ith silt | and gr | avel (S | SP-SN | 1) - grav | / white, c | oarse to fi | ne | |
| Type and | Specificatio | on | S&ME IE |) # | Cal D | ate: | Туре | and S | pecific | ation | S& | xME ID # | Cal I | Date: |
| Balance (| (0.01 g) | | 13942 | 2 | 10/19/ | 2020 | Groo | oving to | ool | | | 23119 | 10/15 | 5/2020 |
| LL Appara | atus | | 23158 | 3 | 2/1/2 | 021 | | | | | | | | |
| Oven | | | 13978 | 3 | 10/7/2 | 2020 | | | | | | | | |
| Pan # | ŧ | | T ana #1 | | 1 | | Liquio | d Limit | | | | | Plastic Limi | t |
| • | Tara Maia | | Tare #: | | | | | | | | | | | |
| A | | jnt Maistat i M | | | | | | | | | | | | |
| B | Wet Soil V | Veight + A | * | | | | | | | | | | | |
| C | Dry Soil V | Veight + A | | | | | | | | | | | | |
| D | Water We | ight (B-C) | | | | | | | | | | | | |
| E | Dry Soil V | /eight (C-/ | 7) | | | | | | | | | | | |
| F | % Moistu | re (D/E)*10 |)0 | | | | | | | | | | | |
| N | # OF DRC | PS | | | | | | | _ | | | Moisture C | ontents det | ermined by |
| LL | LL | = F * FACT | OR | | | | | | | | | A | STM D 221 | 6 |
| Ave. | | Average | | | | | | | | | | | | |
| 4 | 0.0 1 | | | | _ | | 1 1 | | | | | One Point | Liquid Lim | it 🗾 |
| | | | | _ | | | | | | | N 20 | Factor | N | 1 005 |
| | | | | | | | | | | | 20 | 0.979 | 27 | 1.005 |
| ent 3 | 5.0 | | | | | | | | | | 22 | 0.985 | 28 | 1.014 |
| out | | | | | | | | | | | 23 | 0.99 | 29 | 1.018 |
| er 3 | 0.0 | | | | | | | | | | 24 | 0.995 | 30 | 1.022 |
| istu | | | | | | | | | | | 25 | 1.000 | | |
| Mo | | | | | | | | | | | N | IP, Non-Pl | astic L | ×I |
| 8 2 | 5.0 | | | | | | | | | | | Liquid L | imit - | |
| | | | | | - | | | | ++ | - | | Plastic L | limit N | IP |
| 2 | | | | | | | | | | | | Plastic Ir | ndex N | IP |
| 2 | 10 | 15 | 20 | 25 30 | 35 4 | , 10 | <u> </u> | | 1 | 100 | | Group Syn | nbol SP | SM |
| | | | | | | | # OI] | Drops | J | | N | /lultipoint N | /lethod | ~ |
| | | | . Due ne e ne t | | ۸ :- | . Dui a d | | | | | (24 Danaina | Dine-point N | /lethod | |
| Wet Pre | | Deference | y Preparati | ion 🗹 | Air | ^r Dried | ~ | | | | % Passing | the #200 S | leve: | 8.6% |
| Notes / D | eviations / | References | ». | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| ASTM D 4 | 4318: Liquio | 1 Limit, Pla | istic Limit, a | & Plastic | ndex of | f Soils | | | | | | | | |
| D. | oniamin | Kovala | cki | | g /20 | /21 | | D. | tion M | Jaugha | | | 0 / 2 | 0/21 |
| <u>D</u> (| Technicia | an Name | <u>5KI</u> | | 0/50 Dat | <u>/∠1</u> te | | <u>ם</u> ד | echnico | augna al Resnon | <u>11, ┏.⊑.</u> sibilitv | | <u>0/3</u> ת | ur <u>c</u> i ate |
| | | This | report shall | not be repi | roduced, | except i | n full, w | ithout t | he writ | ten appro | val of S&M | E, Inc. | 2. | |



| | | | | | | | | 7211 | | 15 | | | | | | | | | | |
|---|------------------------------------|---|---|---|--------------------------------|---------------------------|--------------------|--------------------------|----------------------------------|--|---|---|---------------------------------------|---|-------------|-------------------------|--|--|--|--------|
| | S | &ME, | Inc. | - Green | ville | e: 4 | 18 Bi | rookfie | eld Oal | ks Dr., | , Su | ite F | Gre | enville, S | C 2 | 960 | 7 | | | |
| Project #: | 213 | 045 | | | | | | | | | | | | | I | Rep | ort D | Date: | 8/30/2 | 21 |
| Project Name: | Bad | Creek | c Pha | se 2 Fea | asibi | ility : | Stuc | ly Proj | ect | | | | | | | T | est D | Date: | 8/10 - 8/2 | 25/21 |
| Client Name: | HDR | | | | | | | | | | | | | | | | | | | |
| Client Address: | 1122 | ' Lady | / Stre | et, Suite | e 11 | 00 | Colu | ımbia, | South | Caro | lina | 2920 |)1 | | | | | | | |
| Boring #: | B-21 | -2 | | | | | | | Log | #: | | ç | 96g | | S | am | ple [| Date: | 4/20/2 | 21 |
| Sample ID: | SS-3 | | | | | | | | Туре | 9: | | Split | -spo | on | | | De | epth: | 8.5' | |
| Sample Descript | tion: | claye | y SAI | ND (SC) | - b | row | n red | d, mec | lium to | o fine | | | | | | | | | | ~ |
| (| 2" 7 | . 15. | 1" 2 | / / " | 2 /0' | | #A | # | 10 | #20 | | #40 | #60 | #100 #14 | n # | 200 | | | | |
| 100% | | 1.3 — | | • <u> </u> | | | | | 1 | | | • | | + + + + | | | 1 1 | | | |
| 90% | | | | | | | | | \geq | | | | | | | | | | | |
| 50,0 | | | | <u> </u> | +++ | | | | | | | | | | | | | _ | | |
| ३ 0% | | | | | | | | | | | | | | | | | | | | |
| <u>ຄ</u>) 70% | ┢┼┼┼┷ | | + | <u> </u> | +++ | | | | | | | | | | | | | | | |
| ssin | | | + | | +++ | | | | | | | | | | | | | | | |
| %06 Ba | | | | | | | | | | | | | | | | | | | | |
| 50% | ┢┼┼┼ | | + | <u> </u> | +++ | | | | | | \square | | | | € | | | _ | | |
| Per 10% | | | | | | | | | | | | | | | | | | | | |
| | | | | <u> </u> | +++ | | | | | | \square | | _ | | | | | _ | | |
| 30% | ╞┼┼┼ | | + | | +++ | | | | | | \square | | | | | | | - | _ | |
| 20% | | | | | | | | | | | | | | | | | | | | |
| | | | + | | +++ | | \vdash | | | | ++ | | | | ++ | \square | ++ | | | |
| 10% | | | | | | | | | | | | | | | | | | | | |
| 0% | L ↓↓ | | | | <u> </u> | | | | <u> </u> | | | | | | | | | | | 1 |
| 100 |).00 | | | 10 |).00 | l | Mill | imeters | 5 | 1.00 | | | | 0.1 | 10 | | | | 0. | 01 |
| Cobbles | | < | 300 n | nm (12") | and | d > 7 | 5 mr | m (3") | | | Fine | e Sano | d | | < 0 | .425 | mm | and : | > 0.075 m | m |
| | | | | | > 4 | .75 r | nm (| (#4) | | | | Silt | | | | 0.0 | 75 21 | d > 0 | | |
| Gravel | | | < 75 | mm and | | | | (" ") | | | | Jiit | | | < | 0.0 | 15 ai | iu - (| 0.005 mm | |
| Gravel Coarse San | d | < | < 75 4.75 | mm and mm and | 1 > 2 | .00 r | nm (| (#10) | | | (| Clay | | | | 0.0 | < 0 | .005 r | 0.005 mm mm | |
| Gravel Coarse San Medium San | id nd | < | < 75 : 4.75 2.00 r | mm and mm and nm and | 2 < 1 > 0 | .00 r .425 | nm (mm | (#10) (#40) | | | Co | Clay Iloids | | | | 0.0 | < 0 < 0 | .005 r .001 r | 0.005 mm nm nm | |
| Gravel Coarse San Medium San Method: B | id nd | < | < 75 4.75 2.00 r Proce | mm and mm and nm and edure for | d >2 > 0. r ob | .00 r .425 taini | nm (mm ng S | (#10) (#40) pecime | en: | Moist | Co t | Clay Iloids | Dis | persion P | roce | ess: | < 0 < 0 | .005 r .001 r Dis | nm nm persant | |
| Gravel Coarse San Medium Sar Method: B Maxin | nd num Par | < | < 75 4.75 2.00 r Proce Size | mm and mm and nm and edure for 4.75 r | d >2 > 0 r ob nm | .00 r .425 taini | nm (mm ng S | (#10) (#40) pecime | en: Co | Moist arse S | Co t Sanc | Clay Iloids | Dis 2.49 | persion P | roce | ess: F | < 0 < 0 < 0 < 0 < 0 < 0 | .005 r .001 r Dis Sand | nm nm persant 35.99 | % |
| Gravel Coarse San Medium Sai Method: B Maxin | nd num Par | <pre></pre> | < 75 4.75 2.00 r Proce Size avel | mm and mm and nm and edure for 4.75 r 1.09 | d >2 > 0 r ob mm % | .00 r .425 taini | nm (mm ng S | (#10) (#40) pecime | en: Co Mec | Moist arse S lium S | Co Co t Sano Sano | clay lloids d | Dis 2.49 14.2 | persion P % | roce | ess: F Si | < 0 < 0 < 0 | 005 r 001 r Dis Sand Clay | 0.005 mm mm persant 35.99 46.59 | % |
| Gravel Coarse San Medium Sar Method: B Maxin | nd num Par Liq | <pre>< columnation </pre> | < 75 : 4.75 2.00 r Proce Size avel imit | mm and mm and edure fo 4.75 r 1.09 | d >2 > 0 r ob mm % | .00 r .425 taini | nm (mm ng S | (#10) (#40) pecime | en: Co Mec Pl | Moist arse S lium S astic I | Co t Sano Sano Limi | Clay Iloids d d t | Dis 2.49 14.2 22 | persion P % % | roce | ess: F Si Plas | < 0 < 0 | 005 r 001 r Dis Sand Clay | 0.005 mm nm persant 35.99 46.59 11 | % |
| Gravel Coarse San Medium Sar Method: B Maxin | nd num Par Liq | <pre>< columnation </pre> | < 75 <u>4.75</u> <u>2.00 r</u> Proce Size avel imit | mm and mm and edure fo 4.75 r 1.09 | d >2 > 0 r ob mm % | .00 r .425 taini | nm (mm ng S | (#40) (#40) pecime | en: Co Mec Pl | Moist arse S lium S astic I | Co Co t Sano Sano Limi | clay lloids d d t | Dis 2.49 14.2 22 | persion P % % | roce | ess: F Si Plas | < 0 < 0 < 0 < 0 | 005 r 001 r Dis Sand Clay ndex | <u>0.005 mm</u> nm persant 35.99 46.59 11 | % |
| Gravel Coarse San Medium Sai Method: B Maxin | ıd nd num Par Liq | < ticle S Gra uid L | < 75 4.75 2.00 r Proce Size avel imit | mm and mm and edure fo 4.75 r 1.09 33 | d >2 > 0 r ob mm % | .00 r .425 taini | nm (mm ng S | (#10) (#40) pecime | en: Co Mec Pl Natura | Moist arse S lium S astic I I Mois | Co t Sano Sano Limi | clay Illoids d d t | Dis 2.49 14.2 22 19.2 | persion P % % | roce | ess: F Si Plas | < 0 < 0 ine S It & itic Ir | 005 r 001 r Dis Sand Clay ndex | 0.005 mm nm persant 35.99 46.59 11 | % |
| Gravel Coarse San Medium Sar Method: B Maxim | nd num Par Liq | < ticle S Gra uid L | < 75 4.75 2.00 r Proce Size avel imit | mm and mm and edure fo 4.75 r 1.09 33 | d >2 > 0 r ob mm % | .00 r .425 taini | nm (mm ng S | (#10) (#40) pecime | en: Co Mec Pl Natura | Moist arse S lium S astic I l Mois | Co t Sano Sano Limi | clay Iloids d d t | Dis 2.49 14.2 22 19.2 | persion P % % | roce | ess: F Si Plas | < 0 < 0 < 0 < 0 | 005 r 001 r Dis Sand Clay ndex | 0.005 mm nm persant 35.99 46.59 11 | % |
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| Gravel Coarse San Medium Sar Method: B Maxim | nd num Par Liq s / Refere | < | < 75 2.00 r Proce Size avel imit | mm and mm and edure fo 4.75 r 1.09 33 | // > 0 r ob mm % | .00 r .425 taini | nm (mm ng S | (#10) (#40) pecime | en: Co Mec Pl Natura | Moist arse S lium S astic I | (<u>Co</u> t Sano Sano Limi | Clay Illoids d d t t | Dis 2.49 14.2 22 19.2 | persion P % % | roce | ess: F Si Plas | < 0 < 0 ine S It & tic Ir | 005 r 001 r Dis Sand Clay ndex | 0.005 mm nm persant 35.99 46.59 11 | % % |
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| Gravel Coarse San Medium Sar Method: B Maxim | nd num Par Liq | < ticle s Gra uid L | < 75 4.75 2.00 r Proce Size avel imit | mm and mm and edure fo 4.75 r 1.09 33 | 2 > 0 r ob mm % | .00 r 1 | nm (mm ng S | (#10) (#40) pecime | en: Co Mec Pl Natura | Moist arse S lium S astic I | Co t Sano Sano Limi | Clay Iloids d d t t | Dis 2.49 14.2 22 19.2 | persion P % % | roce | ess: F Si Plas | <pre>< 0 </pre> <pre>< 0 </pre> <pre></pre> <pre>ine S </pre> <pre>It & </pre> <pre>// tic Ir </pre> | 005 r 1000 r 10000 r 1000 r 10 | 0.005 mm nm persant 35.99 46.59 11 | % % |
| Gravel Coarse San Medium Sar Method: B Maxin Notes / Deviation | nd nd num Par Liq | <pre></pre> | < 75 2.00 r Proce Size avel imit | mm and mm and edure fo 4.75 r 1.09 33 | 3 ≥2 > 0 mm % | .00 r r | nm (mm ng S | (#10) (#40) pecime | en: Co Mec Pl Natura | Moist arse S lium S astic I | (Co t Sano Limi sture | Clay Iloids d d t t e Pri | Dis 2.49 14.2 22 19.2 | persion P % % % | roce | ess: F Si Plas | <pre>< 0 </pre> ine \$ <pre></pre> <pre>// Control in the second secon</pre> | 005 r 001 r Dis Sand Clay ndex | 0.005 mm nm persant 35.99 46.59 11 | % |
| Gravel Coarse San Medium San Method: B Maxim Notes / Deviation | nd nd num Par Liq s / Refere | <pre></pre> | < 75 2.00 r Proce Size avel imit | mm and mm and edure fo 4.75 r 1.09 33 | d >2 > 0 mm % | .00 r r .425 tainii | nm (mm ng S | (#10) (#40) pecime | en: Co Mec Pl Natura | Moist arse S lium S astic I | (Co t Sano Sano Limi sture | Clay Iloids d d t e <u>Pr</u> | Dis 2.49 14.2 22 19.2 | persion P % % % <u>Manage</u> sition | <u>roce</u> | ess: F Si Plas | <pre>< 0 </pre> <pre>< 0 </pre> <pre>< 0 </pre> <pre></pre> <pre< td=""><td>005 r 001 r Dis Gand Clay ndex</td><td>0.005 mm nm persant 35.99 46.59 11 11 8/30/21 Date</td><td>%</td></pre<> | 005 r 001 r Dis Gand Clay ndex | 0.005 mm nm persant 35.99 46.59 11 11 8/30/21 Date | % |

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | | ASTM D 4318 | \mathbf{X} | AASHTO | <i>T 89</i> 🛛 | | SHTO T 90 | | | | |
|--------------------|---|------------------|--------------|--|----------------|-------------------------|---------------|--|---|---|---|
| | | S&ME, Inc Gre | enville | 48 Brook | field Oak | s Dr., Suit | te F Gre | enville, SC | 29607 | | |
| Project | #: 21 | 13045 | | | | | | Report [| Date: | 8/30/2 | 21 |
| Project | Name: Ba | ad Creek Phase 2 | 2 Feasibili | ty Study F | Project | | | Test [| Date: | 8/19/2 | 21 |
| Client N | lame: H | DR | | | - | | | | | | |
| Client A | ddress: 11 | 122 Lady Street, | Suite 110 | 0 Columi | bia, South | n Carolina | a 29201 | - | | | |
| Boring # | #: B-21-2 | | Lo | og #: | 96g | | Sam | ple Date: | | 4/20/21 | |
| Sample | ID: SS-3 | | Т | ype: | Split-sp | oon | | Depth: | | 8.5' | |
| Sample | Description: | clayey SA | AND (SC) | - brown r | ed, medi | um to fin | е | | | | |
| Type and | d Specification | S&ME IL |) # | Cal Date: | Туре | and Speci | ification | S& | ME ID # | Cal I | Date: |
| Balance | (0.01 g) | 13942 | 2 | 10/19/2020 | 0 Groc | oving tool | | | 23119 | 10/15 | 5/2020 |
| LL Appar | ratus | 23158 | 8 | 2/1/2021 | | | | | | | |
| Oven | 4 | 13978 | 8 | 10/7/2020 |) | l l laste | | | | Dia ati a Linai | |
| Pan | # | Tare #· | 1 | 2 | Liquic | | 1 | | 1 | Flastic Limi | t |
| | Taro Woight | | 26.68 | 26.50 | 26.24 | | | | 4 25.01 | 26.96 | |
| | Wet Soil Wei | iaht I A | 47.02 | 20.30 40.11 | 20.34 AE 14 | | | | 23.51 | 24.16 | |
| | | abt I A | 47.02 | 40.11 | 40.14 | | | | 22.50 | 22.05 | |
| | Mater Moigh | giit + A | 42.21 | 42.00 E 2E | 40.30 | | | | 1 50 | 1 21 | |
| | | nt (D-C) | 4.01 | 5.25 | 4.70 | | | | 1.50 | 1.51 | |
| | | gnt (C-A) | 15.53 | 10.30 | 14.04 | | | | 0.07 | 5.89 | |
| | % Moisture (| (D/E)^100 | 31.0% | 32.1% | 33.9% | | | | 22.5% | 22.2% | |
| N | # OF DROPS | | 34 | 27 | 20 | | | | Moisture C | ontents det | ermined by |
| LL | | * FACTOR | | | | | | | A | SIM DZZI | 0 |
| | | | | | <u> </u> | | | | | | |
| Ave. | A | verage | | | | | | | | 22.4% | •• |
| Ave. | 43.0 T | verage | | 1 1 | | · · · · | - | | One Point | 22.4% Liquid Lim | it Eactor |
| Ave. | 43.0 A | verage | | | | | | N | One Point I Factor | 22.4% Liquid Lim N 26 | it Factor |
| Ave. | 43.0 | verage | | | | | | N 20 21 | One Point 1 Factor 0.974 0.979 | 22.4% Liquid Lim N 26 27 | it Factor 1.005 1.009 |
| Ave. | 43.0 38.0 | | | | | | | N 20 21 22 | One Point Factor 0.974 0.979 0.985 | 22.4% Liquid Lim 26 27 28 | it Factor 1.005 1.009 1.014 |
| Ave. | 43.0 | | | | | | | N 20 21 22 23 | One Point Factor 0.974 0.979 0.985 0.99 | 22.4% Liquid Lim N 26 27 28 29 | it Factor 1.005 1.009 1.014 1.018 |
| Ave. | 43.0 38.0 33.0 | | | | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 | 22.4% Liquid Lim 26 27 28 29 30 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| aisture Content | 43.0 38.0 33.0 | | | | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 | 22.4% Liquid Lim 26 27 28 29 30 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| Moisture Content | A 43.0 38.0 33.0 | | | | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl | 22.4% Liquid Lim N 26 27 28 29 30 lastic I imit 2 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| % Moisture Content | 43.0 38.0 33.0 28.0 | | | | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid L Plastic I | 22.4% Liquid Lim 26 27 28 29 30 lastic I .imit 3 imit 2 | it Factor 1.005 1.009 1.014 1.018 1.022 3 |
| % Moisture Content | 43.0 38.0 33.0 28.0 | | | | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-PI Liquid L Plastic L | 22.4% Liquid Lim 26 27 28 29 30 lastic I Limit 3 Limit 2 29 | it Factor 1.005 1.009 1.014 1.018 1.022 33 22 1 |
| % Moisture Content | 43.0 38.0 33.0 28.0 | | | | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-PI Liquid L Plastic I Plastic Ir | 22.4% Liquid Lim 26 27 28 29 30 lastic I .imit 3 .imit 2 ndex 1 | it Factor 1.005 1.009 1.014 1.018 1.022 3 3 2 2 1 6 6 |
| % Moisture Content | 43.0 38.0 33.0 28.0 10 | verage | 25 30 | 35 40 | | | 100 | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-PI Liquid L Plastic L Plastic Ir Group Syn | 22.4% Liquid Lim 26 27 28 29 30 lastic I Limit 3 Limit 2 ndex 1 nbol S | it Factor 1.005 1.009 1.014 1.018 1.022 33 22 1 52 24 |
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| Ave. | 43.0 38.0 38.0 33.0 28.0 23.0 10 | verage | 25 30 | 35 40 | # of I | Drops | | N 20 21 22 23 24 25 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid L Plastic L Plastic Ir Group Syn fultipoint N One-point N the #200 S | 22.4% Liquid Lim 26 27 28 29 30 lastic I .imit 3 .imit 2 ndex 1 nbol S Method ieve: | it Factor 1.005 1.009 1.014 1.018 1.022 33 22 1 33 22 1 34 5C ↓ 46.5% |
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| Ave. | 43.0 38.0 33.0 28.0 23.0 10 reparation Deviations / Re 4318: Liquid Li | verage | 25 30 | 35 40 Air Drie | # of I | Drops | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-PI Liquid L Plastic Ir Group Syn fultipoint N one-point N the #200 S | 22.4% Liquid Lim 26 27 28 29 30 Limit 3 Limit 3 Limit 2 Index 1 Inbol S Method Lieve: | it Factor 1.005 1.009 1.014 1.018 1.022 33 22 1 33 22 46.5% |
| Ave. | 43.0 43.0 38.0 33.0 28.0 23.0 10 reparation Deviations / Re 4318: Liquid Li Benjamin J. k Technician I | verage | 25 30 | 35 40 Air Drie adex of Soil 8/30/21 Date | # of I | Drops Brian Techn | 100 Vaugha | N 20 21 22 23 24 25 N C W C W C W C M Sibility | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-PI Liquid L Plastic Ir Group Syn fultipoint N One-point N the #200 S | 22.4% Liquid Lim 26 27 28 29 30 Lastic I Limit 3 Limit 3 Limit 1 Limit 1 Limit 1 Limit 1 Limit 2 Method Lieve: | it Factor 1.005 1.009 1.014 1.018 1.022 33 22 1 3 3 22 46.5% 0/21 ate |



| Single sieve set | | | | | | ASTM | 1 D 69 | 13 | | | | | | | | | | |
|----------------------|----------------------|-----------|-----------------------------|-------------|---------|---------------|---------|--------|----------|--------------|--------------|---------|--------|-----------|---------|--------|----------------|----------|
| | S&N | AE, Inc. | - Greenvil | le: | 48 Br | ookfie | ld Oak | s Dr., | Suit | e F | Gree | nville, | SC 2 | 2960 | 7 | | | |
| Project #: | 21304 | 5 | | | | | | | | | | | | Rep | ort D | Date: | 8/30/ | /21 |
| Project Name: | Bad Cre | eek Pha | se 2 Feasi | bility | Stud | y Proje | ect | | | | | | | Т | est D | Date: | 8/10 - 8/ | /25/21 |
| Client Name: | HDR | | | | | | | | | | | | | | | | | |
| Client Address: | 1122 La | ady Stre | et, Suite 1 | 100 | Colu | mbia, S | South | Carol | ina 2 | 2920 | 1 | | | | | | | |
| Boring #: | B-21-2 | | | | | | Log # | : | | 9 | 6g | | | Sam | ple D | Date: | 4/20/ | /21 |
| Sample ID: | SS-4 | | | | | | Туре | | S | Split- | spoo | n | | | De | epth: | 13.5 | 5' |
| Sample Description | on: sil [.] | ty SANE | D (SM) - ta | an br | own, | mediu | m to fi | ne | | | | | | | | | | |
| | | | | | | | | | | | #60 | | | #200 | | | | |
| 100% | 3" 2" 1 | .5" 1" 3, | /4" 3/ • | 8" | #4 | #1 | 0 | #20 | , | #40 • | #60 | #100 # | + + | #200 • | 1 1 | | | - L |
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| 80% | | | | | | | | | | | + | | | | ++ | | - | |
| 3 70% | | | | | | | | | | \mathbf{N} | | | | | | | | |
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| Calablas | 1 | . 200 | ···· (12)) ··· | | 75 | - (211) | | | Circ e J | C | | | | 0 4 2 1 | · | | . 0.075 | |
| Copples | | < 300 n | $nm(12^{\circ})$ and \sum | 1a > 175 | 75 mn | n (3°) #4) | _ | | Fine | Sanc | 1 | | < | 0.425 | 0 mm | and N | > 0.075 r | nm |
| Coarse Sand | | < 4.75 | mm and > | ·2.00 | mm (i | #10) | | | Cla | av | | | | < 0.c | < 0. | .005 r | nm | |
| Medium Sand | 1 | < 2.00 ı | mm and > | 0.425 | 5 mm | (#40) | | | Coll | oids | | | | | < 0. | .001 r | nm | |
| Method: B | | Proce | edure for c | btain | ning Sp | pecime | n: | Moist | | | Dis | persion | Prod | cess: | | Dis | persant | |
| Maximu | ım Partic | le Size | 4.75 mr | n | | | Coa | arse S | and | | 1.6% |) | | F | ine S | Sand | 42.7 | '% |
| | | Gravel | 0.2% | | | | Med | ium S | and | | 22.39 | 6 | | S | lt & | Clay | 33.3 | % |
| | Liquio | d Limit | 30 | | | | Pla | stic L | .imit | | 25 | | | Plas | stic Ir | ndex | 5 | |
| | | | | | | | | | | | | | | | | | | |
| | | | | | | N | latural | Mois | ture | | 16.79 | 6 | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| Notes / Deviations / | / Referenc | es: | | | | | | | | | | | | | | | | |
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| | | | F | RAN | CP.M | PLAS | 2 | | | | | | | | | | | |
| Frank M | <u>1orris, P.I</u> | <u>E.</u> | - | | | | | | | Pro | <u>oject</u> | Manag | er | | | | <u>8/30/21</u> | <u>1</u> |
| Technical H | Rocnoncihil | itv | | | Sianati | ıre | | | | | Pos | ition | | | | | Date | |
| | responsibili | ily i | | | 5 | | | | | | | | | | | | | |

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | | ASTM D 4318 | \mathbf{X} | AASHTO | <i>T 8</i> 9 E | | SHTO T 90 | | | | |
|--------------------|--|--|----------------|-------------------|----------------|--------------------------|---------------------------------|--|---|--|--|
| | | S&ME, Inc Gre | enville | 48 Brook | field Oak | s Dr., Suit | te F Gre | enville, SC | 29607 | | |
| Project | #: 2 | 213045 | | | | | | Report [| Date: | 8/30/2 | 21 |
| Project | Name: E | Bad Creek Phase 2 | 2 Feasibili | ty Study F | Project | | | Test [| Date: | 8/19/2 | 21 |
| Client N | lame: F | IDR | | | - | | | | | | |
| Client A | ddress: 1 | 122 Lady Street, | Suite 110 | 0 Colum | oia, South | Carolina | a 29201 | - | | | |
| Boring # | #: B-21- | 2 | Lo | og #: | 96g | | Sam | ple Date: | | 4/20/21 | |
| Sample | ID: SS-4 | | Т | ype: | Split-spo | oon | | Depth: | | 13.5' | |
| Sample | Description | : silty SAN | ID (SM) - | tan browr | n, mediun | n to fine | | - | | | |
| Type and | d Specification | n S&ME IL | D # | Cal Date: | Туре | and Speci | ification | S& | ME ID # | Cal | Date: |
| Balance | (0.01 g) | 1394 | 2 . | 10/19/2020 |) Groo | ving tool | | | 23119 | 10/15 | 5/2020 |
| LL Appar | ratus | 2315 | 8 | 2/1/2021 | | | | | | | |
| Oven | .4 | 1397 | 8 | 10/7/2020 | Linute | L L Long LA | | | | Dia ati a Lina | |
| Pan | # | Taro #: | 6 | 7 | Liquid | i Limit | 1 | | 9 | Plastic Limi | t |
| | Taro Woigh | taie π. | 27.75 | 76.28 | 27 22 | | | | 26.82 | 26.75 | |
| | | aight i A | 44.05 | 42.20 | 45.00 | | | | 20.02 | 20.75 | |
| | | eight + A | 44.03 | 45.50 | 43.90 | | | | 22.00 | 21 57 | |
| | Dry Soll We | eight + A | 40.45 | 2 07 | 41.52 | | | | 35.00 | 51.57 | |
| | | Jnt (B-C) | 3.02 | 3.97 | 4.58 | | | | 1.55 | 1.21 | |
| | | | 12.68 | 13.11 | 14.00 | | | | 6.18 | 4.82 | |
| F | % Moisture | e (D/E)*100 | 28.5% | 30.3% | 32.7% | | | | 25.1% | 25.1% | |
| N | # OF DROP | 5 | 35 | 25 | 15 | | | | Moisture C | ontents det | ermined by |
| LL | 1 LL = | F * FACTOR | | | | | | | A | SIMDZZI | 6 |
| | - | | | | | | | | | | |
| Ave. | , | Average | | | | | | | | 25.1% | |
| Ave. | 40.0 T | Average | | | | | | | One Point I | 25.1% Liquid Lim | it Eastor |
| Ave. | 40.0 | Average | | | | | | N | One Point I Factor | 25.1% Liquid Lim N 26 | it Factor |
| Ave. | 40.0 | Average | | | | | | N 20 21 | One Point I Factor 0.974 0.979 | 25.1% Liquid Lim N 26 27 | it Factor 1.005 1.009 |
| Ave. | 40.0 | Average | | | | | | N 20 21 22 | One Point I Factor 0.974 0.979 0.985 | 25.1% Liquid Lim 26 27 28 | it Factor 1.005 1.009 1.014 |
| .svA | 40.0 | Average | | | | | | N 20 21 22 23 | One Point Factor 0.974 0.979 0.985 0.99 | 25.1% Liquid Lim N 26 27 28 29 | it Factor 1.005 1.009 1.014 1.018 |
| Ave. | | Average | | | | | | N 20 21 22 23 24 24 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 | 25.1% Liquid Lim 26 27 28 29 30 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| oisture Content | | Average | | | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.985 0.99 0.995 1.000 | 25.1% Liquid Lim 26 27 28 29 30 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| Moisture Content | 40.0 | Average | | | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl | 25.1% Liquid Lim N 26 27 28 29 30 astic | it Factor 1.005 1.009 1.014 1.018 1.022 ■ |
| % Moisture Content | | Average | | | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl Liquid L Plastic I | 25.1% Liquid Lim 26 27 28 29 30 astic I imit 3 | it Factor 1.005 1.009 1.014 1.018 1.022 30 5 |
| % Moisture Content | | Average | | | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl Liquid L Plastic L Plastic I | 25.1% Liquid Lim 26 27 28 29 30 astic I .imit 3 .imit 2 odex | it Factor 1.005 1.009 1.014 1.018 1.022 30 25 5 |
| % Moisture Content | | Average | | | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl Liquid L Plastic L Plastic Ir | 25.1% Liquid Lim 26 27 28 29 30 astic Limit 3 .imit 2 ndex | it Factor 1.005 1.009 1.014 1.018 1.022 30 25 5 M |
| % Moisture Content | | Average | 25 30 | 35 40 | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl Liquid L Plastic L Plastic Ir Group Syn fultipoint N | 25.1% Liquid Lim 26 27 28 29 30 lastic I Limit 3 Limit 3 Limit 3 Limit 3 Limit 3 Limit 3 Limit 3 Limit 3 | it Factor 1.005 1.009 1.014 1.018 1.022 30 25 5 M |
| % Moisture Content | | Average | 25 30 | 35 40 | | Drops | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl Liquid L Plastic L Plastic Ir Group Syn fultipoint N | 25.1% Liquid Lim Carrier Constraint Constra | it Factor 1.005 1.009 1.014 1.018 1.022 0 0 0 25 5 M ✓ |
| Ave. | 40.0 35.0 30.0 25.0 20.0 10 reparation | Average | 25 30 | 35 40 | # of I | | | N 20 21 22 23 24 25 1 0 0 0 0 0 0 0 0 0 0 0 0 0 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl Liquid L Plastic L Plastic Ir Group Syn Aultipoint N One-point N the #200 S | 25.1% Liquid Lim 26 27 28 29 30 lastic I imit 3 imit 2 index nbol S Method ieve: | it Factor 1.005 1.009 1.014 1.018 1.022 30 25 5 M ↓ 33.3% |
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| Ave. | 40.0 35.0 30.0 25.0 20.0 10 reparation [Deviations / R | Average | 25 30 | 35 40 | # of I | Drops | | N 20 21 22 23 24 25 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl Liquid L Plastic L Plastic Ir Group Syn fultipoint N Dne-point N the #200 St | 25.1% Liquid Lim 26 27 28 29 30 lastic Limit adex nbol S Method Nethod | it Factor 1.005 1.009 1.014 1.018 1.022 30 25 5 M ✓ 33.3% |
| Ave. | 40.0 35.0 30.0 25.0 20.0 10 reparation [Deviations / R | Average | 25 30 | 35 40 | | | | N 20 21 22 23 24 25 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl Liquid L Plastic Ir Group Syn fultipoint N One-point N the #200 St | 25.1% Liquid Lim 26 27 28 29 30 lastic I imit 3 imit 3 imit 2 Method Method ieve: | it Factor 1.005 1.009 1.014 1.018 1.022 0 0 0 25 5 M □ 33.3% |
| Ave. | 40.0 35.0 30.0 25.0 20.0 10 reparation [Deviations / R 4318: Liquid I | Average Average I I I I I I I I I I I I I I I I I I I | 25 30 ion 🖌 | 35 40 Air Drie | # of I | Drops | | N 20 21 22 23 24 25 (0 (0 % Passing 1) | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl Liquid L Plastic L Plastic Ir Group Syn fultipoint N One-point N the #200 St | 25.1% Liquid Lim 26 27 28 29 30 astic Limit adex nbol S Method ieve: | it Factor 1.005 1.009 1.014 1.018 1.022 30 25 5 M ✓ 33.3% |
| Ave. | 40.0 35.0 30.0 25.0 20.0 10 Teparation [Deviations / R 4318: Liquid I Benjamin 1 | Average Average Is a construction of the second sec | 25 30 ion 2 | 35 40 Air Drie | # of I | Drops | | N 20 21 22 23 24 25 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl Liquid L Plastic L Plastic Ir Group Syn fultipoint N One-point N the #200 S | 25.1% Liquid Lim 26 27 28 29 30 lastic limit 3 imit 4 cimit 5 Method ieve: 8/3 | it Factor 1.005 1.009 1.014 1.018 1.022 30 25 5 M ✓ 33.3% |
| Ave. | 40.0 35.0 30.0 25.0 20.0 10 Technician Technician | Average Average Is a construction of the second sec | 25 30 | 35 40 Air Drie | | Drops Brian Techr. | 100 Vaugha nical Response | N 20 21 22 23 24 25 ((% Passing 1 (% Passing 1 (% Passing 1 (% Passing 1 (% Passing 1) (% Passing 1 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-Pl Liquid L Plastic L Plastic Ir Group Syn fultipoint N One-point N the #200 Sc | 25.1% Liquid Lim 26 27 28 29 30 astic I astic | it Factor 1.005 1.009 1.014 1.018 1.022 30 25 5 M ✓ 33.3% 0/21 ate |



| Single sieve set | | | | | ASTM | D 6913 | | | | |
|--|--|---|---|---|--|--|---|--|--|--|
| | S&ME, | Inc Gree | nville: | 48 B | rookfield | Oaks Dr., S | Suite F | Greenville | e, SC 29607 | |
| Project #: | 213045 | | | | | | | | Report Date: | 8/30/21 |
| Project Name: | Bad Creek | Phase 2 Fe | easibili | ity Stud | dy Projec | t | | | Test Date: | 8/10 - 8/25/21 |
| Client Name: | HDR | | | | | | | | | |
| Client Address: | 1122 Lady | Street, Sui | te 110 | 0 Colu | umbia, S | outh Carolir | na 2920 |)1 | | |
| Boring #: | B-21-2 | | | | | _og #: | ç | 96g | Sample Date: | 4/20/21 |
| Sample ID: | SS-5 | | | | | Туре: | Split | -spoon | Depth: | 18.5' |
| Sample Description | on: silty S | AND (SM) | - tan l | brown, | medium | to fine | | | | |
| (| ² " 2 " 4 5 " | 411 2 / 411 | 2 (0) | #4 | #10 | #20 | #40 | #60 #100 | #140 #200 | |
| 100% | 3 2 1.3 | • | 3/0 | | | #20 | #40 | + + + | • 1+0 #200 | |
| 90% | | | | | | | | | | |
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| ত 80% | | | | | | | | | | |
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| - 50% | | | | | | | | $+ \mathbf{N}$ | | |
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| 30% | | | | | | | | | | |
| 20% | | | | | | | | | | |
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| - | | | | | | | | | | |
| 0% | | | | | | 1.00 | | | 0.10 | |
| 0% 100.0 | 00 | 1 | 10.00 | Mil | limeters | 1.00 | • | | 0.10 | 0.01 |
| 0% 100.0 Cobbles |)0 | 300 mm (12' | 10.00 ") and | Mil > 75 m | limeters m (3") | 1.00 | ine San | d | 0.10 < 0.425 mm and | 0.01 |
| 0% 100.0 Cobbles Gravel | 00 | 300 mm (12' < 75 mm an | 10.00 ") and a d > 4.7 | Mil > 75 m 75 mm | limeters m (3") (#4) | 1.00 | ine San Silt | d | 0.10 < 0.425 mm and < 0.075 and > | 0.01 > 0.075 mm 0.005 mm |
| 0% 100.0 Cobbles Gravel Coarse Sand |)0 0 | 300 mm (12' < 75 mm an 4.75 mm ar | 10.00 ") and d > 4.7 nd > 2.0 | Mil > 75 m 75 mm 00 mm | limeters m (3") (#4) (#10) | 1.00 | ine Sand Silt Clay | d | 0.10 < 0.425 mm and < 0.075 and > < 0.005 | 0.01 > 0.075 mm 0.005 mm mm |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand | 00 C C C C C C C C C C C C C C C C C C C | 300 mm (12 < 75 mm an 4.75 mm an 2.00 mm and | 10.00 ") and d > 4.7 nd > 2.0 d > 0.4 | Miii > 75 m 75 mm 00 mm 25 mm | limeters m (3") (#4) (#10) (#40) | 1.00 | ine San Silt Clay Colloids | d Disconsi | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 | 0.01 > 0.075 mm 0.005 mm mm mm |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand Method: B | 00 < 3 < 4 < 4 < 4 < 4 < 4 < 4 < 4 < 4 | 300 mm (12' < 75 mm an 4.75 mm ar 2.00 mm and Procedure fo | (0.00) (a) $d > 4.7$ (b) $d > 2.0$ (c) $d > 0.4$ (c) $d > 0.4$ (c) $d > 0.4$ | Mil > 75 m 75 mm 00 mm 125 mm aining S | limeters m (3") (#4) (#10) (#40) specimen: | 1.00 F | ine San Silt Clay Colloids | d Dispersic | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Eino Sand | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.0% |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu | d < 3 | 300 mm (12 < 75 mm an 4.75 mm an 2.00 mm and Procedure fi Size 4.75 | ") and : d > 4.7 nd > 2.0 d > 0.4 or obta mm 2% | Mil > 75 mm 75 mm 20 mm 25 mm aining S | timeters m (3") (#4) (#10) (#40) speciment | 1.00 F Moist Coarse Sa | ine San Silt Clay Colloids | d Dispersic 1.4% | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Fine Sand Silt & Claw | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.9% 23.0% |
| Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu | um Particle S Gra | 300 mm (12) < 75 mm an 4.75 mm ar 2.00 mm and Procedure fo size 4.75 ivel 0.2 mit | ") and d > 4.7 nd > 2.0 d > 0.4 or obta mm 2% | Mil > 75 m 75 mm 00 mm 225 mm aining S | limeters m (3") (#4) (#10) (#40) specimen: | 1.00 F Moist Coarse Sa Medium Sa Plactic Lii | ine San Silt Clay Colloids and and mit | d Dispersic 1.4% 20.5% | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Fine Sand Silt & Clay Plastic Index | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.9% 23.0% NP |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu | 00 C C C C C C C C C C C C C | 300 mm (12' < 75 mm an 4.75 mm ar 2.00 mm and Procedure fr Size 4.75 sivel 0.2 mit | 10.00 ") and d > 4.7 nd > 2.0 d > 0.4 or obta mm 2% | Mill > 75 m 75 mm 00 mm 25 mm aining S | limeters m (3") (#4) (#10) (#40) cpecimen: | 1.00 F Moist Coarse Sa Medium Sa Plastic Lin | ine San Silt Clay Colloids and mit | d Dispersic 1.4% 20.5% NP | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Fine Sand Silt & Clay Plastic Index | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.9% 23.0% NP |
| Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu | um Particle S Gra Liquid Li | 300 mm (12 < 75 mm an 4.75 mm ar 2.00 mm and Procedure fe size 4.75 avel 0.2 mit | ") and d > 4.7 nd > 2.0 d > 0.4 or obta mm 2% | Mil > 75 m 75 mm 20 mm 225 mm aining S | limeters m (3") (#4) (#10) (#40) pecimen: | 1.00 F Moist Coarse Sa Medium Sa Plastic Lin tural Moist | ine San Silt Clay Colloids and mit ure | d Dispersic 1.4% 20.5% NP 15.1% | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Fine Sand Silt & Clay Plastic Index | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.9% 23.0% NP |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu | 00 C C C C C C C C C C C C C | 300 mm (12 < 75 mm an 4.75 mm ar 2.00 mm and Procedure fo Size 4.75 ivel 0.2 mit | ") and d > 4.7 nd > 2.0 d > 0.4 or obta mm 2% | Mill > 75 m 75 mm 00 mm 125 mm aining S | limeters m (3") (#4) (#10) (#40) cpecimen: | 1.00 F Moist Coarse Sa Medium Sa Plastic Lin tural Moistu | ine San Silt Clay Colloids and mit ure | d Dispersio 1.4% 20.5% NP 15.1% | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Fine Sand Silt & Clay Plastic Index | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.9% 23.0% NP |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu | um Particle S Gra Liquid Li | 300 mm (12 < 75 mm an 4.75 mm an 2.00 mm and Procedure fo Size 4.75 sivel 0.2 mit | 10.00 ") and : d > 4.7 nd > 2.0 d > 0.4 or obta mm 2% | Mill > 75 m 75 mm 00 mm 25 mm aining S | timeters m (3") (#4) (#10) (#40) (#40) specimen: | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lin tural Moistu | ine San Silt Clay Colloids and mit ure | d Dispersio 1.4% 20.5% NP 15.1% | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Fine Sand Silt & Clay Plastic Index | 0.01 > 0.075 mm 0.005 mm mm spersant 54.9% 23.0% NP |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu | 00 C C C C C C C C C C C C C C C C C C C | 300 mm (12' < 75 mm an 4.75 mm ar 2.00 mm and Procedure fo Size 4.75 ivel 0.2 mit | ") and d > 4.7 nd > 2.0 d > 0.4 or obta mm 2% | Mil > 75 m 75 mm 00 mm 125 mm 125 mm 125 mm | limeters m (3") (#4) (#10) (#40) (#40) speciment | 1.00 F Moist Coarse Sa Medium Sa Plastic Lin tural Moistu | ine San Silt Clay Colloids and mit ure | d Dispersio 1.4% 20.5% NP 15.1% | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Fine Sand Silt & Clay Plastic Index | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.9% 23.0% NP |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu Notes / Deviations | um Particle S Gra Liquid Li | 300 mm (12 < 75 mm an 4.75 mm ar 2.00 mm and Procedure fr Size 4.75 avel 0.2 mit | ") and d > 4.7 nd > 2.0 d > 0.4 or obta mm 2% | Mill > 75 m 75 mm 00 mm 25 mm aining S | timeters m (3") (#4) (#10) (#40) cpecimen: | 1.00 F Moist Coarse Sa Medium Sa Plastic Lin tural Moistu | ine San Silt Clay Colloids and mit ure | d Dispersio 1.4% 20.5% NP 15.1% | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Fine Sand Silt & Clay Plastic Index | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.9% 23.0% NP |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc Method: B Maximu Notes / Deviations , | um Particle S Gra Liquid Li | 300 mm (12' < 75 mm an 4.75 mm an 2.00 mm and Procedure fo Size 4.75 sivel 0.2 mit | ") and d > 4.7 nd > 2.0 d > 0.4 or obta mm 2% | Mill > 75 m 75 mm 00 mm 25 mm aining S | limeters m (3") (#4) (#10) (#40) specimen: | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lin tural Moistu | ine San Silt Clay Colloids and mit ure | d Dispersic 1.4% 20.5% NP 15.1% | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Fine Sand Silt & Clay Plastic Index | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.9% 23.0% NP |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc Method: B Maximu Notes / Deviations , | w Constraints Co | 300 mm (12° < 75 mm an 4.75 mm ar 2.00 mm and Procedure fr Size 4.75 ivel 0.2 mit | ") and d > 4.7 nd > 2.0 d > 0.4 or obta mm 2% | Mill > 75 mm 00 mm 225 mm aining S | limeters m (3") (#4) (#10) (#40) cpecimen: Na | 1.00 F Moist Coarse Sa Medium Sa Plastic Lin tural Moistu | ine San Silt Clay Colloids and mit ure | d Dispersic 1.4% 20.5% NP 15.1% | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Fine Sand Silt & Clay Plastic Index | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.9% 23.0% NP |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc Method: B Maximu Notes / Deviations , | w A A A A A A A A A A A A A | 300 mm (12' < 75 mm an 4.75 mm an 2.00 mm and Procedure fi Size 4.75 avel 0.2 mit | ") and d > 4.7 nd >2.0 d > 0.4 or obta mm 2% | Mill > 75 m 75 mm 00 mm 25 mm aining S | timeters m (3") (#4) (#10) (#40) pecimen: Na | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lin tural Moistu | ine San Silt Clay Colloids and mit ure | d Dispersio 1.4% 20.5% NP 15.1% | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Fine Sand Silt & Clay Plastic Index | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.9% 23.0% NP |
| Cobbles Gravel Coarse Sand Medium Sanc Method: B Maximu Notes / Deviations , | w Contribution | 300 mm (12' < 75 mm an 4.75 mm ar 2.00 mm and Procedure fe Size 4.75 Ivel 0.2 mit | ") and d > 4.7 nd > 2.0 d > 0.4 or obta mm 2% | Mil > 75 m 25 mm 25 | limeters m (3") (#4) (#10) (#40) pecimen: Na | 1.00 I.00 Fi Moist Coarse Sa Medium Sa Plastic Lin tural Moistu | ine San Silt Clay Colloids and and mit ure | d Dispersic 1.4% 20.5% NP 15.1% | 0.10 <pre></pre> | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.9% 23.0% NP 8/30/21 |
| Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu Notes / Deviations , Erank N Technical | w Control Control Con | 300 mm (12" < 75 mm an 4.75 mm an 2.00 mm and Procedure fr Size 4.75 ivel 0.2 mit | ") and d > 4.7 nd > 2.0 d > 0.4 or obta mm 2% | Mill > 75 mm 00 mm 25 mm aining S | timeters m (3") (#4) (#40) (#40) cpecimen: Na | 1.00 I.00 Fi Moist Coarse Sa Medium Sa Plastic Lin tural Moistu | ine San Silt Clay Colloids and mit ure | d Dispersic 1.4% 20.5% NP 15.1% | 0.10 < 0.425 mm and < 0.075 and > < 0.005 < 0.001 on Process: Di Fine Sand Silt & Clay Plastic Index ager | 0.01 > 0.075 mm 0.005 mm mm mm spersant 54.9% 23.0% NP NP <u>8/30/21</u> Date |

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | | AST | M D 4318 | \mathbf{X} | AASH | TO T 89 | | AAS | нто т 90 | | | | |
|--------------------------------|---|---|--|----------------|-------------|---------------------|------------------|----------------|---------------|---------------------|---|---|---|
| | | S&ME, | Inc Gre | enville | 48 Bro | ookfiel | d Oaks E | Dr., Suit | e F Gre | enville, So | 29607 | | |
| Project | #: | 213045 | | | | | | | | Report [| Date: | 8/30/2 | 21 |
| Project | Name: | Bad Cree | ek Phase 2 | 2 Feasibi | ity Stu | dy Proj | ect | | | Test [| Date: | 8/19/2 | 21 |
| Client N | lame: | HDR | | | | | | | | | | | |
| Client A | ddress: | 1122 Lad | ly Street, | Suite 11 | 00 Coli | umbia, | South C | arolina | 29201 | | | | |
| Boring # | #: B-2 | 1-2 | | L | .og #: | | 96g | | Sam | ple Date: | | 4/20/21 | |
| Sample | ID: SS- | 5 | | | Type: | Sp | lit-spoo | n | | Depth: | | 18.5' | |
| Sample | Descripti | on: | silty SAN | ID (SM) - | tan br | own, m | nedium t | o fine | | | | | |
| Type and | l Specificat | ion | S&ME IL | D # | Cal Do | ate: | Type ar | nd Specif | fication | S& | ME ID # | Cal | Date: |
| Balance | (0.01 g) | | 13942 | 2 | 10/19/2 | 2020 | Groovir | ng tool | | | 23119 | 10/15 | 5/2020 |
| LL Appar | ratus | | 2315 | 5 | 2/1/20 | 020 | | | | | | | |
| Oven Pan | # | | 13976 | 5 | 10/7/2 | .020 | Liquid Li | mit | | | | Plastic Limi | + |
| ' un | " | | Tare #: | | | | Elquid El | | | | | | |
| Α | Tare Wei | ght | | | | | | | | | | | |
| В | Wet Soil | Weight + A | ۹. | | | | | | | | | | |
| С | Dry Soil | Weight + A | | | | | | | | | | | |
| D | Water W | eiaht (B-C) | | | | | | | | | | | |
| F | Dry Soil | Weight (C-A | A) | | | | | | | | | | |
| F | % Moistu | ure (D/E)*10 |)0 | | | | | | | | | | |
| N | # OF DR | OPS | | | | | | | | | Moisture C | ontents det | ermined by |
| 11 | 11 | = F * FACT | OR | | | | | | | | A | STM D 221 | 6 |
| Ave. | | Averaae | | | | | | | | | | | |
| | | 5 - | | | | | | | | | One Point I | _iquid Lim | it |
| 2 | 40.0 | | | | | | | | | Ν | Factor | N | Factor |
| | | | | _ | | | | | | 20 | 0.974 | 26 | 1.005 |
| t i | 35.0 | | | | | | | | | 21 | 0.979 | 27 | 1.009 |
| onte | | | | _ | | | | | | 22 | 0.965 | 20 | 1.014 |
| e Cí | ⊨ | | | _ | | | | | | 24 | 0.995 | 30 | 1.022 |
| stur | 30.0 | | | | | | | | | 25 | 1.000 | | |
| Mois | | | | _ | | | | | | N | P, Non-Pla | astic [| X |
| 1% | 25.0 | | | | | | | | | | Liquid L | .imit - | |
| | | | | | | | | | | | Plastic L | imit N | 1P |
| | | | | | | | | | | | Plastic Ir | ndex N | 1P |
| 2 | | | | | | | | <u> </u> | | (| Groun Svn | nbol S | M |
| | 20.0 | 15 | 20 | 25 30 | 35 4 | | | | 100 | | sioup Syn | | |
| | 20.0 | 15 | 20 | 25 30 | 35 4 | 0 | # of Dro | ops | 100 | N | Iultipoint N | /lethod | ~ |
| | 20.0 | 15 | 20 | 25 30 | 35 4 | 0 | # of Dro | ops | 100 | N C | Iultipoint N Ine-point N | Nethod Nethod | |
| Wet Pr | 20.0 10 | 15 | 20 y Preparat | 25 30 | 35 4 Air | 0 Dried | f of Dro | ops | 100 | N C % Passing | fultipoint N Ine-point N the #200 St | Nethod Nethod | ✓ □ 23.0% |
| Wet Providence / D | 20.0 10 reparation Deviations , | 15 | 20 y Preparat | 25 30 | 35 4 | 0 Dried | # of Dro | ops | 100 | N C % Passing | fultipoint N Iultipoint N Ine-point N the #200 St | Aethod Aethod ieve: | ✓ □ 23.0% |
| Wet Province / D | 20.0 10 10 Deviations , | 15 | 20 y Preparat | 25 30 | 35 4 | 0 Dried | # of Dr c | ops | 100 | N C % Passing | fultipoint N Ine-point N <i>the #200 Si</i> | Aethod Aethod ieve: | 23.0% |
| Wet Provide Astronomy Devices | 20.0 10 eparation Deviations , 4318: Liqui | 15 | 20 y Preparat s: stic Limit, o | 25 30 | 35 4 Air | 0 Dried Soils | # of Dro | ops | 100 | N C % Passing | fultipoint N One-point N <i>the #200 Si</i> | Aethod Aethod | 23.0% |
| Wet Pri Notes / L | 20.0 10 reparation Deviations / 4318: Liqui | 15 | 20 y Preparat s: stic Limit, o | 25 30 ion ✓ | 35 4 Air | Dried Soils | # of Dro | ops | 100 | N C % Passing | fultipoint N One-point N the #200 Si | Aethod Aethod ieve: | 23.0% |
| Wet Pri Notes / D ASTM D | 20.0 10 eparation Deviations , 4318: Liqui Benjamin Tachnia | 15 / References id Limit, Pla J. Kovales | 20 y Preparat s: stic Limit, o ski | 25 30 ion ✓ | 35 4 | Dried | # of Dr (| Brian Techn | 100 Vaugha | N C W Passing | Aultipoint N Aultipoint N Aultipoint N the #200 Si | Aethod Aethod ieve: <u>8/3</u> | ✓ ✓ 23.0% ✓ Ø/21 gta |



| | | | | | ASTM | D 6913 | | | | | |
|--|--|---|--|--|---|--|---|--|---|---|--|
| | S&ME | , Inc | Greenville: | 48 B | rookfield | Oaks Dr., S | Suite F | Greenville | e, SC 29607 | | |
| Project #: | 213045 | | | | | | | | Report | : Date: | 8/30/21 |
| Project Name: | Bad Cree | k Phase | e 2 Feasibil | ity Stud | dy Projec | t | | | Test | : Date: | 8/10 - 8/26/21 |
| Client Name: | HDR | | | | | | | | | | |
| Client Address: | 1122 Lad | y Stree | t, Suite 110 | 00 Colu | umbia, S | outh Carolin | na 2920 |)1 | | | |
| Boring #: | B-21-2 | | | | | .og #: | ç | 96g | Sample | Date: | 4/20/21 |
| Sample ID: | SS-6 | | | | | Гуре: | Split | -spoon | [| Depth: | 23.5' |
| Sample Description | on: silty | SAND | (SM) - tan | red, m | edium to | fine | | | | | |
| | | | | | | "20 | | #60 #100 | #140 #200 | | |
| 100% | 3" 2" 1.5 | • 1" 3/4 | | #4 | #10 | #20 | #40 | *80 #100 | *140 *200 | 1 1 | |
| 0.0% | | | | | | | | | | | |
| 90% | | | | | | | | | | | |
| 80% | | | | | | | | | | | |
| <u>کُ</u> 70% | | | | | | | | | | | |
| sing | | | | | | | | | | | |
| 60% Ba | | | | | | | | | | | |
| 50% | | | | | | | | <u> </u> | | | |
| Le Lov | | | | | | | | | | | |
| 40% | | | | | | | | | | | |
| 30% | | | | | | | | | | | |
| 20% | | | | | | | | | | | |
| | | | | | | | | | | | |
| 10% | | | | | | | | | | | |
| | | | | | | | | | | | |
| 0% | | | | | | | | | | | |
| 0% 100.0 | 0 | | 10.00 | Mil | limeters | 1.00 | • | | 0.10 | | 0.01 |
| 0% 100.0 Cobbles | 0 | 300 mr | 10.00 m (12") and | • Mil | limeters m (3") | 1.00 Fi | ne Sano | d | 0.10 | m and > | 0.01 |
| 0% 100.0 Cobbles Gravel | 0 < | 300 mr < 75 m | 10.00 m (12") and nm and > 4. | Mil > 75 m 75 mm | limeters m (3") (#4) | 1.00 Fi | ne Sano Silt | d | 0.10 < 0.425 mi < 0.075 | m and > | 0.01 > 0.075 mm 0.005 mm |
| 0% 100.0 Cobbles Gravel Coarse Sand | 0 < | 300 mr < 75 m < 4.75 r | 10.00 m (12") and nm and > 4. nm and > 2.0 | Mil > 75 m 75 mm 00 mm | limeters m (3") (#4) (#10) | 1.00 Fi | ne Sano Silt Clay | d | 0.10 < 0.425 mi < 0.075 < | m and > and > 0 0.005 n | 0.01 > 0.075 mm 0.005 mm nm |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc | | 300 mr < 75 m < 4.75 r : 2.00 m | 10.00 m (12") and nm and > 4. nm and > 2.0 im and > 0.2 | Mil > 75 m 75 mm 00 mm 425 mm | limeters m (3") (#4) (#10) (#40) | 1.00 Fi | ne Sano Silt Clay Colloids | d | 0.10 | m and 2 and 2 (0.005 n 0.001 n | 0.01 > 0.075 mm 0.005 mm nm nm |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc Method: B | | 300 mr < 75 m < 4.75 r : 2.00 m Procee | 10.00 m (12") and m and > 4 . mm and > 2 . mm and > 0.4 dure for obt | Mil > 75 m 75 mm 00 mm 425 mm aining S | limeters m (3") (#4) (#10) (#40) specimen: | 1.00 Fi | ne Sand Silt Clay Colloids | d Dispersic | 0.10 < 0.425 mi < 0.075 < < on Process: | m and > and > (0.005 n 0.001 n Dis | 0.01 > 0.075 mm 0.005 mm nm persant 44.70(|
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu | i < | 300 mr < 75 m < 4.75 r 2.00 m Proceo Size | 10.00 m (12") and nm and > 4. nm and > 2. m and > 0.4 dure for obt 4.75 mm | Mil > 75 m 75 mm 00 mm 425 mm aining S | limeters m (3") (#4) (#10) (#40) specimen: | 1.00 Fi Moist Coarse Sa | ne Sano Silt Clay Colloids | d Dispersic 1.1% | 0.10 0.425 miles (0.075) < 0.075 < 0.075 < 0.075 < 0.075 Fine (1.075) | m and 2 and 2 (0.005 n 0.001 n Dis 2 Sand | 0.01 > 0.075 mm 0.005 mm nm nm persant 44.7% 25.00% |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu | e contraction of the second se | 300 mr < 75 m < 4.75 r 2.00 m Procect Size ravel | 10.00 m (12") and m and > 4.7 mm and > 2.0 m and > 0.4 dure for obt 4.75 mm 0.0% | Nil Xil Xil Xil Xil Xil Xil Xil Xil Xil X | limeters m (3") (#4) (#10) (#40) specimen: | 1.00 Fi Moist Coarse Sa Medium Sa | ne Sano Silt Clay Colloids nd nd | d Dispersic 1.1% 18.4% | 0.10 < 0.425 mi < 0.075 < < 0.075 < < on Process: Fine Silt & Silt & | m and > 0 and > 0 0.005 n 0.001 n Dis Sand & Clay | 0.01 > 0.075 mm 0.005 mm nm nm persant 44.7% 35.8% |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand Medium Sand Method: B Maximu | o I I Liquid | 300 mr < 75 m < 4.75 r : 2.00 m Proceo Size ravel Limit | 10.00 10.00 10.00 10.00 10.00 10.00 10.0% 10.0% 10.0% 10.0% 10.0% 10.0% 10.0% 10.0% 10.0% 10.00 10 | Mil > 75 m 75 mm 00 mm 425 mm aining S | limeters m (3") (#4) (#10) (#40) pecimen: | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lir | ne Sand Silt Clay Colloids nd nd mit | d Dispersic 1.1% 18.4% 27 | 0.10 0.425 million < 0.425 million < 0.075 < <li< td=""><td>m and 2 and 2 (0.005 n 0.001 n Dis 2 Sand & Clay Index</td><td>0.01 0.005 mm 0.005 mm nm persant 44.7% 35.8% 5</td></li<> | m and 2 and 2 (0.005 n 0.001 n Dis 2 Sand & Clay Index | 0.01 0.005 mm 0.005 mm nm persant 44.7% 35.8% 5 |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu | um Particle G Liquid | 300 mr < 75 m < 4.75 r 2.00 m Proceo Size ravel Limit | 10.00 m (12") and nm and > 4.7 nm and > 0.4 dure for obt 4.75 mm 0.0% 32 | Mil > 75 m 75 mm 00 mm 125 mm aining S | limeters m (3") (#4) (#10) (#40) pecimen: | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lir | ne Sand Silt Clay Colloids nd nd nit | d Dispersio 1.1% 18.4% 27 20.9% | 0.10 0.425 mi < 0.425 mi < 0.075 < < < 0.075 < < 0.075 < < 0.075 < < 0.075 < | m and 2 and 2 (0.005 n 0.001 n Dis 2 Sand & Clay Index | 0.01 > 0.075 mm 0.005 mm nm nm persant 44.7% 35.8% 5 |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sand Method: B Maximu | I < | 300 mr < 75 m < 4.75 r 2.00 m Procec Size ravel Limit | 10.00 m (12") and m and > 4. mm and > 2.0 mm and > 0.4 dure for obt 4.75 mm 0.0% 32 | Xiii > 75 m 75 mm 00 mm 425 mm aining S | limeters m (3") (#4) (#10) (#40) pecimen: | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lir tural Moistu | ne Sano Silt Clay Colloids nd nd nit | d Dispersio 1.1% 18.4% 27 20.9% | 0.10 | m and 2 and 2 (0.005 n 0.001 n Dis 2 Sand & Clay Index | 0.01 > 0.075 mm 0.005 mm nm persant 44.7% 35.8% 5 |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc Method: B Maximu | o Im Particle G Liquid I | 300 mr < 75 m < 4.75 r 2.00 m Proceo Size ravel Limit | 10.00 m (12") and nm and > 4. nm and > 0.4 dure for obt. 4.75 mm 0.0% 32 | Mil > 75 m 75 mm 00 mm 125 mm aining S | limeters m (3") (#4) (#10) (#40) specimen: Na | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lin | ne Sand Silt Clay Colloids nd nd nit | d Dispersic 1.1% 18.4% 27 20.9% | 0.10 < 0.425 mi < 0.075 < on Process: Fine Silt & Plastic | m and > and > (0.005 n 0.001 n Dis 2 Sand & Clay Index | 0.01 > 0.075 mm 0.005 mm nm nm persant 44.7% 35.8% 5 |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc Method: B Maximu | Im Particle G Liquid I | 300 mr < 75 m < 4.75 r ? 2.00 m Procec Size ravel Limit | 10.00 m (12") and m and > 4. mm and > 0.4 dure for obt 4.75 mm 0.0% 32 | <u>Mil</u> > 75 m 75 mm 00 mm 425 mm aining S | limeters m (3") (#4) (#10) (#40) pecimen: Na | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lir tural Moistu | ne Sand Silt Clay Colloids nd nd nit ure | d Dispersic 1.1% 18.4% 27 20.9% | 0.10 | m and > and > (0.005 n 0.001 n Dis 2 Sand 3 Clay Index | 0.01 > 0.075 mm 0.005 mm nm nm persant 44.7% 35.8% 5 |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc Method: B Maximu Notes / Deviations / | I < | 300 mr < 75 m < 4.75 r 2.00 m Procect Size ravel Limit | 10.00 m (12") and m and > 4.7 mm and > 0.4 dure for obt 4.75 mm 0.0% 32 | Mil > 75 m 75 mm 00 mm 425 mm aining S | limeters m (3") (#4) (#10) (#40) pecimen: Na | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lir tural Moistu | ne Sano Silt Clay Colloids nd nd nit ure | d Dispersic 1.1% 18.4% 27 20.9% | 0.10 | m and 2 and 2 (0.005 n 0.001 n Dis 2 Sand & Clay Index | 0.01 0.005 mm nm nm persant 44.7% 35.8% 5 |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc Method: B Maximu Notes / Deviations , | Im Particle G Liquid I | 300 mr < 75 m < 4.75 r ? 2.00 m Proceo Size ravel Limit | 10.00 m (12") and mm and > 4.7 mm and > 0.4 dure for obt 4.75 mm 0.0% 32 | Mil > 75 m 75 mm 00 mm 425 mm aining S | limeters m (3") (#4) (#10) (#40) pecimen: Na | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lin tural Moistu | ne Sand Silt Clay Colloids nd nd nit | d Dispersio 1.1% 18.4% 27 20.9% | 0.10 | m and > (and > (0.005 n 0.001 n Dis 2 Sand 32 Clay Index | 0.01 > 0.075 mm 0.005 mm nm nm persant 44.7% 35.8% 5 |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc Method: B Maximu Notes / Deviations , | Im Particle G Liquid I | 300 mr < 75 m < 4.75 r 2.00 m Procec Size ravel Limit | 10.00 m (12") and nm and > 4. nm and > 0.4 dure for obt. 4.75 mm 0.0% 32 | <u>Mil</u> > 75 m 75 mm 00 mm 425 mm aining S | limeters m (3") (#4) (#10) (#40) pecimen: Na | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lir tural Moistu | ne Sand Silt Clay Colloids nd nd nit ure | d Dispersic 1.1% 18.4% 27 20.9% | 0.10 | m and 2 and 2 (0.005 n Dis 2 Sand 32 Clay Index | 0.01 > 0.075 mm 0.005 mm nm nm persant 44.7% 35.8% 5 |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc Method: B Maximu Notes / Deviations / | I < | 300 mr < 75 m < 4.75 r ? 2.00 m Procect Size ravel Limit | 10.00 m (12") and m and > 4. mm and > 2.0 mm and > 0.4 dure for obt 4.75 mm 0.0% 32 | Mil > 75 m 75 mm 00 mm 425 mm aining S | limeters m (3") (#4) (#10) (#40) pecimen: Na | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lir tural Moistu | ne Sand Silt Clay Colloids nd nd nit ure | d Dispersic 1.1% 18.4% 27 20.9% | 0.10 | m and 2 and 2 (0.005 n 0.001 n Dis 2 Sand & Clay Index | 0.01 > 0.075 mm 0.005 mm nm persant 44.7% 35.8% 5 |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc Method: B Maximu Notes / Deviations , Frank M | Im Particle G Liquid I / References | 300 mr < 75 m < 4.75 r 2.00 m Procec Size ravel Limit | 10.00 m (12") and m and > 4.7 mm and > 0.4 dure for obt 4.75 mm 0.0% 32 | Mil > 75 m 75 mm 00 mm 425 mm aining S | limeters m (3") (#4) (#10) (#40) pecimen: Na | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lir tural Moistu | ne Sand Silt Clay Colloids nd nd nit ure | d Dispersic 1.1% 18.4% 27 20.9% | 0.10 | m and > and > (0.005 n 0.001 n Dis 2 Sand & Clay Index | 0.01 > 0.075 mm 0.005 mm nm nm persant 44.7% 35.8% 5 5 8/30/21 |
| 0% 100.0 Cobbles Gravel Coarse Sand Medium Sanc Method: B Maximu Notes / Deviations / Frank N Technical / | Im Particle G Liquid I / References | 300 mr < 75 m < 4.75 r 2.00 m Procec Size ravel Limit | 10.00 m (12") and m and > 4. mm and > 2.0 im and > 0.4 dure for obt 4.75 mm 0.0% 32 | Mil > 75 m 75 mm 00 mm 425 mm aining S aining S Signa | timeters m (3") (#4) (#10) (#40) pecimen: Na | 1.00 Fi Moist Coarse Sa Medium Sa Plastic Lir tural Moistu | ne Sand Silt Clay Colloids nd nd nit ure | d Dispersic 1.1% 18.4% 27 20.9% oject Mana Position | 0.10 | m and 2 and 2 (0.005 n 0.001 n Dis 2 Sand 32 Clay Index | 0.01 0.01 0.005 mm nm nm persant 44.7% 35.8% 5 5 8/30/21 Date |

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | , | ASTM D 4318 | \boxtimes | AASHTO | <i>T 8</i> 9 E | | SHTO T 90 | | | | |
|--------------------|--|----------------------------|-------------|-------------------|----------------|-------------------------|-----------------------------------|--|---|---|---|
| | S&I | ME, Inc Gre | enville | 48 Brook | field Oak | s Dr., Suit | te F Gre | enville, SC | 29607 | | |
| Project | #: 21304 | 45 | | | | | | Report I | Date: | 8/30/2 | 21 |
| Project | Name: Bad C | Creek Phase 2 | 2 Feasibili | ty Study F | Project | | | Test [| Date: | 8/19/2 | 21 |
| Client N | lame: HDR | | | | | | | | | | |
| Client A | ddress: 1122 | Lady Street, | Suite 110 | 0 Columi | bia, South | Carolina | a 29201 | - | | | |
| Boring a | #: B-21-2 | | Lo | og #: | 96g | | Sam | ple Date: | | 4/20/21 | |
| Sample | ID: SS-6 | | Т | ype: | Split-spo | oon | | Depth: | | 23.5' | |
| Sample | Description: | silty SAN | ID (SM) - | tan red, n | nedium to | o fine | | | | | |
| Type and | d Specification | S&ME IL | D # | Cal Date: | Туре | and Speci | ification | S& | ME ID # | Cal I | Date: |
| Balance | (0.01 g) | 13942 | 2 . | 10/19/2020 | 0 Groo | ving tool | | | 23119 | 10/15 | 5/2020 |
| LL Appai | ratus | 23158 | 8 | 2/1/2021 | | | | | | | |
| Oven | | 13978 | 8 | 10/7/2020 |) | | | | | | |
| Pan | # | T aua #1 | 11 | 10 | Liquid | l Limit | | r | 14 | Plastic Limi | t |
| | - | Tare #: | 11 | 12 | 13 | | | | 14 | 15 | |
| A | Tare Weight | | 26.65 | 26.66 | 26.75 | | | | 26.64 | 27.60 | |
| В | Wet Soil Weight | + A | 41.79 | 42.82 | 43.18 | | | | 34.52 | 35.18 | |
| C | Dry Soil Weight | + A | 38.18 | 38.90 | 39.14 | | | | 32.85 | 33.59 | |
| D | Water Weight (B | S-C) | 3.61 | 3.92 | 4.04 | | | | 1.67 | 1.59 | |
| E | Dry Soil Weight | (C-A) | 11.53 | 12.24 | 12.39 | | | | 6.21 | 5.99 | |
| F | % Moisture (D/E |)*100 | 31.3% | 32.0% | 32.6% | | | | 26.9% | 26.5% | |
| Ν | # OF DROPS | | 32 | 20 | 15 | | | | Moisture C | ontents det | ermined by |
| LL | LL = F * F | ACTOR | | | | | | | A | STM D 221 | 6 |
| | | | | | | | | | | | |
| Ave. | Avera | ige | | | | | | | | 26.7% | |
| Ave. | Avera | ige | | | | | | | One Point | 26.7% Liquid Lim | it |
| Ave. | 42.0 | nge | | | | | | (N | One Point Factor | 26.7% Liquid Lim N | it Factor |
| Ave. | 42.0 | | | | | | | N 20 | One Point Factor 0.974 | 26.7% Liquid Lim N 26 | it Factor 1.005 |
| Ave. | 42.0 Avera | ige | | | | | | N 20 21 | One Point Factor 0.974 0.979 | 26.7% Liquid Lim N 26 27 | it Factor 1.005 1.009 |
| Ave. | 42.0 37.0 | | | | | | | N 20 21 22 | One Point Factor 0.974 0.979 0.985 | 26.7% Liquid Lim 26 27 28 | it Factor 1.005 1.009 1.014 |
| . Soutent | 42.0 37.0 | | | | | | | N 20 21 22 23 24 | Dne Point Factor 0.974 0.979 0.985 0.99 0.995 | 26.7% Liquid Lim 26 27 28 29 20 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| | 42.0 37.0 32.0 | | | | | | | N 20 21 22 23 24 25 | Dne Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 | 26.7% Liquid Lim 26 27 28 29 30 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| isture Content | 42.0 37.0 32.0 | | | | | | | N 20 21 22 23 24 25 | Dne Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 | 26.7% Liquid Lim 26 27 28 29 30 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| Moisture Content | 42.0 37.0 32.0 | | | | | | | N 20 21 22 23 24 25 | Dne Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P | 26.7% Liquid Lim 26 27 28 29 30 astic | it Factor 1.005 1.009 1.014 1.018 1.022 |
| % Moisture Content | 42.0 37.0 32.0 | | | | | | | N 20 21 22 23 24 25 | Dne Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid I | 26.7% Liquid Lim 26 27 28 29 30 lastic I Limit 3 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| % Moisture Content | 42.0 37.0 32.0 27.0 | | | | | | | N 20 21 22 23 24 25 | Dne Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid I Plastic I | 26.7% Liquid Lim 26 27 28 29 30 lastic I .imit 3 .imit 2 | it Factor 1.005 1.009 1.014 1.018 1.022 22 27 |
| % Moisture Content | Avera 42.0 37.0 32.0 27.0 | | | | | | | N 20 21 22 23 24 25 | Dne Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid I Plastic I Plastic I | 26.7% Liquid Lim 26 27 28 29 30 Lastic I Limit 3 Limit 2 Limit 2 | it Factor 1.005 1.009 1.014 1.018 1.022 .2 .2 .7 .5 |
| % Moisture Content | Avera 42.0 37.0 32.0 27.0 22.0 | | | | | | | N 20 21 22 23 24 25 | Dne Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid I Plastic I Plastic I Group Syr | 26.7% Liquid Lim 26 27 28 29 30 imit 2 imit 3 .imit 2 ndex 5 | it Factor 1.005 1.009 1.014 1.018 1.022 2 2 2 2 5 M |
| % Moisture Content | Avera 42.0 37.0 32.0 27.0 10 11 | <i>ige</i> | 25 30 | 35 40 | | | 100 | N 20 21 22 23 24 25 | One Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid L Plastic I Plastic In Group Syr Multipoint N | 26.7% Liquid Lim 26 27 28 29 30 Jastic I Limit 3 Limit 3 Limit 2 ndex 5 Method 5 | it Factor 1.005 1.009 1.014 1.018 1.022 2 2 2 3 5 M ✓ |
| % Moisture Content | 42.0 37.0 32.0 27.0 22.0 10 11 | <i>ige</i> 5 20 | 25 30 | 35 40 | | | 100 | N 20 21 22 23 24 25 | One Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid I Plastic I Plastic I Froup Syr fultipoint N one-point N | 26.7% Liquid Lim 26 27 28 29 30 lastic I Limit 3 Limit 3 Limit 2 ndex 5 Method Method | it Factor 1.005 1.009 1.014 1.018 1.022 32 32 5 M |
| Weither Content | Avera 42.0 37.0 32.0 27.0 10 11 reparation | ge 5 20 Dry Preparat | 25 30 | 35 40 | # of I | | | N 20 21 22 23 24 25 (0 W C % Passing | Dne Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid I Plastic I Plastic I Plastic I Group Syr fultipoint N the #200 S | 26.7% Liquid Lim 26 27 28 29 30 lastic I Limit 3 Limit 3 Limit 3 Limit 3 Method 5 Method Method | it Factor 1.005 1.009 1.014 1.018 1.022 32 35 M 35.8% |
| Ave. | 42.0 Avera 37.0 32.0 32.0 9 27.0 10 10 13 reparation Deviations / Reference | Ige | 25 30 | 35 40 | # of I | Drops | | N 20 21 22 23 24 25 (0 (0 % Passing 1) | One Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid I Plastic I Plastic I Plastic I Froup Syr fultipoint N Ine-point N the #200 S | 26.7% Liquid Lim 26 27 28 29 30 Jastic I Limit 3 Limit 3 Limit 2 ndex 5 Method 5 Method Method | it Factor 1.005 1.009 1.014 1.018 1.022 2 2 2 3 5 M ↓ 3 5.8% |
| Ave. | Avera | Ige | 25 30 | 35 40 | # of I | Drops | 100 | N 20 21 22 23 24 25 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | Dne Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid I Plastic I Plastic I Plastic I Sroup Syr Multipoint N one-point N the #200 S | 26.7% Liquid Lim 26 27 28 29 30 Lastic II Limit 3 Limit 2 Inbol S Method Lieve: | it Factor 1.005 1.009 1.014 1.018 1.022 32 7 5 M ✓ 35.8% |
| Ave. | 42.0 Avera 37.0 32.0 32.0 27.0 22.0 10 10 11 reparation Deviations / Reference | ge | 25 30 | 35 40 | # of I | Drops | | N 20 21 22 23 24 25 | One Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid I Plastic I Plastic I Plastic I Sroup Syr fultipoint N one-point N the #200 S | 26.7% Liquid Lim 26 27 28 29 30 Limit 3 Limit 3 Limit 3 Limit 3 Method 5 Method 4 Method 4 | it Factor 1.005 1.009 1.014 1.018 1.022 2 2 2 7 5 M ✓ 35.8% |
| Ave. | 42.0 Avera 37.0 32.0 32.0 9 27.0 9 22.0 10 10 11 reparation 1 Deviations / Reference 4318: Liquid Limit, | Ige | 25 30 | 35 40 Air Drie | # of I | Drops | | N 20 21 22 23 24 25 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | One Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid I Plastic I Plastic I Plastic I Sroup Syr Multipoint N one-point N the #200 S | 26.7% Liquid Lim 26 27 28 29 30 Lastic II Limit 3 Limit 2 Index S Method Lieve: | it Factor 1.005 1.009 1.014 1.018 1.022 32 7 5 M ✓ 35.8% |
| Ave. | 42.0 37.0 32.0 27.0 22.0 10 11 reparation Deviations / Referent 4318: Liquid Limit, 38enjamin J. Kovo | Ige | 25 30 | Air Drie | # of I | Drops | 100 | N 20 21 22 23 24 25 0 0 0 0 0 0 0 0 0 0 0 0 0 | One Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid I Plastic Ir Group Syr fultipoint N the #200 S | 26.7% Liquid Lim 26 27 28 29 30 Limit 3 Limit 3 Limit 2 Index 5 Method Method Lieve: 8/30 | it Factor 1.005 1.009 1.014 1.018 1.022 2 2 2 3 5 M 3 5.8% 0/21 |
| Ave. | Avera Avera Avera Avera Az.0 Avera Avera Az.0 Avera Av | Ige | 25 30 | 35 40 Air Drie | # of I | Drops Brian Techr | 100 I Vaugha nical Response | N 20 21 22 23 24 25 1 0 0 0 0 0 0 0 0 0 0 0 0 0 | One Point Factor 0.974 0.979 0.985 0.99 0.995 1.000 NP, Non-P Liquid I Plastic I Plastic I Plastic I Group Syr Multipoint N the #200 S | 26.7% Liquid Lim 26 27 28 29 30 lastic I imit 3 imit 2 nbol S Method ieve: 8/30 | it Factor 1.005 1.009 1.014 1.018 1.022 32 7 5 M |



| | | | | | A | ASTMD | 0915 | | | | |
|--|------------------------------------|--|--|----------------------------------|-----------------------------|---------------------------------------|---|--|---|--|--|
| | S& | ME, Inc. | - Greenvill | e: 4 | 8 Broc | okfield C | Daks Dr., | Suite F | Greenvill | e, SC 29607 | |
| Project #: | 21304 | 45 | | | | | | | | Report Da | te: 8/30/21 |
| Project Name: | Bad C | reek Pha | ase 2 Feasib | ility | Study I | Project | | | | Test Da | te: 8/10 - 8/26/21 |
| Client Name: | HDR | | | | | | | | | | |
| Client Address: | 1122 | Lady Stre | eet, Suite 1 ⁻ | 100 | Colum | bia, Sou | th Caroli | na 292 | 01 | | |
| Boring #: | B-21-2 | 2 | | | | Lo | g #: | | 96g | Sample Da | te: 4/20/21 |
| Sample ID: | SS-7 | | | | | Ту | rpe: | Split | -spoon | Dep | th: 28.5' |
| Sample Descripti | on: s | ilty SANI | D (SM) - tai | n bro | wn, m | edium t | o fine | | | | |
| | 2 | | | | | #10 | #20 | # 10 | #60 #100 | #140 #200 | |
| 100% | 3" 2" | 1.5" 1" 3 | 3/4" 3/8 | | #4 | #10 | #20 | #40 | #60 #100 | #140 #200 | |
| 00% | | | | | | | | | | | |
| 90% | | | | | | | | | | | |
| 80% | | + | + | | | | | | | | |
| 3 70% | | | | | | | | N | | | |
| sing | | | | | | | | | | | |
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| 50% - | | | | | | | | | | | |
| erc | | | | | | | | | $+ \mathbf{N}$ | | |
| 40% | | | | | | | | | \ | | |
| 30% | | <u> </u> | | | \vdash | | | | | $\mathbf{\lambda}$ | |
| 20% | | | | | | | | | | - `\ • | |
| 20% | | | | | | | | | | | |
| 10% | | | | | + | | | | | | |
| 0% | | | | | | | | | | | |
| 100.0 |)0 | | 10.00 | [| Millim | eters | 1.00 | | | 0.10 | 0.01 |
| Cabbles | | < 200 | nama (12") an | d \ 7 | E 100 000 (| (2") | | ine Con | 4 | < 0.425 mm a | nd > 0.075 mm |
| Gravel | | < 300 i | nm (12) an | u > 7 4 75 r | 5 mm (#4 | 5)) | Г | Silt | u | < 0.425 mm a | |
| Gruver | | < 75 | mm and > 4 | | | / | | | | 5 0.07 J UNG | > 0.005 mm |
| Coarse Sand | | < 75 < 4.75 | mm and > 5 mm and >2 | 2.00 r | nm (#1 | 0) | | Clav | | < 0.00 | > 0.005 mm 05 mm |
| Coarse Sand Medium Sand | b | < 75 < 4.75 < 2.00 | 5 mm and > 4 5 mm and > 2 mm and > 0 | 2.00 r).425 | nm (#1 mm (#4 | 0) 40) | | Clay Colloid: | 5 | < 0.00 | > 0.005 mm 05 mm 01 mm |
| Coarse Sand Medium Sand Method: B | L L | < 75 < 4.75 < 2.00 Proc | mm and > 5 mm and > 2 mm and > 0 cedure for ob | 2.00 r 0.425 otaini | nm (#1 mm (#4 ng Spec | 0) 40) cimen: | Moist | Clay Colloid: | s Dispersio | < 0.00 < 0.00 < 0.00 < 0.00 | > 0.005 mm 05 mm 01 mm Dispersant |
| Coarse Sand Medium Sand Method: B Maximu | d um Parti | < 75 < 4.75 < 2.00 Proc cle Size | 5 mm and > 2 5 mm and > 2 mm and > 0 cedure for ob 4.75 mm | 2.00 r).425 otaini | nm (#1 mm (#4 ng Spec | 0) 40) cimen: | Moist Coarse Sa | Clay Colloids | s Dispersio 3.8% | < 0.00 < 0.00 < 0.00 < 0.00 < 0.00 Fine Sa | > 0.005 mm 05 mm 01 mm Dispersant nd 45.5% |
| Coarse Sand Medium Sand Method: B Maximu | d um Parti | < 75 < 4.75 < 2.00 Proc cle Size Gravel | 5 mm and > 5 mm and > 6 mm and > 0 2 cedure for ob 4.75 mm 0.5% | 2.00 r).425 otaini | nm (#1 mm (#4 ng Spec | 0) 40) cimen: (M | Moist Coarse Sa edium Sa | Clay Colloids and and | 5 Dispersio 3.8% 27.4% | < 0.00 < 0.00 < 0.00 on Process: Fine Sa Silt & Cl | > 0.005 mm 05 mm 01 mm Dispersant nd 45.5% ay 22.8% |
| Coarse Sand Medium Sand Method: B Maximu | d um Parti Liqu | < 75 < 4.75 < 2.00 Proc cle Size Gravel id Limit | 5 mm and > 5 mm and > 5 mm and > cedure for ob 4.75 mm 0.5% | 2.00 r 0.425 otaini | nm (#1 mm (#4 ng Spec | 0) 40) cimen: (| Moist Coarse Sa edium Sa Plastic Li | Clay Colloids and and mit | s Dispersio 3.8% 27.4% NP | < 0.00 < 0.00 < 0.00 < 0.00 < 0.00 < | > 0.005 mm D5 mm D1 mm Dispersant nd 45.5% ay 22.8% ex NP |
| Coarse Sand Medium Sand Method: B Maximu | um Parti Liqu | < 75 < 4.75 < 2.00 Proc Cle Size Gravel id Limit | 5 mm and > 5 mm and > 2 mm and > 2 cedure for of 4.75 mm 0.5% | 2.00 r).425 otaini | nm (#1 mm (#4 ng Spec | 0) 40) cimen: (| Moist Coarse Sa edium Sa Plastic Li | Clay Colloids and and mit | 5 Dispersio 3.8% 27.4% NP | < 0.00 < 0.00 on Process: Fine Sa Silt & Cl Plastic Ind | S 0.005 mm D5 mm D1 mm Dispersant nd 45.5% ay 22.8% ex NP |
| Coarse Sand Medium Sand Method: B Maximu | d um Parti Liqu | < 75 < 4.75 < 2.00 Proc icle Size Gravel id Limit | 5 mm and > 5 mm and > 5 mm and > cedure for ob 4.75 mm 0.5% | 2.00 r).425 otainin | nm (#1 mm (#4 ng Spea | 0) 40) cimen: (M Natu | Moist Coarse Sa edium Sa Plastic Li ral Moist | Clay Colloide and and mit ure | 5 Dispersio 3.8% 27.4% NP 14.4% | < 0.00 < 0.00 on Process: Fine Sa Silt & Cl Plastic Ind | > 0.005 mm D5 mm D1 mm Dispersant nd 45.5% ay 22.8% ex NP |
| Coarse Sand Medium Sand Method: B Maximu | um Parti Liqu | < 75 < 4.75 < 2.00 Proc icle Size Gravel id Limit | 5 mm and > 5 mm and > 5 mm and > cedure for ob 4.75 mm 0.5% | 2.00 r 0.425 otaini | nm (#1 mm (#4 ng Spec | 0) 40) cimen: (M Natu | Moist Coarse Sa edium Sa Plastic Li ral Moist | Clay Colloid: and and mit ure | 5 Dispersio 3.8% 27.4% NP 14.4% | < 0.00 < 0.00 on Process: Fine Sa Silt & Cl Plastic Ind | > 0.005 mm 05 mm Dispersant nd 45.5% ay 22.8% ex NP |
| Coarse Sand Medium Sand Method: B Maximu | i um Parti Liqu | < 75 < 4.75 < 2.00 Proc icle Size Gravel id Limit | 5 mm and > 5 mm and > 5 mm and > cedure for ob 4.75 mm 0.5% | 2.00 r).425 otaini | nm (#1 mm (#4 ng Spea | 0) 40) cimen: (M Natu | Moist Coarse Sa edium Sa Plastic Li ral Moist | Clay Colloids and and mit ure | 5 Dispersio 3.8% 27.4% NP 14.4% | < 0.00 < 0.00 on Process: Fine Sa Silt & Cl Plastic Ind | > 0.005 mm D5 mm D1 mm Dispersant nd 45.5% ay 22.8% ex NP |
| Coarse Sand Medium Sand Method: B Maximu Notes / Deviations | um Parti Liqu | < 75 < 4.75 < 2.00 Proc icle Size Gravel id Limit | 5 mm and > 5 mm and > 5 mm and > (cedure for ol 4.75 mm 0.5% | 2.00 r).425 otaini | nm (#1 mm (#, ng Spe | 0) 40) cimen: (M Natu | Moist Coarse Sa edium Sa Plastic Li ral Moist | Clay Colloid: and and mit ure | 5 Dispersio 3.8% 27.4% NP 14.4% | < 0.00 < 0.00 on Process: Fine Sa Silt & Cl Plastic Ind | > 0.005 mm D5 mm D1 mm Dispersant nd 45.5% ay 22.8% ex NP |
| Coarse Sand Medium Sand Method: B Maximu Notes / Deviations | um Parti Liqu | < 75 < 4.75 < 2.00 Proc icle Size Gravel id Limit | 5 mm and > 5 mm and > 5 mm and > cedure for ol 4.75 mm 0.5% | 2.00 r 0.425 otaini | nm (#1 mm (#4 ng Spec | 0) 40) cimen: (M Natu | Moist Coarse Sa edium Sa Plastic Li ral Moist | Clay Colloids and and mit ure | 5 Dispersio 3.8% 27.4% NP 14.4% | < 0.00 < 0.00 on Process: Fine Sa Silt & Cl Plastic Ind | > 0.005 mm D5 mm D1 mm Dispersant nd 45.5% ay 22.8% ex NP |
| Coarse Sand Medium Sand Method: B Maximu Notes / Deviations | d um Parti Liqu / Referen | < 75 < 4.75 < 2.00 Proc icle Size Gravel id Limit | 5 mm and > 5 mm and > 5 mm and > cedure for ol 4.75 mm 0.5% | 2.00 r).425 btainii | nm (#1 mm (#- ng Spec | 0) 40) cimen: (M Natu | Moist Coarse Sa edium Sa Plastic Li ral Moist | Clay Colloid: and and mit ure | 5 Dispersio 3.8% 27.4% NP 14.4% | < 0.00 < 0.00 on Process: Fine Sa Silt & Cl Plastic Ind | > 0.005 mm D5 mm D1 mm Dispersant nd 45.5% ay 22.8% ex NP |
| Coarse Sand Medium Sand Method: B Maximu Notes / Deviations | Jum Parti Liqu | < 75 < 4.75 < 2.00 Proc icle Size Gravel id Limit | 5 mm and > 5 mm and > 5 mm and > cedure for ol 4.75 mm 0.5% | 2.00 r).425 Dtaini | nm (#1 mm (#, ng Sper | 0) 40) cimen: // M Natu | Moist Coarse Sa edium Sa Plastic Li ral Moist | Clay Colloid: and and mit ure | 5 Dispersio 3.8% 27.4% NP 14.4% | < 0.00 < 0.00 on Process: Fine Sa Silt & Cl Plastic Ind | > 0.005 mm D5 mm D1 mm Dispersant nd 45.5% ay 22.8% ex NP |
| Coarse Sand Medium Sand Method: B Maximu Notes / Deviations | um Parti Liqu | < 75 < 4.75 < 2.00 Proc icle Size Gravel id Limit | 5 mm and > 5 mm and > 5 mm and > cedure for ol 4.75 mm 0.5% | 2.00 r r).425 Dtainin | nm (#1 mm (# ng Spe | 0) 40) cimen: M Natu | Moist Coarse Sa edium Sa Plastic Li ral Moist | Clay Colloids and and mit ure | 5 Dispersio 3.8% 27.4% NP 14.4% | < 0.00 < 0.00 on Process: Fine Sa Silt & Cl Plastic Ind | > 0.005 mm D5 mm D1 mm Dispersant nd 45.5% ay 22.8% ex NP |
| Coarse Sand Medium Sand Method: B Maximu Notes / Deviations | d um Parti Liqu / Referen | < 75 < 4.75 < 2.00 Proc icle Size Gravel id Limit | 5 mm and > 5 mm and > 5 mm and > cedure for ol 4.75 mm 0.5% | 2.00 r r).425 btaini) | nm (#1 mm (#. ng Sper | 0) 40) cimen: M Natu | Moist Coarse Sa edium Sa Plastic Li ral Moist | Clay Colloid: and and mit ure | Dispersio 3.8% 27.4% NP 14.4% | < 0.00 < 0.00 on Process: Fine Sa Silt & Cl Plastic Ind | <u> 8/30/21</u> |
| Coarse Sand Medium Sand Method: B Maximu Notes / Deviations <u>Frank N</u> Technical | um Parti Liqu / Referen | < 75 < 4.75 < 2.00 Proc icle Size Gravel id Limit nces: | 5 mm and > 5 mm and > 5 mm and > cedure for ol 4.75 mm 0.5% | 2.00 r r 0.425 btaini 1 | nm (#1 mm (# ng Spe | 0) 40) cimen: M Natu | Moist Coarse Sa edium Sa Plastic Li ral Moist | Clay Colloid: and and mit ure | s Dispersio 3.8% 27.4% NP 14.4% 14.4% | < 0.00 < 0.00 on Process: Fine Sa Silt & Cl Plastic Ind | <u> 8/30/21</u> <u>//21 //21 //21 //2 //2 //2 //2 //2 //2 //2 //2 //2 //2 //2 //2 //2 //2 //2 //2 //2 //2 //2 //3 </u> |

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | | AS7 | TM D 4318 | \mathbf{X} | AAS | снто т в | 39 [| | ASHTO | т 90 | | | | |
|-------------|---|--|--|--------------------|----------------|----------|-------------|----------|-----------|-------|-------------|--------------|-------------|-------------|
| | | S&ME | , Inc Gre | enville | 48 E | Brookfie | eld Oak | s Dr., S | uite F | Gre | enville, So | 29607 | | |
| Project | #: | 213045 | | | | | | | | | Report I | Date: | 8/30/ | 21 |
| Project | Name: | Bad Cree | ek Phase 2 | 2 Feasib | ility St | udy Pro | oject | | | | Test I | Date: | 8/19/ | 21 |
| Client N | lame: | HDR | | | | | | | | | | | | |
| Client A | ddress: | 1122 Lao | dy Street, | Suite 1 | 100 Co | olumbia | a, South | n Caroli | na 292 | 201 | | | | |
| Boring # | #: B-2 | 1-2 | | | Log #: | | 96g | | | Sam | ple Date: | | 4/20/21 | |
| Sample | ID: SS- | 7 | | | Type: | S | Split-sp | oon | | | Depth: | | 28.5' | |
| Sample | Descripti | on: | silty SAN | ID (SM) | - tan k | orown, i | mediur | n to fin | e | | | | | |
| Type and | l Specificat | ion | S&ME II | D # | Cal I | Date: | Туре | e and Sp | ecificati | ion | S8 | ME ID # | Cal | Date: |
| Balance | (0.01 g) | | 1394 | 2 | 10/19 | 0/2020 | Groo | oving to | ol | | | 23119 | 10/1 | 5/2020 |
| LL Appar | ratus | | 2315 | 8 | 2/1/ | 2021 | | | | | | | | |
| Oven Pan | # | | 1397 | 0 | 10/7 | /2020 | Liquid | d Limit | | | | Ī | Plastic Lim | it |
| ' un | " | | Tare #: | | | | Liquit | | | | | | | |
| Α | Tare Wei | ght | | | | | | | | | | | | |
| В | Wet Soil | Weight + / | Ą | | | | | | | | | | | |
| С | Dry Soil | Weight + A | A | | | | | | | | | | | |
| D | Water W | eight (B-C) |) | | | | | | | | | | | |
| F | Dry Soil | Weight (C- | A) | | | | | | | | | | | |
| F | % Moistu | ure (D/E)*1 | ý 00 | | | | | | | | | | | |
| N | # OF DR | OPS | | | | | | | | | | Moisture C | ontents de | termined by |
| 11 | 11 | = F * FAC | TOR | | | | | | | | | A A | STM D 22 | 16 |
| Ave. | | Averaae | | | | | | | | | | | | |
| | | 5 - | | | | | | | | | | One Point | Liquid Lin | nit |
| 2 | 40.0 | | | | - | 1 | | | | | N | Factor | N | Factor |
| | | | | _ | | _ | | | | | 20 | 0.974 | 26 | 1.005 |
| t i | 35.0 | | | | | | | | | | 21 | 0.979 | 27 | 1.009 |
| onte | | | | | | _ | | | | | 22 | 0.985 | 20 | 1.014 |
| e Cí | ⊨ | | | | | _ | | | | | 24 | 0.995 | 30 | 1.022 |
| stur | 30.0 | | | | | | | | | | 25 | 1.000 | | |
| Mois | | | | | | | | | | | N | IP, Non-Pl | astic | X |
| 1% | 25.0 | | | | | | | | | | | Liquid I | imit | |
| | | | | | | | | | | | | Plastic I | imit I | NP |
| | | | | | | | | | | | | Plastic Ir | ndex | NP |
| 2 | 20.0 + 10 | 15 | 20 | 25 3(|) 35 | 40 | · · · | | 1 | DO DO | (| Group Syr | nbol S | <u>M</u> |
| | | 10 | 20 | 20 00 | , 55 | 40 | # of] | Drops | | | N | Aultipoint N | Vethod | ~ |
| | | | | | | · | | | | | C | One-point N | vethod | |
| wet Pr | | | D . | • | | ir Dried | ~ | | | | % Passing | the #200 S | ieve: | 22.8% |
| Notos / [| eparation | Di Di | ry Preparat | ion 🔽 | | II Dried | | | | | | | | |
| Notes / E | eparation Deviations , | Di / Reference | ry Preparat es: | ion 🔽 |] A | in Dried | | | | | | | | |
| Notes / E | eparation Deviations , | Di Di Di di Contra di Cont | ry Preparat es: | ion 🔽 | <u>]</u> A | | | | | | | | | |
| Notes / E | eparation Deviations , 4318: Liqui | / Reference | ry Preparat s: astic Limit, | ion 🔽 & Plastic | I A | of Soils | | | | | | | | |
| Notes / E | eparation Deviations , 4318: Lique | Du Reference | ry Preparat es: astic Limit, | ion 🔽 & Plastic | I A | of Soils | | | | I. | | | 0./2 | 0/21 |
| Notes / E | eparation Deviations , 4318: Liqui Benjamin Technic | / Reference | ry Preparat ss: astic Limit, sski | ion 🗹 | : Index of 8/3 | of Soils | | Bria | an Vau | ugha | n, P.E. | | <u>8/3</u> | 0/21 |



| Single sieve set | | | | ASTM | D 6913 | | | | |
|---------------------------------------|------------------|----------|--|------------------------------|---------------|-----------|---------------|--------------|---------------------|
| | S&M | E, Inc | Greenville: | 48 Brookfield | d Oaks Dr., S | Suite F | Greenvill | le, SC 29607 | |
| Project #: | 213045 | | | | | | | Report Da | te: 8/30/21 |
| Project Name: | Bad Cree | ek Phase | e 2 Feasibilit | y Study Proje | t | | | Test Da | te: 8/10 - 8/26/21 |
| Client Name: | HDR | | | | | | | | |
| Client Address: | 1122 Lac | dy Stree | t, Suite 1100 |) Columbia, S | outh Carolir | na 2920 |)1 | | |
| Boring #: | B-21-2 | | | | Log #: | ç | 96g | Sample Da | te: 4/21/21 |
| Sample ID: | SS-8 | | | | Туре: | Split | -spoon | Dep | th: 33.5' |
| Sample Descript | tion: silty | ' SAND | (SM) - gray | brown, mediu | m to fine | | | | |
| | | | | | | | | | |
| 100% | 3" 2" 1.5 | • 1" 3/4 | ······································ | #4 #10 | #20 | #40 | #60 #100 | #140 #200 | |
| 00% | | | | | | | | | |
| 90% | | | | | | | | | |
| 80% | | | | | | | | | |
| %) 70% | | | | | | N | | | |
| ing 10% | | | | | | | | | |
| 809 ^{ASS} | ╺ | | | | | | | | |
| 50% | | | | | | | | | |
| erce | | | | | | | $+ \lambda -$ | | |
| 40% | ╞┼┼┼┼┼ | | | | | | | | |
| 30% | | | | | | | | | |
| | | | | | | | | | |
| 20% | | | | | | | | | |
| 10% | | | | | | | | | |
| | | | | | | | | | |
| 0% 100 | .00 | | 10.00 | Millimeters | 1.00 | · · · • · | · · · | 0.10 | 0.01 |
| | | | | | - | | | | |
| Cobbles | | < 300 mr | n (12") and > | 75 mm (3") | F | ine San | d | < 0.425 mm a | nd > 0.075 mm |
| Gravel | | < 75 m | nm and > 4.75 | 5 mm (#4) | | Silt | | < 0.075 and | > 0.005 mm |
| Coarse San | d | < 4.75 n | nm and >2.00 |) mm (#10) | | Clay | | < 0.0 | 05 mm |
| Method: B | 10 . | < 2.00 m | m and > 0.42 | .5 mm (#40) ning Specimen | Moist | Collolas | Dispersi | on Process: | Di mm Dispersant |
| Maxim | um Particle | Size | 4 75 mm | ning specificit | Coarse Sa | and | 3.6% | Fine Sa | nd 45.8% |
| i i i i i i i i i i i i i i i i i i i | G | iravel | 0.8% | | Medium Sa | and | 29.2% | Silt & C | av 20.7% |
| | Liauid | Limit | | | Plastic Li | mit | NP | Plastic Ind | ex NP |
| | Liquid | Liiiii | | | T lustre En | | | i lustic inc | |
| | | | | Na | atural Moist | ure | 22.5% | | |
| | | | | | | - | | | |
| | | | | | | | | | |
| Notes / Deviations | s / Reference | s: | | | | | | | |
| | , | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | C. | | | | | | |
| Frank | Morris P.F | | FRAN | K-P. MARTSIZ | - | Pr | oiect Man | ager | 8/30/21 |
| Technica | l Responsibility | / | | Signature | | <u></u> | Position | | Date |
| | | | | - | | | | | |

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | | AST | M D 4318 | \mathbf{X} | AASH | TO T 89 | 9 [| | ASHTO | Т 90 | | | | |
|-----------|-------------------------|------------------|---------------------|--------------|----------------|----------------|--------------|------------------|-----------|--------|-------------------------|--------------|--------------------------|-----------------|
| | | S&ME | , Inc Gre | enville | 48 Br | ookfiel | d Oak | s Dr., Si | uite F | Gre | enville, SO | 29607 | | |
| Project : | #: | 213045 | | | | | | | | | Report [| Date: | 8/30/2 | 21 |
| Project | Name: | Bad Cre | ek Phase 2 | 2 Feasibil | ity Stu | dy Proj | ject | | | | Test [| Date: | 8/19/2 | 21 |
| Client N | lame: | HDR | | | | | | | | | | | | |
| Client A | .ddress: | 1122 La | dy Street, | Suite 11(| 0 Col | umbia, | South | n Caroli | na 29 | 201 | • | | | |
| Boring # | #: B-2 | 1-2 | | L | og #: | | 96g | | | Sam | ple Date: | | 4/21/21 | |
| Sample | ID: SS- | 8 | | - | Туре: | Sp | olit-sp | oon | | | Depth: | | 33.5' | |
| Sample | Description | on: | silty SAN | D (SM) - | gray b | orown, | mediu | ım to fi | ne | | | | | |
| Type and | l Specificat | ion | S&ME IE |)# | Cal Do | ate: | Туре | and Spe | ecificati | on | S& | ME ID # | Cal | Date: |
| Balance | (0.01 g) | | 13942 | 2 | 10/19/2 | 2020 | Groo | oving too | bl | | | 23119 | 10/15 | 5/2020 |
| LL Appar | atus | | 23158 | 3 | 2/1/20 | 021 | | | | | | | | |
| Oven | # | | 13978 | 3 | 10///2 | 020 | Liquid | limit | | | | | Plactic Limi | + |
| Full | # | | Tare # [.] | | 1 | | Liquit | | | | | | | |
| Δ | Tare Wei | aht | Ture #. | | | | | | | | | | | |
| B | Wet Soil | Weight + / | ۵ | | | | | | | | | | | |
| | Dry Soil V | Neight + A | | | | | | | | | | | | |
| | Water W | eight (B_C) | , | | | | | | _ | | | | | |
| | | Noight (C | ۸١ | | | | | | | | | | | |
| | % Moist | | n) 00 | | | | | | | | | | | |
| | | | 00 | | | | | | | | | | | |
| | # OF DR | | | | | | | | | | | Moisture C | ontents det 221 ס אדא | ermined by 6 |
| LL | | . = F ~ FAC | IUR | | | | | | | | | | | 0 |
| Ave. | | Average | | | | | | | | _ | | One Doint | Liquid Lim | i+ |
| 4 | ^{40.0} T | | | | | | | | | | N | Factor | N | Factor |
| | | | | | | | | | | | 20 | 0.974 | 26 | 1.005 |
| | 35.0 | | | | | | | | | | 21 | 0.979 | 27 | 1.009 |
| , iten | | | | | | | | | | | 22 | 0.985 | 28 | 1.014 |
| Co | | | | | | | | | | | 23 | 0.99 | 29 | 1.018 |
| ture | 30.0 | | | | | | | | | | 24 | 1.000 | 50 | 1.022 |
| Ioist | | | | | | | | | | | N | P, Non-Pl | astic [| X |
| N % | 25.0 | | | | | | | | | | | Liquid L | imit - | |
| | | | | | | | | | | | | Plastic L | imit N | IP |
| | | | | | | | | | | | | Plastic Ir | ndex N | 1P |
| 2 | 20.0 | | | | | | | | 1 | | (| Group Syn | nbol S | М |
| | 10 | 15 | 20 | 25 30 | 35 4 | 0 | # of l | Drops | Г | 0 | Ν | 1ultipoint N | Nethod | 1 |
| | | | | | | | | | | | С | ne-point N | Nethod | |
| Wet Pr | eparation | D | ry Preparati | ion 🗸 | Air | Dried | \checkmark | | | 9 | % Passing | the #200 S | ieve: | 20.7% |
| Notes / D | , Deviations | / Reference | s: | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| ASTMD | 4318 [.] Liaui | d limit Pl | astic Limit 2 | & Plastic I | ndex of | Soils | | | | | | | | |
| | .575. Liqui | | | | | 20113 | | | | | | | | |
| <u>B</u> | <u>Benjamin</u> | J. Kovale | <u>ski</u> | | <u>8/30/</u> | <u>/21</u> | | <u>Bria</u> | an Vau | ugha | <u>n, P.E.</u> | | <u>8/3</u> | <u>0/21</u> |
| | Technic | ian Name Thic | renort chall | not he reni | Date oduced | e excent ir | n full w | Tec thout the | hnical F | espons | sibility val of S&MI | - Inc | D | ate |



| Single sieve set | | | | | | | A | STM | D 691 | 3 | | | | | | | | | | |
|----------------------|-------------------------|------------------------|--------|-----------|---------|-------|----------------|---------|--------|------------------|-----------|-----------|--------------|--------------|--------------|------|--------|----------|----------|---------|
| | S8 | хME, | Inc | Greenv | ille: | 48 | Brool | kfielc | l Oaks | 5 Dr. | , Sui | ite F | Gre | enville | e, SC | 2960 |)7 | | | |
| Project #: | 2130 | 45 | | | | | | | | | | | | _ | | Re | oort | Date | : 8/3 | 80/21 |
| Project Name: | Bad C | Ireek | Phase | e 2 Feas | sibilit | y Sti | ıdy P | rojec | t | | | | | | | | Test | Date | : 8/10 - | 8/26/21 |
| Client Name: | HDR | | | | | | | | | | | | | | | | | | | |
| Client Address: | 1122 | Lady | Stree | t, Suite | 1100 |) Co | lumb | oia, So | outh (| Caro | lina | 2920 |)1 | | | | | | | |
| Boring #: | B-21- | .2 | | | | | | | _og # | | | Ç | 96g | | | San | nple | Date | : 4/2 | 21/21 |
| Sample ID: | SS-11 | | | | | | | | Туре: | | | Split | -spoo | on | | | 0 | Depth | : 4 | 8.5' |
| Sample Description | on: s | silty S | AND | (SM) - g | gray | brow | vn, m | ediu | m to f | ine | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| 100% | 3" 2 " | 1.5" | 1" 3/4 | • | 3/8" | #4 | 1 1 | #10 | | #20 | | #40 | #60 | #100 | #140 | #200 | | | | _ |
| - | | | | | | | \succ | | | | ++ | | - | | | | - | | _ | |
| 90% | | | | | | | | | | | | | | | | | | | | |
| 80% | | | | | | | | | | | | | _ | | | | _ | | | - |
| 8 | | | | | | | | | | | | | | | | | | | | |
| sing / | | | | | | | | | | | | | | | | | | | _ | |
| - %06 Jas | | ++ | | | | | | | | | | | \leftarrow | | | | | | | |
| 50% | | | | | | | | | | | | | | | | | | | | |
| erc | | _ | | | | | | | | | | | | \mathbf{N} | | | | | _ | - |
| 40% | | | | | | | | | | | | | | | | | | | | |
| 30% | | | | | | | | | | $\left \right $ | \square | | _ | | \mathbf{A} | +++ | _ | | _ | _ |
| 2007 | | ++ | | | | | | | | | ++ | | | | | ╘ | | | | |
| 20% | | | | | | | | | | | | | | | | | | | | |
| 10% | | _ | | | | | | | | | ++ | | - | | | +++ | _ | | _ | - |
| 0% | | | | | | | | | | | | | | | | | | | | |
| 100.0 | 0 | | | 10.0 |)0 | M | illimet | ters | 1 | .00 | | • | | | 0.10 | • | | | | 0.01 |
| | | | | (10 m) | | | | | 1 | | | | | | 1 | | _ | | | |
| Cobbles | | < 3 | 00 mr | m (12") a | and > | 75 n | nm (3 | 3") | | | Fine | e San | d | | < | 0.42 | 5 m | m and | > 0.07 | 5 mm |
| Gravel | | | < 75 m | nm and a | > 4.7: |) mm | 1 (#4) (#10 | <u></u> | | | | Slit | | | | < 0. | 075 | and > | 0.005 r | nm |
| Medium Sand | 4 | < 2 | 200 m | im and > | > 0.42 | 25 mr | n (#4 | 0) | | | <u> </u> | lloids | | | | | < | 0.003 | mm | |
| Method: B | ~ | | Proced | dure for | obtai | ning | Speci | imen: | 1 | Nois | t | | Dis | persic | on Pro | cess | | Di | spersar | nt |
| Maximu | um Part | icle S | ize | 9.50 m | m | 5 | • | | Coa | rse S | Sand | t | 8.8% | 6 | | | Fine | Sand | 42 | 2.8% |
| | | Gra | vel | 2.1% |) | | | | Medi | um S | Sand | t | 23.5 | % | | 5 | Silt 8 | પ્ર Clay | 22 | 2.9% |
| | Liqu | uid Li | mit | | | | | | Pla | stic | Limi | t | NP | | | Pla | stic | Index | : I | NP |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | Na | tural | Mois | sture | e | 26.4 | % | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| Notes / Deviations , | / Refere | nces: | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | I | PAR | KP. | LUPP7 | NO | | | | _ | _ | | _ | _ | _ | | | _ |
| <u>Frank N</u> | 4 | л г | | | | | 1 Proved | -215 | | | | Dr | oioct | Mana | aaer | | | | 8/30/ | 21 |
| | /iorris, i | ^{P.E.} | | | | | | | | | | <u>F1</u> | ojeci | within | <u>. 90.</u> | | | | | |
| Technical I | /IOTTIS, I Responsil | P. <u>E.</u> bility | | _ | | Sign | ature | | | | | <u>F1</u> | Pos | sition | <u></u> | | | | Date | ? |

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | AS | TM D 4318 | X | AASHTO T | 89 🗆 | AASHTO | Т 90 | | | | |
|-------------|----------------------|----------------|-------------|-----------------|-----------------|---------------|-------------------------|---------------------------|--------------|---------------|----------------------|
| | S&ME | , Inc Gree | enville | 48 Brookfi | eld Oaks Dr | ., Suite F | Gree | enville, SC | 29607 | | |
| Project #: | 213045 | | | | | | | Report D | Date: | 8/30/2 | 21 |
| Project Na | me: Bad Cre | ek Phase 2 | Feasibilit | ty Study Pr | oject | | | Test I | Date: | 8/19/2 | 21 |
| Client Nan | ne: HDR | | | , , | 5 | | | | | | |
| Client Add | lress: 1122 La | dy Street, S | uite 110 | 0 Columbi | a, South Ca | rolina 292 | 201 | | | | |
| Boring #: | B-21-2 | | Lo | og #: | 96g | | Sam | ple Date: | | 4/21/21 | |
| Sample ID | : SS-11 | | T | ype: | Split-spoon | | | Depth: | | 48.5' | |
| Sample De | escription: | silty SAND |) (SM) - (| gray browr | n, medium t | o fine | | • | | | |
| Type and Sp | pecification | S&ME ID | # | Cal Date: | Type and | l Specificati | ion | S& | ME ID # | Cal I | Date: |
| Balance (0. | 01 g) | 13942 | 1 | 0/19/2020 | Grooving | g tool | | | 23119 | 10/15 | /2020 |
| LL Apparatu | JS | 23158 | | 2/1/2021 | | | | | | | |
| Oven | | 13978 | | 10/7/2020 | | | | | | | |
| Pan # | | T | | | Liquid Lim | it | | | | Plastic Limit | t |
| • T | | Tare #: | | | | | | | | | |
| A | are weight | | | | | | | | | | |
| B V | Vet Soil Weight + | A | | | | | | | | | |
| C D | Ory Soil Weight + A | 4 | | | | | | | | | |
| D V | Vater Weight (B-C |) | | | | | | | | | |
| E D | Pry Soil Weight (C- | A) | | | | | | | | | |
| F % | 6 Moisture (D/E)*1 | 00 | | | | | | | | | |
| N # | OF DROPS | | | | | | | | Moisture C | ontents dete | ermined by |
| LL | LL = F * FAC | TOR | | | | | | | A | STM D 221 | 6 |
| Ave. | Average | | | | | | | | | | |
| 40.0 |) - | | | | | | | (| One Point I | Liquid Limi | it |
| -0.0 | | | | | | | | N | Factor | N | Factor |
| | | | | | | | | 20 | 0.974 | 26 | 1.005 |
| T 35.0 |) [| | | | | | | 21 | 0.979 | 27 | 1.009 |
| onte | | | | | | | | 23 | 0.99 | 29 | 1.014 |
| Ŭ | | | | | | | | 24 | 0.995 | 30 | 1.022 |
| stur 30.0 | , <u> </u> | | | | | | | 25 | 1.000 | | |
| Moi | | | | | | | | N | P, Non-Pl | astic 🖸 | रा |
| 25.0 | , | | | | | | | | Liquid L | imit - | |
| | | | | | | | | | Plastic L | imit N | IP |
| | | | | | | | | | Plastic Ir | ndex N | IP |
| 20.0 | 10 15 | 20 (| 25 20 | 25 40 | ++ | | 1 DO | (| Group Syn | nbol S | M |
| | 15 | 20 2 | 25 50 | 35 40 | # of Drop | os | | N | Iultipoint N | /lethod | ~ |
| | | | | | | | | C | ne-point N | /lethod | |
| Wet Prepa | aration D | ry Preparatio | on ∠ | Air Dried | J | | 9 | % Passing | the #200 S | ieve: | 22.9% |
| Notes / Dev | viations / Reference | ?S: | | | | | | | | | |
| | | | | | | | | | | | |
| ASTM D 43 | 18: Liquid Limit, Pl | astic Limit, & | Plastic In | dex of Soils | | | | | | | |
| D | hismin L Kaurd | | | 0/20/21 | | | ab - | | | 0 /2/ | 1/21 |
| Ber | IJamin J. KOVale | <u>25KI</u> | | 0/30/21 Date | | Technical P | <u>uynar</u> Respons | <u>I, P.E.</u> ibility | | <u>8/3(</u> | <u>J/ Z </u> 11P |
| | Thic | report shall n | ot be renro | duced. excent | in full. withou | t the written | approv | val of S&MI | . Inc. | | |



| | | | | 71311 | | | | |
|--|---|--|----------------------------------|------------------------------------|---|--|---|--|
| | S&ME | E, Inc G | ireenville: | 48 Brookfie | ld Oaks Dr., S | uite F Greenvill | e, SC 29607 | |
| Project #: | 213045 | | | | | | Report Date: | 8/30/21 |
| Project Name: | Bad Cree | k Phase | 2 Feasibilit | y Study Proje | ect | | Test Date: | 8/10 - 8/26/21 |
| Client Name: | HDR | | | | | | | |
| Client Address: | 1122 Lad | ly Street, | Suite 1100 | Columbia, | South Carolina | a 29201 | | |
| Boring #: | B-21-2 | | | | Log #: | 96g | Sample Date: | 4/21/21 |
| Sample ID: | SS-12 | | | | Туре: | Split-spoon | Depth: | 53.5' |
| Sample Descripti | on: silty | SAND (S | SM) - gray, | medium to | fine | | | |
| (| ² " 2 " 4 5 | | 2 (01 | #4 #* | 10 #20 | #40 #60 #100 | #140 #200 | |
| 100% | 3 2 I.5 | 1 3/4 | 3/8 | | 10 #20 | *40 *00 *100 | * 140 #200 | |
| 90% | | | | | | | | |
| 50% | | | | | | | | |
| ि 80% | | | | | | | | |
| e) ∞ 70% - | | | | | | | | |
| Ssin | | | | | | ++ | | |
| Ba 60% | | | | | | | | |
| - 50% - | | | | | | $+$ $+$ \wedge | | |
| Jow | | | | | | <u> </u> | | |
| - 40% | | | | | | | $\mathbf{Y} = \mathbf{Y}$ | |
| 30% | | + + | | | | | | |
| 20% | | | | | | | | |
| - | | + + | | | | | | |
| 10% - | | | | | | | | |
| 0% | | | 10.00 | | | • | | |
| 100.0 | 0 | | 10.00 | Millimeters | 1.00 | | 0.10 | 0.01 |
| Cobbles | < | : 300 mm | (12") and > | 75 mm (3") | Fir | ne Sand | < 0.425 mm and | > 0.075 mm |
| Gravel | | < 75 mn | n and > 4.75 | 5 mm (#4) | | Silt | < 0.075 and > | 0.005 mm |
| Coarse Sand | | < 4.75 mr | m and >2.00 |) mm (#10) | | Clay | < 0.005 (| mm |
| Medium Sano | 4 / 2 | 2 2 2 | a and b 0.42 | E (#40) | | | | |
| Mathada D | | 2.00 mm | 1 anu > 0.42 | .5 mm (#40) | C | olloids | < 0.001 | nm |
| Method: B | um Darticla | Procedu | re for obtai | ning Specime | n: Moist | olloids Dispersio | on Process: Dis | mm spersant |
| Method: B Maximu | um Particle | 2.00 mm Procedu Size 4 | ure for obtai 1.75 mm | is mm (#40) ning Specime | n: Moist Coarse Sar | olloids Dispersion Dis | on Process: Dis Fine Sand | mm spersant 50.2% |
| Method: B Maximu | um Particle G | 2.00 mm Procedu Size 2 ravel | ure for obtai 4.75 mm 0.2% | ning Specime | n: Moist Coarse Sar Medium Sar | olloids Dispersion ad 2.5% ad 21.4% | < 0.001 r on Process: Dis Fine Sand Silt & Clay Plastic Index | mm spersant 50.2% 25.6% |
| Method: B Maximu | um Particle G Liquid | 2.00 mm Procedu Size 2 ravel Limit | ure for obtai 4.75 mm 0.2% | <u>is mm (#40)</u> ning Specime | n: Moist Coarse Sar Medium Sar Plastic Lim | olloids Dispersion nd 2.5% nd 21.4% nit NP | < 0.001 m on Process: Dis Fine Sand Silt & Clay Plastic Index | mm spersant 50.2% 25.6% NP |
| Method: B Maximu | um Particle G Liquid I | 22.00 mm Procedu Size 2 ravel Limit | ure for obtai 4.75 mm 0.2% | <u>s mm (#40)</u> ning Specime | n: Moist Coarse Sar Medium Sar Plastic Lim | olloids Dispersion ad 2.5% and 21.4% nit NP re 20.4% | < 0.001 microsoft on Process: Disconsistence Fine Sand Silt & Clay Plastic Index | mm spersant 50.2% 25.6% NP |
| Method: B Maximu | um Particle G Liquid I | 22.00 mm Procedu Size 2 ravel Limit | ure for obtai 4.75 mm 0.2% | <u>s mm (#40)</u> ning Specime | n: Moist Coarse Sar Medium Sar Plastic Lim Iatural Moistu | olloids Dispersion ad 2.5% ad 21.4% hit NP re 20.4% | < 0.001 point Process: Dis Fine Sand Silt & Clay Plastic Index | mm spersant 50.2% 25.6% NP |
| Method: B Maximu | um Particle G Liquid I | Procedu Size 4 ravel Limit | 4.75 mm 0.2% | <u>s mm (#40)</u> ning Specime | n: Moist Coarse Sar Medium Sar Plastic Lim Jatural Moistu | olloids Dispersion and 2.5% and 21.4% nit NP re 20.4% | < 0.001 i on Process: Dis Fine Sand Silt & Clay Plastic Index | mm spersant 50.2% 25.6% NP |
| Method: B Maximu Maximu | um Particle G Liquid I | 2.00 mm Procedu Size 2 ravel Limit | 4.75 mm 0.2% | ning Specime | n: Moist Coarse Sar Medium Sar Plastic Lim Jatural Moistu | olloids Dispersion and 2.5% and 21.4% nit NP re 20.4% | < 0.001 i on Process: Dis Fine Sand Silt & Clay Plastic Index | mm spersant 50.2% 25.6% NP |
| Method: B Maximu Notes / Deviations | um Particle G Liquid I / References | 2.00 mm Procedu Size 2 ravel Limit | 4.75 mm 0.2% | ning Specime | n: Moist Coarse Sar Medium Sar Plastic Lim Jatural Moistu | olloids Dispersion and 2.5% and 21.4% nit NP re 20.4% | < 0.001 i on Process: Dis Fine Sand Silt & Clay Plastic Index | mm spersant 50.2% 25.6% NP |
| Method: B Maximu Notes / Deviations | um Particle G Liquid I / References | 2.00 mm Procedu Size 4 ravel Limit | 4.75 mm 0.2% | ning Specime | n: Moist Coarse Sar Medium Sar Plastic Lim Jatural Moistu | olloids Dispersion and 2.5% and 21.4% nit NP re 20.4% | < 0.001 i on Process: Dis Fine Sand Silt & Clay Plastic Index | mm spersant 50.2% 25.6% NP |
| Method: B Maximu Notes / Deviations | um Particle G Liquid I | 2 2.00 mm Procedu Size 2 ravel Limit | 4.75 mm 0.2% | ning Specime | n: Moist Coarse Sar Medium Sar Plastic Lim Jatural Moistu | olloids Dispersion and 2.5% and 21.4% nit NP re 20.4% | < 0.001 point Process: Dis Fine Sand Silt & Clay Plastic Index | mm spersant 50.2% 25.6% NP |
| Method: B Maximu Notes / Deviations | um Particle G Liquid I | 2.00 mm Procedu Size 4 ravel Limit | 4.75 mm 0.2% | ning Specime | n: Moist Coarse Sar Medium Sar Plastic Lim Jatural Moistu | olloids Dispersion and 2.5% and 21.4% nit NP re 20.4% | < 0.001 point Process: Dis Fine Sand Silt & Clay Plastic Index | mm spersant 50.2% 25.6% NP |
| Method: B Maximu Notes / Deviations | um Particle G Liquid I / <i>References</i> // <i>Norris</i> , P.E. | 2.00 mm Procedu Size 2 ravel Limit | 4.75 mm 0.2% | N N N N | n: Moist Coarse Sar Medium Sar Plastic Lim Jatural Moistu | olloids Dispersion and 2.5% and 21.4% nit NP re 20.4% <u>Projec</u> t Man | < 0.001 i on Process: Dis Fine Sand Silt & Clay Plastic Index | mm spersant 50.2% 25.6% NP |
| Method: B Maximu Notes / Deviations <u>Frank N</u> Technical | um Particle G Liquid I / References <u>Aorris, P.E.</u> Responsibility | 2.00 mm Procedu Size 2 ravel Limit | 4.75 mm 0.2% | Signature | n: Moist Coarse Sar Medium Sar Plastic Lim Jatural Moistu | olloids Dispersion and 2.5% and 21.4% nit NP re 20.4% Project Man Position | < 0.001 i on Process: Dis Fine Sand Silt & Clay Plastic Index | mm spersant 50.2% 25.6% NP <u>8/30/21</u> Date |

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | | ASTM D 43 | 18 🗵 | AASHT | TO T 89 | | AASHTO | т 90 | | | | |
|-----------|-------------------|--------------------------------|---------------|--------------|--------------|--------------|-----------------|---------|-------------|--------------|---------------------------|-------------|
| | | S&ME, Inc (| Greenville | e 48 Bro | okfield | Oaks Dr. | , Suite F | Gree | enville, SC | 29607 | | |
| Project # | #: 2 | 213045 | | | | | | | Report [| Date: | 8/30/2 | 21 |
| Project I | Name: E | Bad Creek Phas | se 2 Feasi | bility Stud | ly Projec | t | | | Test I | Date: | 8/19/2 | 21 |
| Client N | ame: H | HDR | | , | <u> </u> | | | | | | | |
| Client A | ddress: ´ | 1122 Lady Stree | et, Suite 1 | 100 Colu | ımbia, So | outh Car | olina 29 | 201 | | | | |
| Boring # | ŧ: B-21- | -2 | | Log #: | | 96g | | Sam | ple Date: | | 4/21/21 | |
| Sample | ID: SS-12 | 2 | | Type: | Split | t-spoon | | | Depth: | | 53.5' | |
| Sample | Description | n: silty S | AND (SM |) - gray, n | nedium | to fine | | | | | | |
| Type and | Specification | n S&M | E ID # | Cal Da | te: | Type and | Specificati | ion | S& | ME ID # | Cal L | Date: |
| Balance | (0.01 g) | 13 | 942 | 10/19/2 | .020 | Grooving | tool | | | 23119 | 10/15 | /2020 |
| LL Appara | atus | 23 | 158 | 2/1/20 | 21 | | | | | | | |
| Oven | | 13 | 978 | 10/7/20 | 020 | | | | | | | |
| Pan Ŧ | # | Tare | <i>#</i> · | - | | Iquid Limit | | | | | Plastic Limit | i |
| Δ | Tare Weigh | t int | <i>m</i> . | | | | | | | | | |
| R | Wet Soil W | $r_{\text{eight}} \pm \Lambda$ | | | | | | | | | | |
| D C | | $right + \Lambda$ | | | | | | | | | | |
| | Matar Mai | | | | _ | | | | | | | |
| | | gint (B-C) | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| N | # OF DROP | | _ | _ | _ | | | | | Moisture C | ontents dete בכב ח אדא | ermined by |
| LL | LL = | F FACTOR | | | | | | | | | 51110 2210 | 5 |
| Ave. | | Average | | | | | | _ | | Dna Baint I | iquid Limi | + |
| 4 | ^{10.0} T | | | | | | | | N | Factor | N | Factor |
| | | | | | | | | | 20 | 0.974 | 26 | 1.005 |
| | 15 0 L | | | | | | | | 21 | 0.979 | 27 | 1.009 |
| , ten | | | | | | | | | 22 | 0.985 | 28 | 1.014 |
| Con | | | | | | | | | 23 | 0.99 | 29 | 1.018 |
| an 3 | io.0 - | | | | | | | | 24 | 0.995 | 30 | 1.022 |
| oist | | | | | | | | | N | P. Non-Pla | astic D | ব |
| W S | | | | | | | | | | Liquid L | imit - | |
| | .5.0 | | | | | | | | | Plastic L | imit N | IP |
| | - | | | | | | | | | Plastic Ir | ndex N | IP |
| 2 | 20.0 | | | +++ | | | | | (| Group Syn | nbol S | М |
| | 10 | 15 20 | 25 | 30 35 40 |) [# | t of Drops | , ¹⁰ | 00 | Ν | Iultipoint N | /lethod | 1 |
| \square | | | | | | | | | C | ne-point N | /lethod | |
| Wet Pre | eparation | Dry Prepa | aration | ∠ Air l | Dried | ~ | | 0 | % Passing | the #200 S | ieve: | 25.6% |
| Notes / D | Deviations / R | References: | | | | | | | | | | |
| | | | | | | | | | | | | |
| | 1218. Liquid | Limit Plastic Lim | nit & Plact | ic Index of | Soils | | | | | | | |
| ASTIND2 | +5 10. LIYUU | Lanti, Flustic Litt | ni, a riusii | ic muex of . | 50115 | | | | | | | |
| B | <u>enjamin J.</u> | Kovaleski | | <u>8/30/</u> | <u>21</u> | E | Brian Vau | ughai | n, P.E. | | <u>8/30</u> | <u>)/21</u> |
| | Techniciar | n Name | | Date | | | Technical F | Respons | ibility | | Da | ite |
| | | This report sh | hall not be r | eproduced, e | except in fu | ıll, without | the written | appro | val of S&ME | , Inc. | | |



| | | | | ASTI | 4 D 6913 | | | |
|--------------------------------|---|-----------------------------------|---------------------|---------------|--|---|---|--|
| | S&M | E, Inc G | reenville: | 48 Brookfie | eld Oaks Dr., Su | uite F Greenvil | le, SC 29607 | |
| Project #: | 213045 | | | | | | Report Date: | 8/30/21 |
| Project Name: | Bad Cree | ek Phase 2 | 2 Feasibilit | y Study Proj | ect | | Test Date: | 8/10 - 8/26/21 |
| Client Name: | HDR | | | | | | | |
| Client Address: | 1122 Lac | dy Street, | Suite 1100 |) Columbia, | South Carolina | a 29201 | | |
| Boring #: | B-21-2 | | | | Log #: | 96g | Sample Date: | 4/21/21 |
| Sample ID: | SS-13 | | | | Туре: | Split-spoon | Depth: | 58.5' |
| Sample Description | on: silty | / SAND (S | M) - gray, | coarse to fir | าย | | | |
| | <u>)</u> | | 2 (0) | <i>""</i> " | 10 #20 | #40 #60 #100 | #140 #200 | |
| 100% | 3 2 1.5 ● ● ● | ■ 3/4 | 3/8 | | ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ | +40 #00 #100 | * 140 #200 | |
| 90% | | | | | | | | |
| 50% | | | | | | | | |
| ত ^{80%} | | | | | | | | |
| <u>ຄ</u> . 70% - | | | | | | | | I |
| liss cox | | | | | | | | |
| %00 It Ba | | | | | | | | |
| 50% | | | | | | | | |
| <u>ق</u> 40% | | | | | | | | |
| | | | | | | | \mathbf{X} | |
| 30% | | | | | | | | |
| 20% | | _ | | | | | | I I |
| 10% | | | | | | | | |
| 10% | | | | | | | | |
| 0% | ♦) | | 10.00 | Millimeters | 1.00 | | 0.10 | 0.01 |
| | | | | [<u></u> | | | | |
| Cobbles | < | < 300 mm | (12") and > | • 75 mm (3") | Fin | e Sand | < 0.425 mm and | > 0.075 mm |
| Gravel | | < 75 mm | n and > 4.7 | 5 mm (#4) | | Silt | < 0.075 and > | 0.005 mm |
| Coarse Sand | | < 4.75 mn | n and > 2.00 | 0 mm (#10) | | Clay | < 0.005 | mm |
| Method: B | | Procedu | re for obtai | inina Specime | en: Moist | Dispersi | on Process: Dis | spersant |
| | | | | 5 1 | | | | |
| Maximu | m Particle | Size 9 | .50 mm | | Coarse San | d 9.6% | Fine Sand | 40.0% |
| Maximu | m Particle G | e Size 9 iravel | .50 mm 4.3% | | Coarse San Medium San | id 9.6% id 22.0% | Fine Sand Silt & Clay | 40.0% 24.0% |
| Maximu | m Particle G Liquid | e Size 9 iravel Limit | 0.50 mm 4.3% | | Coarse San Medium San Plastic Lim | id 9.6% id 22.0% it NP | Fine Sand Silt & Clay Plastic Index | 40.0% 24.0% NP |
| Maximu | m Particle G Liquid | e Size 9 iravel Limit | .50 mm 4.3% | | Coarse San Medium San Plastic Lim | id 9.6% id 22.0% it NP | Fine Sand Silt & Clay Plastic Index | 40.0% 24.0% NP |
| Maximu | m Particle G Liquid | e Size 9 iravel Limit | .50 mm 4.3% | 1 | Coarse San Medium San Plastic Lim Natural Moistur | d 9.6% d 22.0% it NP re 17.5% | Fine Sand Silt & Clay Plastic Index | 40.0% 24.0% NP |
| Maximu | m Particle G Liquid | e Size 9 Gravel Limit | .50 mm 4.3% | 1 | Coarse San Medium San Plastic Lim Natural Moistur | d 9.6% d 22.0% it NP re 17.5% | Fine Sand Silt & Clay Plastic Index | 40.0% 24.0% NP |
| Maximu | m Particle G Liquid | e Size 9 iravel Limit | .50 mm 4.3% | 1 | Coarse San Medium San Plastic Lim Natural Moistur | d 9.6% d 22.0% it NP re 17.5% | Fine Sand Silt & Clay Plastic Index | 40.0% 24.0% NP |
| Maximu Notes / Deviations / | m Particle G Liquid | e Size 9 Gravel Limit | .50 mm 4.3% | 1 | Coarse San Medium San Plastic Lim Natural Moistur | d 9.6% d 22.0% it NP re 17.5% | Fine Sand Silt & Clay Plastic Index | 40.0% 24.0% NP |
| Maximu | m Particle G Liquid <i>Reference</i> | e Size 9 Gravel Limit | 9.50 mm 4.3% | 1 | Coarse San Medium San Plastic Lim Natural Moistur | d 9.6% d 22.0% it NP re 17.5% | Fine Sand Silt & Clay Plastic Index | 40.0% 24.0% NP |
| Maximu Notes / Deviations / | m Particle G Liquid | e Size 9 iravel Limit | 9.50 mm 4.3% | 1 | Coarse San Medium San Plastic Lim Natural Moistur | d 9.6% d 22.0% it NP re 17.5% | Fine Sand Silt & Clay Plastic Index | 40.0% 24.0% NP |
| Maximu Notes / Deviations / | m Particle G Liquid | e Size 9 iravel Limit s: | 9.50 mm 4.3% | 1 | Coarse San Medium San Plastic Lim Natural Moistur | Id 9.6% Id 22.0% Iit NP re 17.5% | Fine Sand Silt & Clay Plastic Index | 40.0% 24.0% NP |
| Notes / Deviations / | m Particle G Liquid | e Size 9 iravel Limit | .50 mm 4.3% | 1xPrugets | Coarse San Medium San Plastic Lim Natural Moistur | Id 9.6% Id 22.0% It NP Te 17.5% | Fine Sand Silt & Clay Plastic Index | 40.0% 24.0% NP |
| Maximu Notes / Deviations / | m Particle G Liquid Reference | e Size 9 iravel Limit s: | 1.50 mm 4.3% | Signature | Coarse San Medium San Plastic Lim Natural Moistur | d 9.6% d 22.0% it NP re 17.5% Project Man Position | Fine Sand Silt & Clay Plastic Index | 40.0% 24.0% NP <u>8/30/21</u> Date |

LIQUID LIMIT, PLASTIC LIMIT, & PLASTIC INDEX



| | | ASTM D 43 | 318 | × 4 | ASHTO T | <i>89</i> | | ASHTO T 90 | | | | |
|------------|-------------------------------|--------------------|-------------|--------------|-----------------------|--------------|---------------------|--------------|------------------------|--------------|---------------|-------------|
| | | S&ME, Inc | Greenvi | lle 4 | 8 Brookfi | eld Oak | s Dr., Su | ite F Gr | eenville, So | 29607 | | |
| Project # | <i>t</i> : | 213045 | | | | | | | Report [| Date: | 8/30/2 | 21 |
| Project N | Name: | Bad Creek Pha | se 2 Fea | sibility | Study Pr | oject | | | Test I | Date: | 8/19/2 | 21 |
| Client Na | ame: | HDR | | , | , | 5 | | | | | | |
| Client Ac | ddress: | 1122 Lady Stre | et, Suite | e 1100 | Columbi | a, South | Carolin | a 29201 | - | | | |
| Boring # | : B-21 | -2 | | Log | #: | 96g | | Sar | nple Date: | | 4/21/21 | |
| Sample I | ID: SS-1 | 3 | | Тур | be: | Split-sp | oon | | Depth: | | 58.5' | |
| Sample I | Description | n: silty S | SAND (S | M) - gr | ay, coars | e to fine | 9 | | • | | | |
| Type and | Specificatio | n S&M | 1E ID # | C | al Date: | Туре | and Spe | cification | S& | ME ID # | Cal I | Date: |
| Balance (| (0.01 g) | 13 | 3942 | 10 | /19/2020 | Groc | ving too | I | | 23119 | 10/15 | /2020 |
| LL Appara | atus | 2 | 3158 | 2, | /1/2021 | | | | | | | |
| Oven | | 13 | 3978 | 10 |)/7/2020 | | | | | | | |
| Pan # | ŧ | T | | | | Liquic | l Limit | | | | Plastic Limi | t |
| | T | . I are | #: | | | | | | | | | |
| A | Tare Weigi | nt | | | | | | | | | | |
| В | Wet Soil W | /eight + A | | | | | | | | | | |
| C | Dry Soil W | eight + A | | | | | | | | | | |
| D | Water Wei | ght (B-C) | | | | | | | | | | |
| E | Dry Soil W | eight (C-A) | | | | | | | | | | |
| F | % Moistur | e (D/E)*100 | | | | | | | | | | |
| Ν | # OF DROI | PS | | | | | | | | Moisture C | ontents dete | ermined by |
| LL | LL = | F * Factor | | | | | | | | A | STM D 221 | 6 |
| Ave. | | Average | | | | | | | | | | |
| | 0.0 - | | | _ | | | | | | One Point I | _iquid Lim | it |
| 1 | | | | | | | | | N | Factor | N | Factor |
| | | | | | | | | | 20 | 0.974 | 26 | 1.005 |
| t 3 | 5.0 | | | | | | | | 21 | 0.979 | 28 | 1.009 |
| onte | | | | | | | | | 23 | 0.99 | 29 | 1.014 |
| Č Č | | | | | | | | | 24 | 0.995 | 30 | 1.022 |
| stur | 0.0 | | | | | | | | 25 | 1.000 | | |
| Moi | | | | | | | | | N | P, Non-Pl | astic 🛛 | र |
| 8 2 | 5.0 | | | | | | | | | Liquid L | .imit - | |
| | | | | | | | | | | Plastic L | imit N | IP |
| | | | | | | | | | | Plastic Ir | ndex N | IP |
| 2 | 0.0 + 10 | 15 20 | 25 | 20 2 | 5 40 | • • • | | 100 | (| Group Syn | nbol S | M |
| | | 15 20 | 23 | 50 5 | 5 40 | # of I | Drops | | N | Iultipoint N | /lethod | 7 |
| | | | | | | | | | C | ne-point N | /lethod | |
| Wet Pre | eparation | Dry Prep | aration | \checkmark | Air Dried | \checkmark | | | % Passing | the #200 S | ieve: | 24.0% |
| Notes / D | eviations / I | References: | | | | | | | | | | |
| | | | | | | | | | | | | |
| ASTM D 4 | 1318: Liquid | Limit, Plastic Lin | nit, & Pla | stic Inde | ex of Soils | | | | | | | |
| | oniomia | Kovalaski | | 0 | /20/21 | | Duin | | | | 0 /2/ | 1/21 |
| <u>B</u> (| <u>enjamn J.</u> Technicia | n Name | | <u>8</u> | <u>130/21</u> Date | | <u>BIID</u> Tech | nical Respo | aii, r.c. nsibility | | <u>ס אס</u> | $J/ \leq I$ |
| | | This report s | hall not be | e reprodi | iced, except | in full, wi | thout the | written appi | oval of S&MI | E, Inc. | 20 | - |

SIEVE ANALYSIS OF SOIL

| Single sieve set | | | | | | | | ASTN | 1 D 69 | 13 | | | | | | | | | | | |
|----------------------|-----------------|----------------|----------|------------|---------|-----------|------------|--------------|-----------|-----------|---------|------------|--------------|-------------|-------|--------|---------|-------------|---------|---------------|-------------|
| | | S&N | /IE, Ind | c Spa | rtar | nbur | g: | 301 Z | ima Pa | ırk D | rive | , Spai | tanb | urg, S | C 29 | 930 |)1 | | | | |
| Project #: | 2130 | 045 | | | | | | | | | | | | | | F | Rep | ort | Date: | 8/30 |)/21 |
| Project Name: | Bad | Creek | Phas | e 2 Fea | sibi | lity | Stud | y Proj | ect | | | | | | | ٦ | [est | t Da | te(s): | 8/16 - 8 | /18/21 |
| Client Name: | HDR | | | | | | | | | | | | | | | | | | | | |
| Client Address: | 1122 | Lady | / Stree | et, Suite | e 11 | 00 | Colu | ımbia, | South | Car | olin | a 292 | 201 | | | | | | | | |
| Borehole: | B-21 | -3 | | | | | | | Log # | #: | | | 135 | | | Sa | am | ple | Date: | 4/20 |)/21 |
| Sample ID: | SS-1 | | | | | | | | Туре | : | | Split | -spoc | on | | | | D | epth: | 0 | |
| Sample Description | on: | silty S | SAND | (SM) - | red | bro | own, | mediu | um to f | fine | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| 100% - | | | 1" 3/ | 4" 3 | /8" | | #4 | # | 10 | #20 |) | #40 | #60 | #100 | #140 | #20 | 0 | | | | _ |
| | | | | - | _ | | | | | | | | _ | | | | | | | _ | - |
| 90% | | | | | | | | | | | \prec | | | | | | | | | | |
| 80% | | | | | | | | | | | | N | | | | | | | | | |
| (%) | | | | | | | | | | | | | \mathbf{N} | | | | | | | | - |
| ຸ _ສ 70% | | | | | | | | | | | | | | | | | | | | | |
| SSB 60% | | | | | | | | | | | | | | | | | | | | | - 1 |
| | | | | | | | | | | | | | | | V | | | | | | - |
| 50% | | | | | | | | | | | | | | | | / | | | | | |
| <u>40%</u> | | | | | | \square | | | | | | | _ | | | | | | | _ | - 1 |
| 30% | | | | | | | | | | | | | | | | | | | | | |
| 50% | | | | | | | | _ | | | | | | | | | | | | | |
| 20% | | | | | | | | _ | | | | | | | | | _ | | | | |
| 10% | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | _ | | | | | | | _ | - |
| 0% - | | | <u> </u> | 10 | .00 | <u> </u> | ♦ M:II: | motors | | 1.00 | | _ | | | 0.10 | | | <u> </u> | | | 0.01 |
| 100.0 | ,0 | | | 10 | .00 | l | IVIIIII | meters | | 1.00 | | | | | 0.1 | 0 | | | | | |
| Cobbles | | < | 300 m | m (12") | and | > 7 | 5 mm | า (3") | | | Fin | e San | d | | | < 0. | .425 | 5 mr | n and | > 0.075 | mm |
| Gravel | | | < 75 n | nm and | > 4. | .75 r | nm (# | <i>‡</i> 4) | | | | Silt | | | | < | 0.0 |)75 a | and > (| 0.005 mi | n |
| Coarse Sand | | < | : 4.75 ı | mm and | >2. | .00 r | nm (# | <i>‡</i> 10) | | | | Clay | | | | | | < | 0.005 r | nm | |
| Medium Sand | k | < | 2.00 m | nm and | > 0.4 | 425 | mm (| (#40) | | | Co | olloids | | | | | | < | 0.001 r | nm | |
| Method: B | D | 4:-I- <i>(</i> | Proce | dure for | obt | taini | ng Sp | pecime | n: | Mois | st C | | Dis | persic ⁄ | on Pr | oce | ss: | • | Dis | persant | C 0/ |
| Maximu | im Par | ticle : | Size | 9.50 n | nm ⁄ | | | | | arse | San | a | 2.9% | 6 24 | | | ۲ د. | ine In o | Sand | 35. | 0% 00/ |
| | | Gra | avei | 1.2% | 6 | | | | Med | ium | San | a | 13.5 | % | | _ | 51 | IT & | Clay | 46. | 8% |
| | Liq | uid Li | Imit | 33 | | | | | Pla | astic | Lim | it | 25 | | | ŀ | las | tic | ndex | ٤ | 3 |
| | | | | | | | | | | | | | 10.00 | 24 | | | | | | | |
| | (| | | | | | | N | latural | IVIOI | stur | re | 16.3 | % | | | | | | | |
| Notes / Deviations , | / Refere | ences: | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | | | | 1 | FR | ANK | Pru | PRISC | 2. | | | | | | | | | | | | |
| <u>Frank N</u> | <u>/lorris,</u> | <u>P.E.</u> | | _ | | | | | | | | <u>Pr</u> | oject | Mana | ager | | | | | <u>8/30/2</u> | 1 |
| Technical | kespons | wiity | | | | S | ıgnatı | ire | | | | | Pos | sition | | | | | | Date | |
| | | This | report s | hall not l | be re | prod | uced, (| except i | n full, w | ithout | t the | written | appro | val of S | &ME | :, Inc | с. | | | | |



| | | ASTM D 4318 | X | AASHTO | <i>T 89</i> 🗖 | I AAS | 5НТО Т 90 | | | | |
|-----------|-------------------------------|---------------------|--------------|--------------|---------------|-----------|-----------|-------------|--------------|---------------|------------|
| | | S&ME, Inc | Spartanb | ourg: 301 | 1 Zima Par | k Drive, | Spartanb | urg, SC 29 | 9301 | | |
| Project # | #: 2130 |)45 | | | | | | Report I | Date: | 8/30/2 | 21 |
| Project N | Name: Bad | Creek Phase 2 | 2 Feasibili | ty Study F | Project | | | Test [| Date: | 8/26/2 | 21 |
| Client Na | ame: HDR | | | | - | | | | | | |
| Client Ac | ddress: 1122 | 2 Lady Street, | Suite 110 | 0 Columl | bia, South | Carolina | a 29201 | | | | |
| Borehole | e: B-21-3 | | Lo | og #: | 135 | | Sam | ple Date: | | 4/20/21 | |
| Sample I | ID: SS-1 | | 1 | Гуре: | Split-spc | on | | Depth: | | 0' | |
| Sample | Description: | silty SAN | D (SM) - | red brow | n, medium | to fine | | | | | |
| Type and | Specification | S&ME IE |)# | Cal Date: | Туре | and Speci | ification | S& | ME ID # | Cal | Date: |
| Balance (| (0.01 g) | 7537 | | 1/29/2021 | Groov | ving tool | | | 14185 | 9/28 | /2020 |
| LL Appara | atus | 13859 | 9 | 9/28/2020 |) | | | | | | |
| Oven | | 7313 | | 7/30/2021 | | | | | | | |
| Pan # | # | Τ | D 1 | | Liquid | Limit | 1 | 1 | 1 | Plastic Limi | t |
| | T N (1) | Tare #: | P-1 | P-2 | P-3 | | | | 12.11 | 2 | |
| A | Tare Weight | | 16.31 | 15.20 | 16.52 | | | | 12.11 | 12.16 | |
| В | Wet Soil Weigh | it + A | 37.37 | 36.51 | 36.80 | | | | 19.71 | 19.55 | |
| C | Dry Soil Weight | t + A | 32.33 | 31.23 | 31.59 | | | | 18.22 | 18.08 | |
| D | Water Weight (| B-C) | 5.04 | 5.28 | 5.21 | | | | 1.49 | 1.47 | |
| E | Dry Soil Weight | t (C-A) | 16.02 | 16.03 | 15.07 | | | | 6.11 | 5.92 | |
| F | % Moisture (D/ | E)*100 | 31.5% | 32.9% | 34.6% | | | | 24.4% | 24.8% | |
| Ν | # OF DROPS | | 32 | 23 | 17 | | | | Moisture C | ontents det | ermined by |
| LL | LL = F * | FACTOR | | | | | | | A | STM D 221 | 6 |
| Ave. | Aver | rage | | | | | | | | 24.6% | |
| 4 | 3.0 T | 1 1 | | | | | | (| One Point I | Liquid Lim | it _ |
| | | | | | | | | N 20 | Factor | N | Factor |
| | | | | | | | | 20 | 0.974 | 26 | 1.005 |
| ti 3 | 8.0 | | | | | | | 22 | 0.985 | 28 | 1.014 |
| onto | | | _ | | | | | 23 | 0.99 | 29 | 1.018 |
| U e C | 2.0 | | | | | | | 24 | 0.995 | 30 | 1.022 |
| stur ° | 3.0 | | | | | | | 25 | 1.000 | | |
| Moi | | | | | | | | I | NP, Non-Pl | lastic | |
| × 2 | 8.0 | | | | | | | | Liquid L | imit 3 | 3 |
| | | | | | | | | | Plastic L | imit 2 | 25 |
| | | | | | | | | | Plastic Ir | ndex | 8 |
| 2 | 3.0 + | + + | | | | | 100 | (| Group Syn | nbol S | М |
| | | 15 20 | 25 30 | 35 40 | # of D | rops | 100 | Ν | Iultipoint N | /lethod | 1 |
| | | | | | | | | C | ne-point N | lethod | |
| Wet Pre | eparation | Dry Preparati | ion 🗸 | Air Drie | ed 🗸 | | 9 | % Passing t | he #200 Si | eve: | 46.8% |
| Notes / D | eviations / Refer | ences: | | | | | | | | | |
| | | | | | | | | | | | |
| ASTM D 4 | | | | | | | | | | | |
| 7,511104 | 1318 [.] Liquid Limi | t Plastic Limit 2 | & Plactic I | ndex of Soil | lc | | | | | | |
| | 4318: Liquid Limi | t, Plastic Limit, a | & Plastic Iı | ndex of Soil | ls | | | | | | |
| | 1318: Liquid Limi | t, Plastic Limit, a | & Plastic II | ndex of Soil | ls | Eror | k Morrie | DE | | د/ و | 0/21 |

S&ME, INC. - Corporate

3201 Spring Forest Road Raleigh, NC. 27616

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SIEVE ANALYSIS OF SOIL

| Single sieve set | | | | | | ASTM | D 6913 | | | | | | | | | |
|----------------------|--------------|-----------|----------|--------------|---------|----------|-------------------|--------------|--------|----------|-------------|----------|------------|----------------|-----------------|-------|
| | | S&ME, In | c Spa | irtank | ourg: | 301 Zii | ma Park | Drive | e, Spa | rtanb | urg, S | C 2930 |)1 | | | |
| Project #: | 21304 | 45 | | | | | | | | | | F | Repo | rt Date: | 8/30/ | ′21 |
| Project Name: | Bad C | reek Pha | se 2 Fea | asibili | ty Stud | dy Proje | ect | | | | | ٦ | lest l | Date(s): | 8/16 - 8/ | 18/21 |
| Client Name: | HDR | | | | | | | | | | | | | | | |
| Client Address: | 1122 I | Lady Stre | et, Suit | e 110 | 0 Colu | umbia, | South Ca | arolir | na 29 | 201 | | | | | | |
| Borehole: | B-21-3 | 3 | | | | | Log #: | | | 135 | | Sa | ampl | e Date: | 4/20/ | '21 |
| Sample ID: | SS-2 | | | | | | Type: | | Split | -spoc | on | | | Depth: | 2.7 | |
| Sample Description | on: si | ilty SANE |) (SM) - | brov | vn gray | y tan, m | edium t | o fin | e | | | | | | | |
| 100% - | | 1" 3 | /4" 3 | \$/8" • | #4 | #10 |) # | 20 | #40 | #60 | #100 | #140 #20 | 0 | | | |
| | | | | | | | | | | _ | | | | | | |
| 90% | | | | | | | | | | | | | | | | |
| 80% | | | | | | | | \checkmark | | | | _ | ++ | | | - |
| ∞ ∞ 70% | | | | | | | | | | | | | | | | |
| iiss cox | | | | | | | | | | | | | | | | |
| ×00 It Da | | | | | | | | | | | | | | | | |
| 50% - | | | | | | | | | | | | | | | | |
| ਕ <mark>ੋ</mark> 40% | | | | | | | | | | _ | | | | | | - |
| 30% | | | | | | | | | | | | | | | | |
| 50% | | | | | | | | | _ | _ | | N | | | | |
| 20% | | | | | | | | | | | | | | | | |
| 10% | | | | | | | | | | _ | | | | | | - |
| 0% | | | | | | | | | | | | | | | | |
| 100.0 | 0 | | 10 | .00 | Mill | imeters | 1.00 | | | | | 0.10 | | | 0 | .01 |
| Cobbles | | < 300 n | nm (12") | and > | > 75 mr | m (3") | | Fir | ne San | d | | < 0. | 425 r | nm and : | > 0.075 m | nm |
| Gravel | | < 75 | mm and | > 4.7 | 5 mm (| (#4) | | | Silt | | | < | 0.07 | 5 and > (|).005 mm | 1 |
| Coarse Sand | | < 4.75 | mm and | 1 > 2.0 | 0 mm (| #10) | | | Clay | | | | | < 0.005 r | nm | |
| Medium Sanc | | < 2.00 r | nm and | > 0.42 | 25 mm | (#40) | No. | C | olloid | 5 Die | norsio | Droco | | < 0.001 r | nm | |
| Method: B Maximu | ım Parti | cle Size | 19 00 | r obta mm | ining S | pecimer | i: ivic Coarsi | e Sar | nd | 6 19 | persio 6 | n Proce | ss: Fin | Dis Ne Sand | persant 47 3 | % |
| THEXITTE | Gravel 64% | | | | | | Mediun | n Sar | nd | 17.89 | % | | Silt | & Clav | 22.3 | % |
| | Liquid Limit | | | | | | | c Lin | nit | NP | | F | Plasti | c Index | NF |) |
| | 1- | | | | | | | | | | | | | | | |
| | | | | | | Na | atural M | oistu | re | 13.69 | % | | | | | |
| Notes / Deviations , | / Referen | ices: | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

FRANK P.MORTSR. Frank Morris, P.E. <u>8/30/21</u> Project Manager Technical Responsibility Signature Position Date This report shall not be reproduced, except in full, without the written approval of S&ME, Inc.

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| | | ASTM D 4318 | 3 🛛 | AASHTO | т 89 🛛 | AAS | SHTO T 90 | | | | |
|---|------------------|-----------------------|---------------|-----------------------|-------------------|-------------|------------------|----------------|--------------|--------------|---------------|
| | | S&ME, Inc. | - Spartan | burg: 30 ⁻ | 1 Zima Park | Drive, | Spartanb | urg, SC 29 | 9301 | | |
| Project # | #: | 213045 | | | | | | Report I | Date: | 8/30/ | 21 |
| Project N | Name: | Bad Creek Phase | 2 Feasib | ility Study I | Project | | | Test l | Date: | 8/18/ | 21 |
| Client N | ame: | HDR | | | | | | | | | |
| Client Ad | ddress: | 1122 Lady Street | , Suite 11 | 00 Colum | bia, South (| Carolina | a 29201 | - | | | |
| Borehole | e: B-21 | -3 | | Log #: | 135 | | Sam | ple Date: | | 4/20/21 | |
| Sample | ID: SS-2 | | | Туре: | Split-spoo | on | | Depth: | | 2.7' | |
| Sample | Descriptio | n: silty SA | ND (SM) | - brown gr | ay tan, meo | lium to | fine | | | | |
| Type and | Specificatio | n S&ME | ID # | Cal Date: | Туре а | nd Spec | ification | S8 | xME ID # | Cal | Date: |
| Balance | (0.01 g) | 753 | 7 | 1/29/2021 | Groovi | ng tool | | | 14185 | 9/28 | /2020 |
| LL Appara | atus | 138 | 59 2 | 9/28/2020 |) | | | | | | |
| Oven Pan # | # | /51 | 5 | 7/30/2021 | Liquid L | imit | | | | Plastic Limi | t |
| | | Tare #: | | | | | | | | | |
| А | Tare Weig | ht | | | | | | | | | |
| В | Wet Soil V | Veight + A | | | | | | | | | |
| С | Dry Soil W | /eight + A | | | | | | | | | |
| D | Water We | ight (B-C) | | | | | | | | | |
| E | Dry Soil W | eight (C-A) | | | | | | | | | |
| F | % Moistur | e (D/E)*100 | | | | | | | | | |
| Ν | # OF DRO | PS | | | | | | | Moisture C | ontents det | ermined by |
| LL | LL : | = F * Factor | | | | | | | A | STM D 221 | 6 |
| Ave. | | Average | | | | | | | | | |
| 4 | 0.0 T | | | | | | | | One Point I | Liquid Lim | it - (|
| | | | | | | | | N 20 | Factor | N | 1 005 |
| | | | | | | | | 20 | 0.974 | 20 | 1.005 |
| tent 3 | 5.0 | | | | | | | 22 | 0.985 | 28 | 1.014 |
| Con | | | | | | | | 23 | 0.99 | 29 | 1.018 |
| e I I I I I I I I I I I I I I I I I I I | 60.0 | | | | | | | 24 | 0.995 | 30 | 1.022 |
| loist | | | | | | | | N | IP. Non-Pla | astic | X |
| N N | <u></u> | | | | | | | | Liquid L | imit - | |
| | | | | | | | | | Plastic L | .imit N | NP |
| | | | | | | | | | Plastic Ir | ndex 🖡 | IP |
| 2 | 0.0 | | | | | <u>+</u> _+ | | (| Group Syn | nbol S | M |
| | 10 | 15 20 | 25 30 | 35 40 | # of Dr | ops | 100 | Ν | Aultipoint N | /lethod | 7 |
| | | | | | | | | C | Dne-point N | /lethod | |
| Wet Pre | eparation | Dry Prepara | ition 🔽 | Air Drie | ed 🗹 | | 6 | % Passing t | the #200 Si | eve: | 22.3% |
| Notes / D | eviations / | References: | | | | | | | | | |
| | | | | | | | | | | | |
| ASTM D 4 | 4318: Liquid | Limit, Plastic Limit, | & Plastic | Index of Soi | ls | | | | | | |
| | | | | | | | | | | | |
| | <u>Matt J</u> | <u>acobs</u> | | <u>8/30/21</u> | | <u>Frar</u> | <u>nk Morris</u> | <u>, P.E.</u> | | <u>8/3</u> | <u>0/21</u> |
| | Technicia | n Name | | Date | | Techr | nical Respon | sibility | | D | ate |
| | | This report sha | ll not be rep | produced, exce | ept in full, with | out the w | vritten appro | oval of S&M | E, Inc. | | |

SIEVE ANALYSIS OF SOIL

| Single sieve set | | | | | | | | ASTM | 1 D 69 | 913 | | | | | | | | | | | |
|----------------------|----------------|---------|--------|-----------|-----------------|--------------|---------|----------|----------|---------|------|----------|--------------|--------------|-------------|------|-------|----------|-------------------|----------|----|
| | | S&N | 1E, In | c S | part | anb | urg: | 301 Z | ima Pa | ark Dri | ive, | Spar | tanb | urg, S | C 29 | 301 | | | | | |
| Project #: | 2130 |)45 | | | | | | | | | | | | | | Re | por | t Date: | 8, | /30/21 | |
| Project Name: | Bad (| Creek | Phas | se 2 F | easi | bilit | y Stu | dy Proj | ect | | | | | | | Te | st D | Date(s): | 8/16 | - 8/18/2 | 21 |
| Client Name: | HDR | | | | | | | | | | | | | | | | | | | | |
| Client Address: | 1122 | Lady | / Stre | et, Su | ite ' | 1100 |) Col | umbia, | Sout | ו Caro | lina | a 292 | 201 | | | | | | | | |
| Borehole: | B-21 | -3 | | | | | | | Log | #: | | 1 | 35 | | | Sar | nple | e Date: | 4, | /20/21 | |
| Sample ID: | SS-3 | | | | | | | | Тур | e: | | Split- | -spoc | on | | | | Depth: | | 7.7' | |
| Sample Description | on: | silty S | SAND |) (SM) |) - g | ray | tan, n | nedium | n to fir | ne | | | | | | | | | | | |
| | | | | | | | | | | | | | "~~ | #100 | | | | | | | |
| 100% | | | 1" 3/ | /4" • | 3/8' | | #4 | #1 | 10 | #20 | | #40 | #60 | #100 | #140 : | #200 | | | | _ | |
| | | | | | | $+ \Box$ | - | | | | | | | | | | | | | | |
| 90% | | | | | | | | | | | | | | | | | | | | | |
| 80% | | _ | | | | ++ | | | | | | | | | | | | | _ | | |
| »» 70% | | | | | | | | | | | | | | | | | | | | | |
| l is 10% | | | | | | | | | | | | | | | | | | | | | |
| Pas 60% | | | | | | | | | | | | | \mathbf{h} | | | | | | | | |
| 50% | | | | | | | | | | | | | | | | | | | | | |
| erc | | | | | | | | | | | | | | \mathbf{N} | | | | | _ | | |
| 40% | | | | | | | | | | | | | | Ì | | | | | | | |
| 30% | | | | | | | | | | | | | | | | | | | | | |
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| 20% | | | | | | | | | | | | | | | | | | | | | |
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| 0% | | | | | | | | | | | | | | | | | | | | | |
| 100.0 | 00 | | | | 10.00 |) | Mil | limeters | Ì | 1.00 | | | | | 0.10 | | | | | 0.01 | |
| | | | | | | | | | | | | | | | - | | | | | | / |
| Cobbles | | < , | 300 m | 12 nm יחר | 2") ar | nd > | 75 m | m (3") | _ | | Fine | e Sano | ł | | < | 0.42 | 25 m | nm and | > 0.0 | 75 mm | |
| Gravel | | | < 75 I | mm ar | nd > | 4.75 | 5 mm (| (#4) | | | | Silt | | | | < 0 | .075 | and > | 0.005 | mm | |
| Coarse Sand | J | < | 4.75 | mm a | nd > | 0.42 |) mm (| (#10) | | | (| lay | | | | | < | < 0.005 | mm | | |
| Method: B | 1 | ~ | Proce | | $\frac{10}{10}$ | 0.42 htai | nina S | (#40) | n. | Moist | CO | liolus | Dis | nersio | n Pro | | | | sners | ant | |
| Maximu | ım Parl | ticle S | Size | 9.50 |) mr | n | ining 5 | peenne | | arse S | and | ł | 4.3% | 6 | | | Fine | e Sand | iperse I | 50.2% | |
| | | Gra | avel | 3. | 5% | | | | Mec | lium S | and | - L | 21.4 | ~ | | | Silt | & Clav | | 20.6% | |
| | Lia | uid Li | mit | - | | | | | PI | astic I | imi | t | NP | - | | Pla | astic | Index | _ | NP | |
| | 9 | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | Ν | latura | l Mois | ture | _ | 18.09 | % | | | | | | | |
| Notes / Deviations / | / Refere | nces: | | | | | | | | | | - | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | | | | — |
| | | | | | - | | | - | | | | | | | | | | | | | |
| Frank M | <i>l</i> orris | P.F | | | + | RAN | K-P.A | HERTS! | 2. | | | Pro | niect | Mana | nder | | | | 8/3(|)/21 | |
| Technical I | Responsi | bility | | | | | Signa | ture | | | | <u></u> | Pos | ition | <u> 901</u> | | | | <u>, 50</u> Da | te | |

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| | | ASTM D 4318 | 🗵 AASH | ITO T 89 | | SHTO T 90 | | | | |
|--|----------------|-----------------------|--------------------|-------------------|---------------|--------------|---------------|-------------|--------------|--------------|
| | | S&ME, Inc | Spartanburg: | 301 Zima P | ark Drive, | Spartanb | urg, SC 29 | 9301 | | |
| Project # | ⊧: 2´ | 3045 | | | | | Report I | Date: | 8/30/2 | 21 |
| Project N | Jame: Ba | d Creek Phase 2 | Feasibility Stu | dy Project | | | Test l | Date: | 8/18/2 | 21 |
| Client Na | ame: H | DR | - | , , | | | | | | |
| Client Ac | dress: 11 | 22 Lady Street, | Suite 1100 Col | umbia, Sout | h Carolina | 29201 | - | | | |
| Borehole | e: B-21-3 | | Log #: | 135 | 5 | Sam | ple Date: | | 4/20/21 | |
| Sample I | D: SS-3 | | Type: | Split-sp | boon | | Depth: | | 7.7' | |
| Sample [| Description: | silty SAN | D (SM) - gray t | an, medium | to fine | | | | | |
| Type and | Specification | S&ME IE | 0 # Cal D | ate: Typ | e and Speci | ification | S8 | ME ID # | Cal | Date: |
| Balance (| 0.01 g) | 7537 | 1/29/2 | 2021 Gro | oving tool | | | 14185 | 9/28 | /2020 |
| LL Appara | atus | 13859 | 9/28/2 | 2020 | | | | | | |
| Oven | | 7313 | 7/30/2 | 2021 | | | | | DI | |
| Pan # | <u>:</u> | Tare #: | | Liqu | id Limit | | | | Plastic Limi | lt I |
| ^ | Taro Woight | Tale #. | | | | | | | | |
| A P | | icht I A | | | | | | | | |
| | | abt - A | | | | | | | | |
| | Dry Soll Wei | ynt + A | | | | | | | | |
| | water weigr | | | | | | | | | |
| E | | | | | | | | | | |
| F | % Moisture | (D/E)^100 | | | | | | | | |
| N | # OF DROPS | | | | | | | Moisture C | ontents det | ermined by |
| LL | LL = I | * FACTOR | | | | | | A | ISTM D 221 | 6 |
| Ave. | A | verage | | | | | Ī | | | |
| 40 | 0.0 T | | | I | |) | N | One Point I | Liquid Lim | it Fastar |
| | | | | | | | 20 | 0.974 | 26 | 1 005 |
| | | | | | | | 21 | 0.979 | 27 | 1.009 |
| ent 3 | 5.0 | | | | | | 22 | 0.985 | 28 | 1.014 |
| ont | | | | | | | 23 | 0.99 | 29 | 1.018 |
| | | | | | | | 24 | 0.995 | 30 | 1.022 |
| in the second se | | | | | | | 25 | 1.000 | | |
| Ioi | | | | | | | N | IP, Non-Pla | astic | X |
| | | | | | | | | Liquid L | imit - | |
| | | | | | | | | Plastic I | imit N | JP |
| | | | | | | | | Plastic Ir | ndev N | JD |
| 20 | 0.0 | | | | | | | | | чт 'NЛ |
| | 10 | 15 20 | 25 30 35 4 | 10 # of | Drong | 100 | | Jioup Syn | | |
| | | | | # 01 | Drops | | IN C | | | ~ |
| Wet Bro | paration | Dry Proparati | op / Air | Dried (| | | V Passina t | | vietnod | 20.6% |
| Notes / Di | eviations / Re | ferences: | | Dheu | | / | o Fussing i | 11e #200 St | eve. | 20.076 |
| Notes / De | eviations / ne | ferences. | | | | | | | | |
| | | | | | | | | | | |
| ASTM D 4 | 318: Liquid Li | mit, Plastic Limit, & | & Plastic Index of | f Soils | | | | | | |
| | | | | | | | | | | |
| | Matt Jac | <u>cobs</u> | <u>8/30</u> | <u>/21</u> | <u>Frar</u> | nk Morris | <u>, Р.Е.</u> | | <u>8/3</u> | <u>0/21</u> |
| | Technician | Name | Dat | e | Techr | nical Respon | sibility | | D | ate |
| | | This report shall | not be reproduced, | except in full, v | vithout the w | ritten appro | oval of S&M | E, Inc. | | |
| | ~ | | 220 | | | | | | | (|

S&ME, INC. - Corporate

SIEVE ANALYSIS OF SOIL

| Single s | sieve set | | | | | | | | AS | TM D | 6913 | | | | | | | | | | | |
|----------|-------------|------|-----------|--------|--------|--------|--------|-------|--------------|----------|--------|-------|--------|--------|--------|--------|------------------|---------------|-------|-------|----------|---------|
| | | | S&I | √E, In | c S | parta | anbu | urg: | 301 | l Zima | Park | Drive | e, Spa | rtanb | urg, S | C 29 | 301 | | | | | |
| Project | #: | 213 | 045 | | | | | | | | | | | | | | Rep | oort | Dat | e: | 8/30 |)/21 |
| Project | Name: | Bad | Creel | k Pha | se 2 F | easi | bility | y Stu | dy P | roject | | | | | | | Tes | st Da | ate(s | 5): 8 | 3/16 - 8 | 8/18/21 |
| Client I | Name: | HDR | <u>.</u> | | | | | | | | | | | | | | | | | | | |
| Client A | Address: | 1122 | 2 Lad | y Stre | et, Sı | uite 1 | 1100 | Col | lumb | oia, Soι | ith Ca | rolir | na 29 | 201 | | | | | | | | |
| Boreho | ole: | B-21 | -3 | | | | | | | Log | g #: | | | 135 | | | Sam | ple | Dat | e: | 4/20 |)/21 |
| Sample | e ID: | SS-4 | • | | | | | | | Ту | pe: | | Spli | t-spoo | on | | | D | Dept | h: | 12 | .7' |
| Sample | e Descripti | on: | silty | SAND |) with | n gra | vel (| SM) | - gra | у, соа | rse to | fine | | | | | | | | | | |
| | 100% | •• | ••- | 1" 3, | /4" | 3/8" | | #4 | | #10 | #2 | 20 | #40 | #60 | #100 | #140 # | ¢200 | | | | | |
| | 90% | | | | | | | | | | | | | | | | | | | | | |
| (% | 80% | | | | | | | | \mathbf{i} | | | | | | | | | | | | | |
| 1g (° | 70% | | \square | | | | | | | | | | | | | | | + | | | | - |
| Passir | 60% | | | | | | | | | | | | | | | | | | | | | - |
| rcent | 50% | | | | | | | | | | | | | | | | | | | | | |
| Pe | 40% | | | | | | | | | | | | | | | | | | | | | |
| | 30% | | | | | | | | | | | | | | | | | | | | | |
| | 20% | | | | | | | | | | | | | | | | | | | | | |
| | 10% | +++ | \square | + | | | +++ | | | _ | | +++ | | _ | | | $\left \right $ | \rightarrow | | | | _ |

| 10% 0% 100.00 | 10.00 Millimeter | s 1.00 | 0.10 0.01 |
|---------------------|---------------------------------|---------------------|---------------------------|
| Cobbles | < 300 mm (12") and > 75 mm (3") | Fine Sand | < 0.425 mm and > 0.075 mm |
| Gravel | < 75 mm and > 4.75 mm (#4) | Silt | < 0.075 and > 0.005 mm |
| Coarse Sand | < 4.75 mm and >2.00 mm (#10) | Clay | < 0.005 mm |
| Medium Sand | < 2.00 mm and > 0.425 mm (#40) | Colloids | < 0.001 mm |
| Method: B | Procedure for obtaining Specim | en: Moist Dispersic | on Process: Dispersant |
| Maximum Pa | rticle Size 19.00 mm | Coarse Sand 9.9% | Fine Sand 37.4% |
| | Gravel 17.2% | Medium Sand 17.9% | Silt & Clay 17.6% |
| Lic | quid Limit | Plastic Limit NP | Plastic Index NP |

Notes / Deviations / References:

 Frank Morris, P.E.
 Project Manager
 8/30/21

 Technical Responsibility
 Signature
 Position
 Date

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Natural Moisture

13.9%

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| | | ASTM D 4318 | 🗵 AASH1 | го т 89 🛛 | AASHTO T 9 | 00 🗆 | | | |
|-----------|-------------------|-------------------------|----------------------|-----------------------|--------------------|------------------|--------------|-------------|-------------|
| | | S&ME, Inc | Spartanburg: 3 | 301 Zima Park I | Drive, Spartan | burg, SC 2 | 9301 | | |
| Project # | #: 2 | 13045 | | | | Report | Date: | 8/30/ | 21 |
| Project I | Name: B | ad Creek Phase 2 | Preasibility Stud | y Project | | Test | Date: | 8/18/ | 21 |
| Client N | ame: H | IDR | · | | | | | | |
| Client A | ddress: 1 | 122 Lady Street, | Suite 1100 Colu | mbia, South Ca | arolina 29201 | _ | | | |
| Borehole | e: B-21- | 3 | Log #: | 135 | Sa | mple Date | | 4/20/21 | |
| Sample | ID: SS-4 | | Type: | Split-spoor | ו | Depth | : | 12.7' | |
| Sample | Description | : silty SAN | D with gravel (S | M) - gray, coar | se to fine | | | | |
| Type and | Specification | S&ME IE | D # Cal Dat | te: Type and | d Specification | SE | &ME ID # | Cal | Date: |
| Balance | (0.01 g) | 7537 | 1/29/20 |)21 Groovin | g tool | | 14185 | 9/28 | /2020 |
| LL Appar | atus | 13859 | 9/28/20 |)20 | | | | | |
| Oven | | 7313 | 7/30/20 | | | | | | |
| Pan + | # | Taro #: | | Liquid Lin | nit | | | Plastic Lim | it I |
| | Taro Woigh | t are #. | | | | | | | |
| P A | Wot Soil W | r | | | | | | | |
| | | | | | | | | | |
| | Dry Soli We | Hynt + A | | | | | | | |
| | Water Weig | Jnt (B-C) | | | | | | | |
| E | | Right (C-A) | | | | | | | |
| F | % Moisture | (D/E)^100 | | | | | | | |
| N | # OF DROP | 5 | | | | | Moisture Co | ontents det | ermined by |
| LL | LL = | F * FACTOR | | | | | A | STM D 221 | 6 |
| Ave. | A | Average | | | | . 1 | | | •. |
| 4 | ^{40.0} T | | · · · · · | | | | Eactor | | Factor |
| | | | | | | 20 | 0.974 | 26 | 1.005 |
| | | | | | | 21 | 0.979 | 27 | 1.009 |
| tent | 35.0 | | | | | 22 | 0.985 | 28 | 1.014 |
| on | | | | | | 23 | 0.99 | 29 | 1.018 |
| e e | 30.0 | | | | | 24 | 0.995 | 30 | 1.022 |
| stu | | | | | | 25 | 1.000 | | |
| Moi | | | | | | 1 | NP, Non-Pla | astic | X |
| × 2 | 25.0 | | | | | | Liquid L | imit - | |
| | | | | | | | Plastic L | imit 🚺 | IP |
| | | | | | | | Plastic Ir | ndex N | IP |
| 2 | 20.0 | | + $+$ $+$ $+$ | | | | Group Svn | nbol S | M |
| | 10 | 15 20 | 25 30 35 40 | # of Dro | ps 100 | 1 | Aultipoint N | /lethod | 7 |
| | | | | | | | Dne-point N | 1ethod | |
| Wet Pre | eparation | Dry Preparati | ion 🗹 Air [| Dried 🗸 | | % Passing | the #200 Sie | eve: | 17.6% |
| Notes / D | Deviations / R | eferences: | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| ASTM D 4 | 4318: Liquid L | Limit, Plastic Limit, a | & Plastic Index of S | Soils | | | | | |
| | | | | | | | | | o (o í |
| | <u>Matt Ja</u> | <u>cobs</u> | <u>8/30/2</u> | 21 | Frank Mori | <u>ris, P.E.</u> | | <u>8/3</u> | <u>0/21</u> |
| | Technician | ivame | . Date | | Technical Respo | onsibility | | D | ate |
| | | This report shall | not be reproduced, e | xcept in full, withou | ut the written app | proval of S&M | IE, Inc. | | |



| Single sieve set | | ASTM | D 6913 | | | |
|--------------------------------|---|--|--|---|--|--------------------------------|
| | S&ME, Inc Spar | rtanburg: 301 Zin | na Park Drive, Spa | artanburg, SC 293 | 301 | |
| Project #: 21 | 3045 | | | | Report Date: | 8/30/21 |
| Project Name: Ba | d Creek Phase 2 Feas | ibility Study Projec | t | | Test Date: | 8/16 - 8/18/21 |
| Client Name: HD |)R | | | | | |
| Client Address: 11 | 22 Lady Street, Suite | 1100 Columbia, So | outh Carolina 29 | 201 | | |
| Boring #: B-2 | 21-4 | · · · · · · · · · · · · · · · · · · · | _og #: | 135 | Sample Date: | 4/6/21 |
| Sample #: SS | -1 | | Type: Spli | it-spoon | Depth: | 0' |
| Sample Description: | poorly graded SAN | ND with silt and gra | vel (SP-SM) - gra | ay, coarse to fine | | |
| Bumple Description: | | 3/8" #4 #10 | | | #200 | |
| 0% | 10.0 | 00 Millimeters | 1.00 | 0.10 | | 0.01 |
| Cobbles | < 300 mm (12") = | and $> 75 \text{ mm}(3")$ | Fine Sa | nd | 0.425 mm and 3 | 0.075 mm |
| Gravel | < 75 mm and 2 | > 4.75 mm (#4) | Silt | | < 0.075 and > (|).005 mm |
| Coarse Sand | < 4.75 mm and | >2.00 mm (#10) | Clay | | < 0.005 r | nm |
| Medium Sand | < 2.00 mm and > | • 0.425 mm (#40) | Colloid | ds | < 0.001 n | nm |
| Method: B Maximum P L | Procedure for article Size 19.00 m Gravel 37.0% .iquid Limit | obtaining Specimen: nm 6 | Moist Coarse Sand Medium Sand Plastic Limit | Dispersion Pro 17.9% 17.8% NP | cess: Dis Fine Sand Silt & Clay Plastic Index | persant 18.0% 9.3% NP |
| | $Cc = D_{30}^{2}/2$ | (D ₁₀ x D ₆₀) 0.9 | tural Moisture Cu = [| 3.9% D ₆₀ /D ₁₀ | 49.4 | |
| D10 = 0.084 | D30 = 0 . | 55 D60 = | 4.15 | | | |
| Notes / Deviations / Ref | erences: | | | | | |
| Frank Morri Technical Respo | <u>s, P.E.</u> nsibility This report shall not b | Signature e reproduced, except in | E full, without the writte | Project Manager Position en approval of S&ME, | Inc. | <u>8/30/21</u> Date |

| | | 9. |
|----|----|----|
| | - | X |
| 11 | h. | _ |
| | | _ |

| | | ASTM D 4318 | 🗵 AASHT | 0 Т 89 🔲 🛛 🗛 | SHTO T 90 | | | | |
|----------------------|---|---|---|---|----------------------------|---|--|--|---|
| | | S&ME, Inc S | Spartanburg: 3 | 01 Zima Park Drive, | Spartanbu | urg, SC 29 | 9301 | | |
| Project # | #: 2130 |)45 | | | | Report [| Date: | 8/30/2 | 21 |
| Project I | Name: Bad | Creek Phase 2 | Feasibility Study | / Project | | Test I | Date: | 8/18/2 | 21 |
| Client N | ame: HDR | l | | | | | | | |
| Client A | ddress: 1122 | 2 Lady Street, S | Suite 1100 Colur | mbia, South Carolin | a 29201 | | | | |
| Borehol | e: B-21-4 | - | Log #: | 135 | Sam | ple Date: | | 4/6/21 | |
| Sample | ID: SS-1 | | Type: | Split-spoon | | Depth: | | 0' | |
| Sample | Description: | poorly gr | aded SAND with | silt and gravel (SP- | -SM) - gray | , coarse | to fine | | |
| Type and | Specification | S&ME ID |) # Cal Dat | e: Type and Spec | cification | S& | ME ID # | Cal L | Date: |
| Balance | (0.01 g) | 7537 | 1/29/20 | 21 Grooving tool | | | 14185 | 9/28/ | /2020 |
| LL Appar | atus | 13859 | 9/28/20 | 20 | | | | | |
| Oven | | 7313 | 7/30/20 | 21 | | | | | |
| Pan : | # | Taro #: | | Liquid Limit | | 1 | P | lastic Limit | |
| ^ | Tara Waight | Tale #. | | | | | | | |
| | | s+ ι Λ | | | | | | | |
| Б | Dry Soil Weight | n + A | | | | | | | |
| | Dry Soll Weight | I + A | | | | | | | |
| | Water Weight (| | | | | | | | |
| E | | t (C-A) | | | | | | | |
| F | % Moisture (D/ | E)^100 | | | | | | | |
| N | # OF DROPS | | | | | | Moisture Co | ntents dete | ermined by |
| LL | LL = F * | FACTOR | | | | | AS | IM D 2210 | 0 |
| Ave. | Aver | rage | | | | | | | |
| 4 | 40.0 T | | | | —) | N | One Point L | Iquid Limi | t Eactor |
| | | | | | | 20 | 0.974 | 26 | 1.005 |
| | | | | | | 21 | 0.979 | 27 | 1.009 |
| tent | 35.0 | | | | | 22 | 0.985 | 28 | 1.014 |
| Juo | | | | | | 23 | 0.99 | 29 | 1.018 |
| e e | | | | | | 24 | 0.995 | 30 | 1.022 |
| , stu | | | | | | 25 | 1.000 | | |
| | | 1 1 | | | | 25 | | | |
| Mo V | | | | | | 25 N | IP, Non-Pla | stic | X |
| 0W % 2 | 25.0 | | | | | 25 N | I P, Non-Pla Liquid Li | stic mit - | × |
| OM % | 25.0 | | | | | 25 N | I P, Non-Pla Liquid Li Plastic Li | stic mit mit N | ⊠ P |
| OW % | 25.0 | | | | | 25 N | I P, Non-Pla Liquid Li Plastic Li Plastic In | stic mit mit N dex N | ⊠ P |
| | 25.0 | | | | | N | IP, Non-Pla Liquid Li Plastic Li Plastic In Group Sym | stic mit mit N dex N bol SP- | ⊠ P SM |
| ₩ <mark>≫</mark> 2 | 25.0 | 15 20 | 25 30 35 40 | # of Drops | 100 | 25 N (| IP, Non-Pla Liquid Li Plastic Li Plastic In Group Sym Jultipoint M | stic mit mit N dex N bol SP- ethod | IP SM |
| ₩% 2 2 | 25.0 | 15 20 | 25 30 35 40 | # of Drops | 100 | (| IP, Non-Pla Liquid Li Plastic Li Plastic In Group Sym Aultipoint M | stic mit mit N dex N bol SP- ethod ethod | ⊠ P SM √ |
| Wet Pro | 25.0 | 15 20 | 25 30 35 40 | # of Drops | 100 | Constant of the second | IP, Non-Pla Liquid Li Plastic Li Plastic In Group Sym Aultipoint M One-point M the #200 Sie | stic mit mit N dex N bol SP- ethod ethod ve: | ⊠ P SM _ 9.3% |
| Wet Pro Notes / D | 25.0 20.0 10 eparation Deviations / Reference | 15 20 Dry Preparati | 25 30 35 40 on \checkmark Air D | ried ✓ | 100 | 25 N (M C 6 Passing t | IP, Non-Pla Liquid Li Plastic Li Plastic In Group Sym Aultipoint M One-point M the #200 Sie | stic mit mit N dex N bol SP- ethod ethod ve: | ⊠ P SM ↓ 9.3% |
| Wet Pro Notes / D | 25.0 10 | 15 20 Dry Preparati ences: | 25 30 35 40 | # of Drops | 100 | 23 N (M C 6 Passing t | IP, Non-Pla Liquid Li Plastic Li Plastic In Group Sym Aultipoint M One-point M the #200 Sie | stic mit mit N dex N bol SP- ethod ethod ve: | ⊠ P P SM √ - 9.3% |
| Wet Pro | 25.0 + | 15 20 Dry Preparati ences: | 25 30 35 40 | # of Drops | 100 | N N C 6 Passing t | IP, Non-Pla Liquid Li Plastic Li Plastic In Group Sym Aultipoint M One-point M the #200 Sie | stic mit mit N dex N bol SP- ethod ethod ve: | ⊠ P SM √ 9.3% |
| Wet Pre Notes / D | 25.0 20.0 10 eparation Deviations / Reference 4318: Liquid Limit | 15 20 Dry Preparati ences: | 25 30 35 40 on \checkmark Air D | # of Drops | 100 | N (((((((((((((((((((| IP, Non-Pla Liquid Li Plastic Li Plastic In Group Sym Aultipoint M One-point M the #200 Sie | stic mit mit N dex N bol SP- ethod ethod ve: | ⊠ P SM √ 9.3% |
| Wet Pro Notes / D | 25.0 + | 15 20 Dry Preparati ences: | 25 30 35 40 on ✓ Air D | ried 7 | 100 | 25 N (C 6 Passing t | IP, Non-Pla Liquid Li Plastic Li Plastic In Group Sym Aultipoint M One-point M the #200 Sie | stic mit mit N dex N bol SP- ethod ethod ve: | ⊠ P SM √ 9.3% |
| Wet Pro Notes / L | 25.0 10 20.0 10 eparation Deviations / Reference 4318: Liquid Limit | 15 20 Dry Preparati ences: t, Plastic Limit, & | 25 30 35 40 on ✓ Air D | # of Drops Irried | nk Morris | 23 N ((6 Passing t , P.E. | IP, Non-Pla Liquid Li Plastic Li Plastic In Group Sym Aultipoint M One-point M the #200 Sie | stic mit mit N dex N bol SP- ethod ethod ve: 8/30 | ⊠ P SM 9.3% |
| Wet Pro Notes / D | 25.0 20.0 10 20.0 10 10 20.0 10 10 20.0 10 10 10 20.0 10 10 10 10 10 10 10 10 10 10 10 10 10 | 15 20 Dry Preparati ences: t, Plastic Limit, & | 25 30 35 40 on \checkmark Air D & Plastic Index of S $\frac{8/30/2}{Date}$ | # of Drops mied ✓ oils ½1 Fra Tech | nk Morris nical Respons | , P.E. sibility | IP, Non-Pla Liquid Li Plastic Li Plastic In Group Sym Aultipoint M One-point M the #200 Sie | stic mit mit N dex N bol SP- ethod ethod ethod ve: | 図 IP SM ✓ 9.3% |



| Single sieve set | | | | | | Α | STM I | D 691. | 3 | | | | | | | | | | | |
|--------------------|--------------------------|------------------------------|---------------|---------------------------------|---------------------|------------------------|--------------|------------|--------|--------------|---------------------|-------------------------------|-----------------------|--------------|----------|------------|------------|-------|------------------------|----------|
| | | S&ME, I | nc Sp | artan | burg: | 30 | 1 Zim | na Par | k Dri | ve, S | Spar | tanb | urg, S | SC 29 | 30 | 1 | | | | |
| Project #: | 21304 | 45 | | | _ | | | | | | | | | | R | epo | ort | Date: | 8/30/ | /21 |
| Project Name: | Bad C | reek Pha | ise 2 Fe | asibil | ity Stı | udy P | rojec | t | | | | | | | | Te | est | Date: | 8/16 - 8/ | '18/21 |
| Client Name: | HDR | | | | | | | | | | | | | | | | | | | |
| Client Address: | 1122 l | ∟ady Stre | eet, Suit | te 110 |)0 Co | lumb | oia, So | outh C | arol | ina 2 | 2920 | 01 | | | | | | | | |
| Boring #: | B-21-4 | 4 | | | | | l | .og #: | | | 1 | 35 | | | Sa | amp | ole | Date: | 4/6/2 | 21 |
| Sample #: | SS-2 | | | | | | | Type: | | S | plit- | -spoo | n | | | | D | epth: | 3.5 | |
| Sample Descript | tion: w | /ell-grad | ed SAN | ID wit | th gra | vel (S | SW) - | gray, | coar | se to | o me | ediur | n | | | | | | | |
| 100% | 3" 2 " | 1.5" 1" 3 | 3/4" | 3/8" | #4 | | #10 | | #20 | # | #40 • | #60 | #100 | #140 | #2 | 00 | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| (%) | | | | N | | | | | | | _ | | | | | | | | | |
| ສ | ┝┼┼┼┼┼ | + + | | + N | | | | | | | | | | | | - | | | | |
| assi 90% | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | ++ | + | | | | + | + | | _ | | |
| 50% | | | | | | | | | | | | | | | | | | | | |
| 40% | | | | | | $\left \right\rangle$ | | | | | _ | | | | + | + | | _ | | |
| 30% | | | | | | | \mathbf{N} | | | | | | | | | | | | | |
| 5670 | | + | | | | | | | | | _ | | | | | - | | | | |
| 20% | | | | | | | | | | | | | | | | | | | | |
| 10% | | + | | | | | | | | \succ | | | | | + | + | | | | |
| 0% | | | | | | | | | | | $\mathbf{\Gamma}$ | \ | | -• | | | | | | |
| 100. | .00 | | 1 | 0.00 | M | lillime | ters | 1. | 00 | | • | | | 0.10 | | | | | 0 | 0.01 |
| | | | (4.0.1 | | | (| | | | | | | | 1 | _ | 40.5 | | | 0.075 | |
| Cobbles | | < 300 r | nm (12" | $\frac{1}{1}$ and $\frac{1}{1}$ | > /5 r 75 mm | mm (: 2 (#4) | 3") | | | Fine : Si | Sanc | | | < | : 0.4 | 425 0.0 | mn 75 a | n and | > 0.075 n | nm |
| Coarse Sand | d | < 4.75 | i mm an | d >2 (| 00 mm | n (#4) |)) | | | Cla | av | | | | <u> </u> | 0.0 |) > | 005 | mm | |
| Medium San | nd | < 2.00 | mm and | d > 0.4 | 425 mr | m (#4 | 0) | | | Colle | oids | | | | | | < (| 0.001 | mm | |
| Method: B | - | Proc | edure fo | or obta | aining | Spec | imen: | N | /loist | | | Dis | persic | on Pro | oce | ss: | | Dis | spersant | |
| Maxim | num Parti | cle Size | 25.00 | mm | | | | Coa | rse S | and | | 22.0 | % | | | Fi | ine | Sand | 6.19 | % |
| | | Gravel | 48.1 | 1% | | | | Mediu | um S | and | | 22.5 | % | | | Sil | lt & | Clay | 1.49 | % |
| | Liqu | id Limit | | - | | | | Plas | tic L | imit | | NP | | | Ρ | las | tic I | ndex | NF |) |
| | | | | | | | Na | tural N | Nois | ture | | 5.9% | 6 | | | | | | | |
| | | (| $Cc = D_{30}$ | ² /(D ₁₀ | x D ₆₀) |) | 1.3 | | | Cu = | = D ₆ | ₀ /D ₁₀ | | | 11 | .5 | | | | |
| D10 = | 0.52 | D: | 30 = | 2.00 | | 0 | 060 = | 6.0 |) | | | | | | | | | | | |
| Notes / Deviations | s / Referen | ices: | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| <u>Frank</u> | Morris, P | <u>.E.</u> ility | | FRA | WKP. Sign | nature | BR | -• | | | Pro | oject | Mana | ager | | | | | <u>8/30/21</u> Date | <u>1</u> |
| Frank Technical | Morris, P I Responsib | P.E. ility This report | t shall not | FRA t be rer | Sign | nature ed, exc | ept in 1 | full, with | hout t | he wr | <u>Pro</u> itten | oject Po: appro | <u>Mana</u> Sition | ager S&MF | Inc | | | | <u>8/30/21</u> Date | <u>1</u> |



| | | ASTM D 4318 | \boxtimes , | ааѕнто т | 89 🗆 A | ASHTO T 90 | | | | |
|---------------------------------|--|---------------------------------------|---------------|------------|-------------------|----------------|--|--|---|---|
| | | S&ME, Inc S | Spartanbu | rg: 301 | Zima Park Drive | e, Spartanbu | urg, SC 29 | 9301 | | |
| Project + | #: 2130 |)45 | • | 5 | | | Report I | Date: | 8/30/2 | 21 |
| Project | Name: Bad | Creek Phase 2 | Feasibility | Study Pr | oject | | Test I | Date: | 8/18/2 | 21 |
| Client N | lame: HDR | | , , | , | 5 | | | | | |
| Client A | .ddress: 1122 | 2 Lady Street, S | Suite 1100 | Columbi | a, South Carolii | na 29201 | | | | |
| Borehol | e: B-21-4 | , , , , , , , , , , , , , , , , , , , | Loc | 1#: | 135 | Sam | ple Date: | | 4/6/21 | |
| Sample | ID: SS-2 | | Tv | pe: | Split-spoon | | Depth: | | 3.5' | |
| Sample | Description: | well-grad | led SAND | with grav | el (SW) - grav. (| coarse to m | edium | | 0.0 | |
| Type and | Specification | S&ME ID |)# (| Cal Date: | Type and Spe | ecification | S8 | ME ID # | Cal | Date: |
| Balance | (0.01 g) | 7537 | 1 | /29/2021 | Grooving too | ol | | 14185 | 9/28 | /2020 |
| LL Appar | ratus | 13859 | 9 | /28/2020 | | | | | | |
| Oven | | 7313 | 7 | /30/2021 | | | | | | |
| Pan | # | | | | Liquid Limit | | T | ŀ | Plastic Limi | t |
| | | Tare #: | | | | | | | | |
| Α | Tare Weight | | | | | | | | | |
| В | Wet Soil Weigh | t + A | | | | | | | | |
| С | Dry Soil Weight | t + A | | | | | | | | |
| D | Water Weight (| B-C) | | | | | | | | |
| E | Dry Soil Weight | t (C-A) | | | | | | | | |
| F | % Moisture (D/ | E)*100 | | | | | | | | |
| N | # OF DROPS | | | | | | | Moisture Co | ontents det | ermined hy |
| 11 | = F * | FACTOR | | | | | | A. | STM D 221 | 6 |
| Ave | Aver | | | | | | <u> </u> | | | |
| 7176. | , | age | | | | | | | | |
| | | | | | | | | One Point L | iquid Lim | it |
| 4 | 40.0 | | | | | | N | One Point L Factor | iquid Lim. N | it Factor |
| 4 | 40.0 | | | | | \blacksquare | N 20 | One Point L Factor 0.974 | iquid Lim. N 26 | it Factor 1.005 |
| | 40.0 | | | | | | N 20 21 | One Point L Factor 0.974 0.979 | iquid Lim. N 26 27 | it Factor 1.005 1.009 |
| tent 5 | 35.0 | | | | | | N 20 21 22 | One Point L Factor 0.974 0.979 0.985 | iquid Lim. N 26 27 28 | it Factor 1.005 1.009 1.014 |
| Content | 35.0 | | | | | | N 20 21 22 23 | One Point L Factor 0.974 0.979 0.985 0.99 | iquid Lim. N 26 27 28 29 29 | it Factor 1.005 1.009 1.014 1.018 |
| are Content | 40.0 | | | | | | N 20 21 22 23 24 25 | One Point L Factor 0.974 0.979 0.985 0.99 0.995 | iquid Lim N 26 27 28 29 30 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| oisture Content | 40.0 35.0 30.0 | | | | | | N 20 21 22 23 24 25 | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 | iquid Lim N 26 27 28 29 30 29 30 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| Moisture Content | 40.0 | | | | | | N 20 21 22 23 24 25 N | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla | iquid Lim N 26 27 28 29 30 astic imit | it Factor 1.005 1.009 1.014 1.018 1.022 |
| % Moisture Content | | | | | | | N 20 21 22 23 24 25 N | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Plate Liquid L | iquid Lim N 26 27 28 29 30 astic imit - | it Factor 1.005 1.009 1.014 1.018 1.022 X |
| % Moisture Content | | | | | | | N 20 21 22 23 24 25 N | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L | iquid Lim N 26 27 28 29 30 astic imit - imit N | it Factor 1.005 1.009 1.014 1.018 1.022 X IP |
| % Moisture Content | | | | | | | N 20 21 22 23 24 25 N | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In | iquid Lim N 26 27 28 29 30 astic imit - imit N idex N | it Factor 1.005 1.009 1.014 1.018 1.022 |
| % Moisture Content | | | | | | | N 20 21 22 23 24 25 N | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym | iquid Lim N 26 27 28 29 30 astic imit - imit - imit N adex N abol S | it Factor 1.005 1.009 1.014 1.018 1.022 X JP W |
| % Moisture Content | | | 25 30 | 35 40 | # of Drops | 100 | N 20 21 22 23 24 25 N | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym | iquid Lim N 26 27 28 29 30 astic imit - imit N idex N abol S 1ethod | it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |
| % Moisture Content | 40.0 35.0 30.0 25.0 20.0 10 | | | 35 40 | # of Drops | | N 20 21 22 23 24 25 N ((N (((((((((((((| One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M One-point M | iquid Lim N 26 27 28 29 30 astic imit - imit N adex N abol S Aethod Aethod | it Factor 1.005 1.009 1.014 1.018 1.022 |
| % Woisture Content | 40.0 35.0 30.0 25.0 20.0 10 eparation | 15 20 | 25 30 3 | 35 40 | # of Drops | | N 20 21 22 23 24 25 N 6 Passing t | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint N One-point N the #200 Side | iquid Lim N 26 27 28 29 30 astic imit - imit - imit N adex N adex N abol S Aethod Aethod Aethod | it Factor 1.005 1.009 1.014 1.018 1.022 |
| Wet Pri Notes / D | 40.0 35.0 30.0 25.0 20.0 10 eparation Deviations / Reference | 15 20 Dry Preparati ences: | 25 30 S | Air Driec | # of Drops | 100 | N 20 21 22 23 24 25 N (((((((((((((| One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M One-point N the #200 Side | iquid Lim N 26 27 28 29 30 astic imit - imit N idex N abol S Aethod Aethod Aethod | it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |
| % Woisture Content Notes / D | 40.0 35.0 30.0 25.0 20.0 10 eparation Deviations / Reference | 15 20 Dry Preparati ences: | 25 30 3 | Air Driec | # of Drops | | N 20 21 22 23 24 25 N (((((((((((((| One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M One-point M the #200 Side | iquid Lim N 26 27 28 29 30 astic imit - imit N adex N adex N abol S 4ethod 4ethod | it Factor 1.005 1.009 1.014 1.018 1.022 I I I I V U 1.4% |
| Wet Pro Notes / D ASTM D | 40.0 35.0 30.0 25.0 20.0 10 20.0 4318: Liquid Limit | 15 20 | 25 30 3 | Air Driec | # of Drops | 100 | N 20 21 22 23 24 25 N (0 (0 (0 (0 (0 (0 (0) (0) (0) | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M One-point M the #200 Side | iquid Lim N 26 27 28 29 30 astic imit - imit N idex N 1ethod 4ethod 2eve: | it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |
| Wet Pro Notes / L ASTM D | 40.0 35.0 30.0 25.0 20.0 10 eparation 10 eparation 20.0 10 4318: Liquid Limit | t, Plastic Limit, & | 25 30 3 | Air Driec | # of Drops | 100 | N 20 21 22 23 24 25 N 6 Passing t | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M One-point M the #200 Side | iquid Lim N 26 27 28 29 30 astic imit - imit N adex N adex N abol S Aethod Aethod action | it Factor 1.005 1.009 1.014 1.018 1.022 I I I I I I I I I I I I |
| Wet Pro Notes / D ASTM D | 40.0 35.0 30.0 25.0 20.0 10 eparation 20.0 10 eparations / Reference 4318: Liquid Limits Matt Jacob | 15 20 Dry Preparati ences: | 25 30 3 | Air Driec | # of Drops | 100 % | N 20 21 22 23 24 25 N 6 Passing t | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M One-point M the #200 Side | iquid Lim N 26 27 28 29 30 astic imit - imit N adex N 1ethod 1ethod 2ethod 1ethod 1ethod | it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |
| Wet Pro Wet Pro Notes / D | 40.0 35.0 30.0 25.0 20.0 10 eparation 20.0 10 eparation Matt Jacok Technician Nar | bry Preparati ences: | 25 30 3 | Air Driece | # of Drops | 100 % | N 20 21 22 23 24 25 N (((((((((((((| One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M One-point N he #200 Sie | iquid Lim N 26 27 28 29 30 astic imit - imit N idex N hool S Aethod Aethod Aethod Aethod | it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |

SIEVE ANALYSIS OF SOIL

| Single sieve set | ASTM D 6913 | | |
|--------------------|--|---------------|----------------|
| | S&ME, Inc Spartanburg: 301 Zima Park Drive, Spartanburg, SC 2 | 9301 | |
| Project #: | 213045 | Report Date: | 8/30/21 |
| Project Name: | Bad Creek Phase 2 Feasibility Study Project | Test Date(s): | 8/16 - 8/18/21 |
| Client Name: | HDR | | |
| Client Address: | 1122 Lady Street, Suite 1100 Columbia, South Carolina 29201 | | |
| Borehole: | B-21-4 Log #: 135 | Sample Date: | 4/6/21 |
| Sample ID: | SS-3 Type: Split-spoon | Depth: | 18.5' |
| Sample Description | on: silty SAND (SM) - brown, medium to fine with little gravel | | |
| 100% - | | 0 #200 | |
| 90% | | | |
| 80% | | | |
| ຼັງ 70% | | | |
| Passir 809 | | | |
| 50% | | | |
| 19 40% | | | |

| 40% | | | | | | | | |
|-----------------|---------|------------|----------------|------------------|----------------|-----------|--------------|----------------|
| 30% | | | | | | | | |
| 20% | | | | | | | | |
| 10% | | | | | | | | |
| 0% 10 | 0.00 | | 10.00 | Millimeters | 1.00 | | 0.10 | 0.01 |
| Cobbles | | < 300 r | nm (12") and : | > 75 mm (3") | Fine Sa | and | < 0.425 mm a | and > 0.075 mm |
| Gravel | | < 75 | mm and > 4.7 | '5 mm (#4) | Silt | | < 0.075 and | d > 0.005 mm |
| Coarse Sar | nd | < 4.75 | mm and >2.0 | 0 mm (#10) | Clay | 1 | < 0.0 | 005 mm |
| Medium Sa | nd | < 2.00 | mm and > 0.4 | 25 mm (#40) | Colloi | ds | < 0.0 | 001 mm |
| Method: B | | Proc | edure for obta | aining Specimen: | Moist | Dispersio | n Process: | Dispersant |
| Maxin | num Pai | ticle Size | 19.00 mm | | Coarse Sand | 3.5% | Fine Sa | and 39.7% |
| | | Gravel | 12.1% | | Medium Sand | 14.2% | Silt & C | lay 30.5% |
| | Liq | uid Limit | 28 | | Plastic Limit | 26 | Plastic Ind | dex 2 |
| | | | | Na | tural Moisture | 23.4% | | |

Notes / Deviations / References:

| Frank Morris. P.E. | FRANKP. MORTS. 2. | Project Manager | 8/30/21 |
|--------------------------|---|---------------------------------------|---------|
| Technical Responsibility | Signature | Position | Date |
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| ASTM D 4318 | \mathbf{X} | AASHTO | <i>T 89</i> 🛛 | | SHTO T 90 | | | | |
|---|--------------|------------------------|---------------|---------------|-------------|---------------------------|--------------|--------------|--------------------|
| S&ME, Inc | Spartanb | ourg: 301 | l Zima Pa | rk Drive, | Spartanbu | urg, SC 29 | 9301 | | |
| Project #: 213045 | | | | | | Report I | Date: | 8/30/2 | 21 |
| Project Name: Bad Creek Phase 2 | Feasibili | ity Study F | Project | | | Test [| Date: | 8/26/2 | 21 |
| Client Name: HDR | | | - | | | | | | |
| Client Address: 1122 Lady Street, | Suite 110 | 0 Colum | oia, South | n Carolina | a 29201 | | | | |
| Borehole: B-21-4 | Lo | og #: | 135 | | Sam | ple Date: | | 4/6/21 | |
| Sample ID: SS-3 | ٦ | Гуре: | Split-sp | oon | | Depth: | | 18.5' | |
| Sample Description: silty SAN | D (SM) - | brown, m | edium to | fine with | little grav | /el | | | |
| Type and Specification S&ME ID |)# | Cal Date: | Туре | and Speci | ification | S& | ME ID # | Cal | Date: |
| Balance (0.01 g) 7537 | | 1/29/2021 | Groo | oving tool | | | 14185 | 9/28 | /2020 |
| LL Apparatus 13859 |) | 9/28/2020 | 1 | | | | | | |
| Oven 7313 | | 7/30/2021 | | | | | | | |
| Pan # | 0.1 | | Liquic | l Limit | 1 | 1 | 2 | Plastic Limi | t |
| lare #: | Q-T | Q-2 | Q-3 | | | | 3 | 4 | |
| A lare weight | 16.65 | 16.59 | 15.72 | | | | 11.60 | 12.27 | |
| B Wet Soil Weight + A | 40.12 | 41.77 | 40.31 | | | | 18.27 | 18.96 | |
| C Dry Soil Weight + A | 35.04 | 36.12 | 34.68 | | | | 16.88 | 17.57 | |
| D Water Weight (B-C) | 5.08 | 5.65 | 5.63 | | | | 1.39 | 1.39 | |
| E Dry Soil Weight (C-A) | 18.39 | 19.53 | 18.96 | | | | 5.28 | 5.30 | |
| F % Moisture (D/E)*100 | 27.6% | 28.9% | 29.7% | | | | 26.3% | 26.2% | |
| N # OF DROPS | 32 | 21 | 15 | | | | Moisture Co | ontents det | ermined by |
| LL LL = F * FACTOR | | | | | | | A | STM D 221 | 6 |
| Ave. Average | | | | | | | | 26.3% | |
| 38.0 | | | | | | (N | One Point l | Liquid Lim | it Feator |
| | | | | \rightarrow | | 20 | 0.974 | 26 | 1 005 |
| | | | | | | 21 | 0.979 | 27 | 1.009 |
| 33.0 | | | | | | 22 | 0.985 | 28 | 1.014 |
| | | | | | | 23 | 0.99 | 29 | 1.018 |
| 28.0 | | | | | | 24 | 0.995 | 30 | 1.022 |
| l listr | | | | | | 25 | I.000 | actic | |
| W H | | | | | | | NP, NON-PI | imit 7 | |
| 23.0 | | | | | | | Diactic L | imit 2 | .0 |
| | | | | | | | | | 2 |
| 18.0 | | | | | | C | Froup Syn | abol S | M |
| 10 15 20 | 25 30 | 35 40 | # of] | Drops | 100 | N | Jultinoint N | Aethod | |
| L | | | L | .1 | | 0 | ne-point N | /lethod | |
| Wet Preparation Dry Preparati | on 🗸 | Air Drie | ed 🗸 | | % | 6 Passing t | he #200 Sid | eve: | 30.5% |
| Notes / Deviations / References: | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| ASTM D 4318: Liquid Limit, Plastic Limit, & | & Plastic II | ndex of Soil | ls | | | | | | |
| | | | | | | | | | |
| Matt Jacobs Technician Name | | <u>8/30/21</u> Date | | <u>Frar</u> | nk Morris | <u>, P.E.</u> sibility | | <u>8/3</u> | <u>0/21</u> ate |

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SIEVE ANALYSIS OF SOIL

| Single sieve set | | | | | | | ASTM E | 6913 | | | | | | | | | | |
|------------------|---------|-----------------------|-------------|----------|--------|--------|----------|---------|---------|--------------------|-------|--------|--------------|------|-------|---------|----------|---------|
| | | S&ME, | Inc | Sparta | nbu | rg: 3 | 01 Zim | a Park | Driv | e, Spa | rtanb | urg, S | C 293 | 301 | | | | |
| Project #: | 213 | 045 | | | | | | | | | | | | Rep | oort | Date: | 8/30 | 0/21 |
| Project Name: | Bad | Creek P | hase 2 | Feasib | oility | Study | Projec | t | | | | | | Tes | st Da | ate(s): | 8/16 - 8 | 8/18/21 |
| Client Name: | HDR | ł | | | | | - | | | | | | | | | | | |
| Client Address: | 1122 | 2 Lady S [.] | treet, S | Suite 1 | 100 | Colur | nbia, So | outh Ca | arolir | na 29 | 201 | | | | | | | |
| Borehole: | B-21 | -4 | | | | | L | og #: | | | 135 | | | San | nple | Date: | 4/6 | /21 |
| Sample ID: | SS-4 | ļ | | | | | ٦ | уре: | | Split | -spoc | on | | | D | Pepth: | 23 | 8.5' |
| Sample Descrip | tion: | silty SA | ND (SM | И) - bro | own | , medi | um to f | fine | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| 100% | | 1 • • • • • | " 3/4" • | 3/8" | | #4 | #10 | # | 20 • | #40 | #60 | #100 | #140 # | 200 | | | | _ |
| | | | _ | | | | | | | | _ | | | | | | | - |
| 90% | | | | | | | | | | | | | | | | | | |
| 80% | ┣┼┼┼┼ | | <u> </u> | | ++ | | | | | $\mathbf{\lambda}$ | _ | | | | | | | - 1 |
| ») 70% | | | | | | | | | | | | | | | | | | |
| 10% | | | | | | | | | | | | | | | | | | |
| 809 ASS | ┝┼┼┼ | | | | | | | | | | | | | | | | | - |
| 50% | | | | | | | | | | | | | | | | | | |
| erc | | | — | | | | | | | | | | \mathbf{H} | | | | | - |
| 40% | | | | | | | | | | | | | | | | | | |
| 30% | ┝┼┼┼ | | _ | | ++ | | | | | | | | | | | | | - |
| 20% | | | | | ++ | | | | | | | | | | _ | | | |
| 20% | | | | | | | | | | | | | | | | | | |
| 10% | ┝┼┼┼ | | | | ++ | | | | | | | | | | | | | - |
| 0% | | | | | | | | | | | | | | | | | | |
| 100 | 0.00 | | | 10.00 | | Millin | neters | 1.00 | | · | | | 0.10 | | | | | 0.01 |
| Cobbles | | < 30 | 0 mm (| 12") and | d > 7 | 75 mm | (3") | | Fi | ne San | d | | < | 0.42 | .5 m | m and | > 0.075 | mm |
| Gravel | | < 7 | 75 mm | and > 4 | 1.75 i | mm (#4 | 4) | | | Silt | | | | < 0. | 075 | and > | 0.005 m | m |

| Coarse Sand | < 4.75 | mm and >2.00 m | ım (#10) | Clay | / | < | 0.005 mr | n |
|-------------|------------|--------------------|--------------|----------------|-----------|------------|----------|--------|
| Medium Sand | < 2.00 r | nm and > 0.425 r | nm (#40) | Colloi | ds | < | 0.001 mr | n |
| Method: B | Proce | edure for obtainir | ig Specimen: | Moist | Dispersio | n Process: | Disp | ersant |
| Maximum Par | ticle Size | 9.50 mm | | Coarse Sand | 2.7% | Fine | Sand | 46.2% |
| | Gravel | 2.2% | | Medium Sand | 15.6% | Silt 8 | ર Clay | 33.4% |
| Liq | uid Limit | 27 | | Plastic Limit | 26 | Plastic | Index | 1 |
| | | | | | | | | |
| | | | Na | tural Moisture | 23.2% | | | |

Notes / Deviations / References:

| Frank Morris, P.E. | t-KANKT. MORALSIZ. | Project Manager | 8/30/2 |
|--------------------------|--------------------|-----------------|--------|
| Technical Responsibility | Signature | Position | Date |



| ASTM D 4318 | \mathbf{X} | AASHTO | 789 E |] AAS | SHTO T 90 | | | | |
|---|--------------|-------------|------------|-----------|-----------|-------------|--------------|--------------|------------|
| S&ME, Inc | Spartanb | ourg: 301 | 1 Zima Pa | rk Drive, | Spartanbu | urg, SC 29 | 301 | | |
| Project #: 213045 | | | | | | Report D | Date: | 8/30/ | 21 |
| Project Name: Bad Creek Phase 2 | 2 Feasibili | ity Study F | Project | | | Test [| Date: | 8/27/ | 21 |
| Client Name: HDR | | | | | | | | | |
| Client Address: 1122 Lady Street, | Suite 110 | 0 Columl | bia, South | Carolina | 29201 | | | | |
| Borehole: B-21-4 | L | og #: | 135 | | Sam | ple Date: | | 4/6/21 | |
| Sample ID: SS-4 | - | Гуре: | Split-spo | oon | | Depth: | | 23.5' | |
| Sample Description: silty SAN | ID (SM) - | brown, m | edium to | fine | | | | | |
| Type and Specification S&ME II | D # | Cal Date: | Туре | and Speci | ification | S& | ME ID # | Cal | Date: |
| Balance (0.01 g) 7537 | , | 1/29/2021 | Groo | ving tool | | | 14185 | 9/28 | /2020 |
| LL Apparatus 13859 | 9 | 9/28/2020 |) | | | | | | |
| Oven 7313 | } | 7/30/2021 | | | | | 1 | | |
| Pan # | V 1 | | Liquid | Limit | 1 | | | Plastic Limi | t |
| Tare #: | Y-1 | Y-2 | Y-3 | | | | 5 | 6 | |
| A lare weight | 16.40 | 16.43 | 16.99 | | | | 12.10 | 12.30 | |
| B Wet Soil Weight + A | 39.70 | 39.56 | 38.82 | | | | 18.45 | 18.69 | |
| C Dry Soil Weight + A | 34.77 | 34.53 | 33.96 | | | | 17.14 | 17.36 | |
| D Water Weight (B-C) | 4.93 | 5.03 | 4.86 | | | | 1.31 | 1.33 | |
| E Dry Soil Weight (C-A) | 18.37 | 18.10 | 16.97 | | | | 5.04 | 5.06 | |
| F % Moisture (D/E)*100 | 26.8% | 27.8% | 28.6% | | | | 26.0% | 26.3% | |
| N # OF DROPS | 30 | 22 | 15 | | | | Moisture C | ontents det | ermined by |
| LL LL = F * FACTOR | | | | | | | A | STM D 221 | 6 |
| Ave. Average | | | | | | | | 26.2% | |
| 37.0 - | | | | | | (| One Point I | Liquid Lim | it |
| | | | | | | N | Factor | N | Factor |
| | | | | | | 20 | 0.974 | 26 | 1.005 |
| 32.0 | | | | | | 21 | 0.979 | 27 | 1.009 |
| | | | | | | 23 | 0.99 | 29 | 1.014 |
| | | | | | | 24 | 0.995 | 30 | 1.022 |
| | | | | | | 25 | 1.000 | | |
| | | | | | | 1 | VP, Non-Pl | astic | |
| \$ 22.0 | | | | | | | Liquid L | imit 2 | 27 |
| | | | | | | | Plastic L | imit 2 | 26 |
| | | | | | | | Plastic Ir | ndex | 1 |
| 17.0 | + + | | | | | C | Group Syn | nbol S | М |
| 10 15 20 | 25 30 | 35 40 | # of I | Drops | 100 | N | lultipoint N | /lethod | 1 |
| | | | | | | 0 | ne-point N | /lethod | |
| Wet Preparation 🗌 Dry Preparat | ion 🗸 | Air Drie | ed 🗸 | | % | 6 Passing t | he #200 Si | eve: | 33.4% |
| Notes / Deviations / References: | | | | | | | | | |
| | | | | | | | | | |
| | 0.01 | | , | | | | | | |
| ASTM D 4318: LIQUIA LIMIT, Plastic Limit, o | & Plastic I | naex of Sou | 15 | | | | | | |
| Matt Jacobs | | 0 /20 /21 | | _ | | D. F. | | o (0 | 0.01 |

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SIEVE ANALYSIS OF SOIL

| Single sieve set | ASTM D 6913 | | |
|--------------------|---|---------|----------------|
| | S&ME, Inc Spartanburg: 301 Zima Park Drive, Spartanburg, SC 29301 | | |
| Project #: | 213045 Report | Date: | 8/30/21 |
| Project Name: | Bad Creek Phase 2 Feasibility Study Project Test Da | ate(s): | 8/16 - 8/18/21 |
| Client Name: | HDR | | |
| Client Address: | 1122 Lady Street, Suite 1100 Columbia, South Carolina 29201 | | |
| Borehole: | B-21-4 Log #: 135 Sample | Date: | 4/6/21 |
| Sample ID: | SS-5 Type: Split-spoon D | Depth: | 28.5' |
| Sample Description | ion: silty SAND with gravel (SM) - gray tan, medium to fine | | |
| 100% | | | |
| 90% | | | |
| 80% | | | |
| ം) ഇ. 70% | | | |
| 60% | | | |
| 50% | | | |
| 40% | | | |

| 20% 10% 0% 100.00 | 10.00 <u>Millin</u> | neters 1.00 | | 0.10 | 0.01 |
|----------------------------|-----------------------------|---------------|-----------|----------------|------------|
| Cobbles | < 300 mm (12") and > 75 mm | (3") Fine S | and | < 0.425 mm and | > 0.075 mm |
| Gravel | < 75 mm and > 4.75 mm (#4 | 4) Sil | t | < 0.075 and > | 0.005 mm |
| Coarse Sand | < 4.75 mm and >2.00 mm (# | 10) Cla | у | < 0.005 | mm |
| Medium Sand | < 2.00 mm and > 0.425 mm (# | #40) Collo | oids | < 0.001 | mm |
| Method: B | Procedure for obtaining Spe | ecimen: Moist | Dispersio | on Process: Di | spersant |
| Maximum Pa | rticle Size 19.00 mm | Coarse Sand | 7.4% | Fine Sand | 39.0% |
| | Gravel 16.5% | Medium Sand | 17.8% | Silt & Clay | 19.2% |
| Lic | quid Limit | Plastic Limit | NP | Plastic Index | NP |

Notes / Deviations / References:

30%

| Frank Morris, D.F. | FRANKP.MERTSIZ. | Project Manager | 9/20/21 |
|--------------------------|-----------------|-----------------|---------|
| FIANK WOINS, P.E. | | Project Manager | 0/30/21 |
| Technical Responsibility | Signature | Position | Date |

Natural Moisture

16.6%
| = | 9. |
|-----|----|
| | α. |
| 111 | = |
| | |

| | | ASTM D 4318 | X AA | SHTO T & | 89 🗆 AA | ASHTO T 90 | | | | |
|---|--|------------------------|-------------------|-----------------|------------------|---|---|---|--|---|
| | | S&ME, Inc | Spartanburg | : 301 Z | Zima Park Drive | , Spartanbu | urg, SC 29 | 9301 | | |
| Project : | #: 2130 | 045 | | | | | Report [| Date: | 8/30/2 | 21 |
| Project | Name: Bad | Creek Phase 2 | 2 Feasibility S | tudy Pro | oject | | Test [| Date: | 8/18/2 | 21 |
| Client N | lame: HDR | { | - | - | - | | | | | |
| Client A | ddress: 1122 | 2 Lady Street, S | Suite 1100 C | Columbia | a, South Carolin | na 29201 | - | | | |
| Borehol | e: B-21-4 | - | Log # | <i>‡</i> : | 135 | Sam | ple Date: | | 4/6/21 | |
| Sample | ID: SS-5 | | Туре | e: S | Split-spoon | | Depth: | | 28.5' | |
| Sample | Description: | silty SAN | D with grave | el (SM) - | gray tan, medi | um to fine | | | | |
| Type and | Specification | S&ME ID |) # Cal | Date: | Type and Spe | cification | S& | ME ID # | Cal | Date: |
| Balance | (0.01 g) | 7537 | 1/2 | 9/2021 | Grooving too | 1 | | 14185 | 9/28 | /2020 |
| LL Appar | atus | 13859 | 9 9/2 | 8/2020 | | | | | | |
| Oven | | 7313 | 7/3 | 0/2021 | | | | | | |
| Pan | # | | | | Liquid Limit | | | 1 | Plastic Limi | it |
| | | Tare #: | | | | | | | | |
| A | Tare Weight | | | | | | | | | |
| В | Wet Soil Weigh | nt + A | | | | | | | | |
| С | Dry Soil Weigh | t + A | | | | | | | | |
| D | Water Weight (| (B-C) | | | | | | | | |
| E | Dry Soil Weigh | t (C-A) | | | | | | | | |
| F | % Moisture (D/ | /E)*100 | | | | | | | | |
| N | # OF DROPS | | | | | | | Moisture Co | ontents det | ermined by |
| LL | LL = F * | FACTOR | | | | | | A | STM D 221 | 6 |
| A.v.o | | **** | | 1 | | | | | | |
| Ave. | Aver | rage | | | | | | | | |
| Ave. | Aver | ruge | | | | | | One Point I | Liquid Lim | iit |
| Ave. | 40.0 | | | - | | | N | One Point L Factor | Liquid Lim N | it Factor |
| Ave. | 40.0 | | | | | | N 20 | One Point L Factor 0.974 | Liquid Lim N 26 | iit Factor 1.005 |
| Ave. | 40.0 Aver | | | | | | N 20 21 | One Point I Factor 0.974 0.979 | Liquid Lim N 26 27 | it Factor 1.005 1.009 |
| et e | 40.0 Aver | | | | | | N 20 21 22 | One Point L Factor 0.974 0.979 0.985 | Liquid Lim N 26 27 28 20 | it Factor 1.005 1.009 1.014 1.018 |
| Content | 40.0 40.0 55.0 55.0 55.0 55.0 55.0 55.0 | | | | | | N 20 21 22 23 24 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 | Liquid Lim N 26 27 28 29 30 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| ure Content | | | | | | | N 20 21 22 23 24 25 | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 | iquid Lim N 26 27 28 29 30 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| oisture Content | 40.0 35.0 30.0 | | | | | | N 20 21 22 23 24 25 N | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 P. Non-Plá | Liquid Lim N 26 27 28 29 30 astic | it Factor 1.005 1.009 1.014 1.018 1.022 |
| 6 Moisture Content | | | | | | | N 20 21 22 23 24 25 N | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid I | Liquid Lim N 26 27 28 29 30 astic imit - | it Factor 1.005 1.009 1.014 1.018 1.022 X |
| % Moisture Content | | | | | | | N 20 21 22 23 24 25 N | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L | iquid Lim N 26 27 28 29 30 astic imit - | it Factor 1.005 1.009 1.014 1.018 1.022 |
| % Moisture Content | 40.0 35.0 30.0 25.0 | | | | | | N 20 21 22 23 24 25 N | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic L | Liquid Lim N 26 27 28 29 30 astic .imit - .imit N odex N | it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |
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| % Moisture Content | | 15 20 | | 40 | | 100 | N 20 21 22 23 24 25 N | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn 4ultipoint N | iquid Lim N 26 27 28 29 30 astic imit - imit N ndex N nbol S Aethod | it Factor 1.005 1.009 1.014 1.018 1.022 VP VP M |
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| Wet Pro | 40.0 35.0 30.0 25.0 20.0 10 eparation | 15 20 | | 40 | # of Drops | | N 20 21 22 23 24 25 N (((((((((((((| One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N Dne-point N the #200 Sid | Liquid Lim N 26 27 28 29 30 astic .imit - .imit - .imit M nbol S Method Method Pethod | it Factor 1.005 1.009 1.014 1.018 1.022 I I I I I I I I I I I I |
| Weitert Wotes / D | 40.0 35.0 30.0 25.0 20.0 10 Peparation | 15 20 Dry Preparati | 25 30 35 | 40 Air Dried | # of Drops | | N 20 21 22 23 24 25 N 0 </td <td>One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N One-point N the #200 Side</td> <td>Liquid Lim N 26 27 28 29 30 astic .imit - .imit N ndex N nbol S Method Method eve:</td> <td>it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ▼ ▼ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓</td> | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N One-point N the #200 Side | Liquid Lim N 26 27 28 29 30 astic .imit - .imit N ndex N nbol S Method Method eve: | it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ▼ ▼ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |
| Wet Pro Notes / D | 40.0 35.0 30.0 25.0 20.0 10 eparation Deviations / Refer | It 20 | 25 30 35 | 40 | # of Drops | 100 | N 20 21 22 23 24 25 N 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N Dne-point N the #200 Sid | Liquid Lim N 26 27 28 29 30 astic .imit - .imit N ndex N nbol S Method Aethod eve: | it Factor 1.005 1.009 1.014 1.018 1.022 ⊠ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |
| Weitent Wet Pro Notes / D | 40.0 35.0 30.0 25.0 20.0 10 Periation Deviations / Refer | Its 20 | 25 30 35 | 40 | # of Drops | 100 | N 20 21 22 23 24 25 N 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N One-point N the #200 Sid | Liquid Lim N 26 27 28 29 30 astic .imit - .imit N ndex N nbol S Aethod Aethod eve: | it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ▼ ▼ NP SM ↓ 19.2% |
| Weit Pri Notes / D ASTM D | 40.0 35.0 30.0 25.0 20.0 10 20.0 4318: Liquid Limit | It, Plastic Limit, & | 25 30 35 | 40 Air Dried | # of Drops | 100 | N 20 21 22 23 24 25 N 0 (0 0 0 6 Passing t | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N Dne-point N the #200 Sid | Liquid Lim N 26 27 28 29 30 astic .imit - .imit N ndex N nbol S Aethod Aethod | it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |
| Weitent Weitent Notes / D ASTM D | 40.0 35.0 30.0 25.0 20.0 10 20.0 10 21.0 22.0 20.0 | It, Plastic Limit, & | 25 30 35 | 40 Air Dried | # of Drops | 100 | N 20 21 22 23 24 25 N 0 (0 6 Passing t | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N One-point N the #200 Sid | iquid Lim N 26 27 28 29 30 astic .imit - .imit N nbol S Method Method eve: | it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ■ ■ 1.022 ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ |
| Weit Pri Notes / D ASTM D | 40.0 35.0 30.0 25.0 20.0 10 25.0 20.0 10 25.0 20.0 10 25.0 20.0 10 25.0 20.0 10 25.0 26.0 27.0 | bs | 25 30 35 ion ✓ | 40 Air Dried | # of Drops | 100 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 | N 20 21 22 23 24 25 N (((((((((((((| One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N Dne-point N the #200 Sid | Liquid Lim N 26 27 28 29 30 astic .imit .imit Method Aethod Aethod Aethod | it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |
| Wet Provident Astron D | 40.0 40.0 35.0 30.0 25.0 20.0 10 25.0 20.0 10 25.0 20.0 10 25.0 20.0 10 25.0 20.0 20.0 25.0 20 | It, Plastic Limit, & | 25 30 35 | 40 Air Dried | # of Drops | 100 9 mnk Morris | N 20 21 22 23 24 25 N 6 Passing t 5, P.E. sibility | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N Dne-point N he #200 Sid | Liquid Lim 26 27 28 29 30 astic .imit - .imit - .imit M nbol S Method Aethod Aethod Aethod Aethod | it Factor 1.005 1.009 1.014 1.018 1.022 ▼ ▼ NP NP NP NP NP NP NP NP NP NP |

| Single sieve set | ASTM D 6913 | |
|--------------------|---|------------------------------|
| | S&ME, Inc Spartanburg: 301 Zima Park Drive, Spartanburg, SC | 29301 |
| Project #: | 213045 | Report Date: 8/30/21 |
| Project Name: | Bad Creek Phase 2 Feasibility Study Project | Test Date(s): 8/16 - 8/18/21 |
| Client Name: | HDR | |
| Client Address: | 1122 Lady Street, Suite 1100 Columbia, South Carolina 29201 | |
| Borehole: | B-21-4 Log #: 135 | Sample Date: 4/6/21 |
| Sample ID: | SS-6 Type: Split-spoon | Depth: 33.5' |
| Sample Description | n: silty SAND (SM) - brown, medium to fine with little gravel | |
| 100% - | 1" 3/4" 3/8" #4 #10 #20 #40 #60 #100 | #140 #200 |
| 100% | | |
| 90% | | |
| 80% | | |
| ວິ ພ 70% - | | |





| | | ASTM D 4318 | X | AASHTO | T 89 🛛 | ⊐ AAS | нто т 90 | | | | |
|-----------|---------------------|--------------------|--------------|----------------|------------|-------------|------------------|---------------|--------------|---------------|--------------|
| | | S&ME, Inc | Spartanb | ourg: 301 | Zima Pa | rk Drive, S | Spartanbu | urg, SC 29 | 301 | | |
| Project # | #: 2130 | 45 | | | | | | Report D | Date: | 8/30/2 | 21 |
| Project I | Name: Bad (| Creek Phase 2 | 2 Feasibili | ity Study F | Project | | | Test D | Date: | 8/27/2 | 21 |
| Client N | ame: HDR | | | | - | | | | | | |
| Client A | ddress: 1122 | Lady Street, | Suite 110 | 0 Columb | oia, South | n Carolina | 29201 | | | | |
| Borehol | e: B-21-4 | | Lo | og #: | 135 | | Sam | ple Date: | | 4/6/21 | |
| Sample | ID: SS-6 | | 1 | Гуре: | Split-sp | oon | | Depth: | | 33.5' | |
| Sample | Description: | silty SAN | D (SM) - | brown, m | edium to | fine with | little grav | /el | | | |
| Type and | Specification | S&ME IE |)# | Cal Date: | Туре | and Speci | fication | S& | ME ID # | Cal I | Date: |
| Balance | (0.01 g) | 7537 | | 1/29/2021 | Groo | oving tool | | | 14185 | 9/28, | /2020 |
| LL Appar | atus | 13859 | 9 | 9/28/2020 | | | | | | | |
| Oven | | 7313 | | 7/30/2021 | | | | | | | |
| Pan : | # | Ta#a #. | 7 1 | 70 | | d Limit | | | 7 | Plastic Limit | t |
| | Tara Waight | Tare #: | Z-1 | 2-2 16 E9 | 2-3 | | | | 12.00 | 9 | |
| A | | + . Λ | 15.90 | 10.50 | 10.77 | | | | 10.24 | 12.23 | |
| В | Wet Soll Weight | (+ A | 40.44 | 40.83 | 39.00 | | | | 18.34 | 17.40 | |
| | Dry Soll Weight | + A | 35.31 | 35.61 | 34.64 | | | | 17.09 | 17.40 | |
| D | Water Weight (I | B-C) | 5.13 | 5.22 | 5.02 | | | | 1.25 | 1.28 | |
| E | Dry Soil Weight | (C-A) | 19.41 | 19.03 | 17.87 | | | | 5.09 | 5.17 | |
| F | % Moisture (D/I | E)*100 | 26.4% | 27.4% | 28.1% | | | | 24.6% | 24.8% | |
| N | # OF DROPS | | 31 | 21 | 16 | | | | Moisture C | ontents dete | ermined by |
| LL | LL = F * F | ACTOR | | | | | | | A | STM D 221 | 6 |
| Ave. | Avero | age | | | | | | | | 24.7% | |
| 3 | ^{37.0} T | | | | | | —) | (N | Jne Point | | It Eactor |
| | - | | | | | | | 20 | 0.974 | 26 | 1.005 |
| | | | | | | | | 21 | 0.979 | 27 | 1.009 |
| tent | 52.0 | | | | | | | 22 | 0.985 | 28 | 1.014 |
| Con | | | | | | | | 23 | 0.99 | 29 | 1.018 |
| l l 2 | 27.0 | | | | | | | 24 | 0.995 | 30 | 1.022 |
| oistu | | | | | | | | 25 | I.000 | lactic | |
| Ň | | | | | | | | I | | imit 7 | 7 |
| × 2 | 22.0 | | | | | | | | Diactic I | imit 2 | .7 |
| | | | | | | | | | | | . <u>.</u> |
| 1 | 7.0 | | | | | | | C | | nhol S | |
| | 10 1 | 5 20 | 25 30 | 35 40 | # of] | Drops | 100 | C | Iultinoint N | Method | |
| | | | | | | Julia | | 0 | ne-noint N | Vethod | |
| Wet Pre | eparation | Drv Preparati | ion 🗸 | Air Drie | ed √ | | % | 6 Passina t | he #200 Si | eve: | 29.6% |
| Notes / D | Deviations / Refere | ences: | | | | | | <u>g</u> | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| ASTM D 4 | 4318: Liquid Limit | , Plastic Limit, a | & Plastic II | ndex of Soil | s | | | | | | |
| | | | | | | | | | | | |
| | <u>Matt Jacob</u> | <u>)S</u> | | <u>8/30/21</u> | | Fran | <u>ık Morris</u> | <u>, P.E.</u> | | <u>8/3</u> | <u> 0/21</u> |
| | Technician Nan | ne | | Date | | Techn | ical Respons | sibility | | Do | ite |

3201 Spring Forest Road Raleigh, NC. 27616

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| Single sieve set | | | | | | | ASTM | D 6913 | | | | | | | | |
|----------------------|-----------|--------|----------|-----------|---------|-----------|-----------|-----------|-------|----------|--------------|----------------|----------|-----------|-------------|------|
| | | S&M | IE, Inc. | - Spar | tanb | urg: | 301 Zii | ma Park I | Driv | e, Spar | tanburg | g, SC 2930 | 1 | | | |
| Project #: | 2130 | 45 | | | | | | | | | | R | epor | t Date: | 8/30/2 | !1 |
| Project Name: | Bad C | reek | Phase | e 2 Feas | sibilit | ty Stu | udy Proje | ect | | | | Т | est D | Date(s): | 8/16 - 8/18 | 8/21 |
| Client Name: | HDR | | | | | | | | | | | | | | | |
| Client Address: | 1122 | Lady | Street | t, Suite | 110 | 0 Cc | lumbia, | South Ca | roliı | na 292 | 201 | | | | | |
| Borehole: | B-21- | 4 | | | | | | Log #: 1 | | | 135 | 35 Sample Date | | | 4/6/2 | 1 |
| Sample ID: | RC-1 | | | | | | | Type: | | Split | -spoon | | | Depth: | 60.7' | |
| Sample Description | on: s | ilty S | AND (| (SM) - 1 | tan b | rowr | n, mediu | m to fine | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 100% - | | _ | 1" 3/4" | 3/8 | 8" | #4 | #10 |) #2 | :0 | #40 | #60 # | 100 #140 #200 |) | | | |
| 100 % | | | | | | | | | | | | | | | | |
| 90% | | | | | | | | | | | | | | | + | |
| 80% | | | | | | | | | | | | | | | | |
| (%) (%) | | | | | | | | | | | | | | | | |
| ్లు 70% - | | | | | | \square | | | | | \mathbf{N} | | | | + | |
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| ^{%00} IB | | | | | | | | | | | | | | | | |
| 9 50% | | | | | | | | | | | | | | | + | |
| Lee 10% | | | | | | | | | | | | | | | + | |
| 40% | | | | | | | | | | | | N | | | | |
| 30% | | _ | | | | \square | | | | | | | | | + | |
| | | | | | | | | | | | | | | | | |
| 20% | | | | | | | | | | | | | | | | |
| 10% | | | | | | | | | | | | | | | + | |
| | | | | | | | | | | | | | | | + | |
| 0% ➡ 100.0 | 0 | | | 10.0 |)0 | Mi | llimeters | 1.00 | | • | | 0.10 | <u> </u> | | 0.0 | 01 |
| | | | | | | | | | | | | | | | | J |
| Cobbles | | < 3 | 300 mn | n (12") a | and > | 75 n | רm (3") | | Fi | ne Sano | d | < 0.4 | 425 m | nm and > | > 0.075 mr | n |
| Gravel | | | < 75 m | m and : | > 4.7 | 5 mm | (#4) | | | Silt | | < | 0.075 | 5 and > 0 |).005 mm | |
| Coarse Sand | | < | 4.75 m | nm and | >2.00 |) mm | (#10) | | | Clay | | | < | < 0.005 n | nm | |
| Medium Sand | | < 2 | 2.00 mr | m and > | > 0.42 | 25 mn | n (#40) | | C | Colloids | | | < | < 0.001 n | nm | |
| Method: B | | | Proced | ure for | obtai | ining | Specimer | i: Mo | ist | | Dispe | rsion Proce | SS: | Dis | persant | |
| Maximu | m Parti | icle S | ize | 4.75 m | m | | | Coarse | e Sai | nd | 2.3% | | Fine | e Sand | 52.0% | Ď |
| | | Gra | vel | 0.5% |) | | | Medium | i Sai | nd | 17.3% | | Silt | & Clay | 27.9% | ò |
| | Liqu | id Liı | mit | | | | | Plastic | : Lin | nit | NP | Р | lastic | : Index | NP | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | Na | atural Mo | oistu | ire | 2.1% | | | | | |
| Notes / Deviations / | ′ Referer | nces: | | | | | | | | | | | | | | |
| | | | | - | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | - | - | | | | | | | | | | | |
| Frank M | 1orris. F | P.E. | | + | -RAM | KA: | HERTSIG | 2. | | Pro | oiect M | anager | | | 8/30/21 | |

Technical Responsibility

3201 Spring Forest Road Raleigh, NC. 27616

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Position

Signature

Date

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| | | ASTM D 4318 | 🗵 AASH | ITO T 89 | a AAS | SHTO T 90 | | | | |
|------------|-----------------------------------|----------------------|--------------------|--------------------|----------------------|------------------|---------------------|--------------|-----------------|--------------------|
| | | S&ME, Inc 3 | Spartanburg: | 301 Zima Pa | ark Drive, | Spartanb | urg, SC 2 | 9301 | | |
| Project #: | : 213 | 045 | | | | | Report | Date: | 8/30/2 | 21 |
| Project N | lame: Bad | Creek Phase 2 | Peasibility Stu | dy Project | | | Test | Date: | 8/18/2 | 21 |
| Client Na | ame: HDI | २ | | | | | | | | |
| Client Ad | ldress: 112 | 2 Lady Street, S | Suite 1100 Col | umbia, Sout | h Carolina | a 29201 | - | | | |
| Borehole | : B-21-4 | | Log #: | 135 | | Sam | ple Date | : | 4/6/21 | |
| Sample II | D: RC-1 | | Type: | Split-sp | oon | | Depth | : | 60.7' | |
| Sample D | Description: | silty SAN | D (SM) - tan bi | own, mediu | m to fine | | | | | |
| Type and S | Specification | S&ME ID | D # Cal D | ate: Type | e and Speci | ification | S& | ME ID # | Cal | Date: |
| Balance ((| 0.01 g) | 7537 | 1/29/2 | 2021 Gro | oving tool | | | 14185 | 9/28 | /2020 |
| LL Appara | itus | 13859 | 9/28/2 | 2020 | | | | | | |
| Oven | | 7313 | 7/30/2 | 2021 | | | | | | |
| Pan # | | Taro #: | | Liqui | d Limit | | | | Plastic Limi | t |
| Δ | Tara Waight | Tale #. | | | | | | | | |
| A P | | at I A | | | | | | | | |
| Б | Dry Cail Maiah | 1L + A | | | | | | | | |
| | Dry Soll Weigh | (I + A | | | | | | | | |
| D - | | (B-C) | | | | | | | | |
| E | Dry Soil Weigh | it (C-A) | | | | | | | | |
| F | % Moisture (D | /E)*100 | | | | | | | | |
| N | # OF DROPS | | | | | | | Moisture Co | ontents det | ermined by |
| LL | LL = F * | FACTOR | | | | | | A | SIM D 221 | 6 |
| Ave. | Ave | rage | | | | | T | | | |
| 40 |).0 T | <u> </u> | | | | —) | N | One Point I | | it Eastar |
| | | | | | | | 20 | 0.974 | 26 | 1 005 |
| | | | | | | | 21 | 0.979 | 27 | 1.009 |
| ten 35 | 5.0 | | | | | | 22 | 0.985 | 28 | 1.014 |
| on | | | | | | | 23 | 0.99 | 29 | 1.018 |
| | | | | | | | 24 | 0.995 | 30 | 1.022 |
| itu 30 | | | | | | | 25 | 1.000 | | |
| Ioi | | | | | | | Ν | IP, Non-Pla | astic | X |
| 25 | 5.0 | | | | | | | Liquid L | imit - | |
| | | | | | | | | Plastic L | imit N | IP |
| | | | | | | | | Plastic Ir | ndex N | IP |
| 20 | 0.0 | 1 1 | | | | | | Group Svn | nbol S | M |
| | 10 | 15 20 | 25 30 35 4 | 0 # of | Drops | 100 | N | Aultipoint N | lethod | 7 |
| | | | | L | - | | (| Dne-point N | 1ethod | |
| Wet Prei | paration | Dry Preparati | on 🗸 Air | Dried 🗸 | | 9 | % Passing | the #200 Sid | eve: | 27.9% |
| Notes / De | eviations / Refe | rences: | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| ASTM D 43 | 318: Liquid Lim | it, Plastic Limit, 8 | & Plastic Index of | ^r Soils | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | <u>Matt Jaco</u> | <u>bs</u> | <u>8/30</u> | <u>/21</u> | Fran | <u>nk Morris</u> | <u>, P.E.</u> | | <u>8/3</u> | <u>0/21</u> |
| | <u>Matt Jaco</u> Technician Na | bs me | <u>8/30</u> Dat | <u>/21</u> e | <u>Fran</u> Techn | nk Morris | s, P.E. sibility | | <u>8/3</u> D | <u>0/21</u> ate |

| Single sieve set | ASTM D 6913 | | | | | | | | | |
|---|--|---------------|----------------|--|--|--|--|--|--|--|
| | S&ME, Inc Spartanburg: 301 Zima Park Drive, Spartanburg, SC 29 | 9301 | | | | | | | | |
| Project #: | 213045 | Report Date: | 8/30/21 | | | | | | | |
| Project Name: | Bad Creek Phase 2 Feasibility Study Project | Test Date(s): | 8/17 - 8/19/21 | | | | | | | |
| Client Name: | HDR | | | | | | | | | |
| Client Address: 1122 Lady Street, Suite 1100 Columbia, South Carolina 29201 | | | | | | | | | | |
| Borehole: | B-21-5 Log #: 135 | Sample Date: | 6/2/21 | | | | | | | |
| Sample ID: | SS-1 Type: Split-spoon | Depth: | 2.6' | | | | | | | |
| Sample Description | n: silty SAND (SM) - gray brown white, coarse to fine | | | | | | | | | |
| 100% | 1" 3/4" 3/8" #4 #10 #20 #40 #60 #100 #140 | #200 | | | | | | | | |
| 90% | | | | | | | | | | |
| 80% | | | + | | | | | | | |
| %) giuis | | | | | | | | | | |
| ent Pass | | | | | | | | | | |

| | 100% | | • • • • | • • | | | • | • | • | |
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| | 90% | ┣┼┼┼┥ | | | | | | | | |
| | 80% | | | | | | | | | |
| g (% | 70% | | | | | | | | | |
| sing | 60% | | | | | | | | | |
| nt Pa | 00 /6 | | | | | | | | | |
| ercei | 50% | ┣┥┥┥ | | | | | | | | |
| Ĕ. | 40% | | | | | | | | | |
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| | | | | | | | | | | |
| | 0% | | | 1 | _ | | | | | |
| | 10 | 0.00 | | 10.00 | I | Millimeters | 1.00 | | 0.10 | 0.01 |
| | Cobbles | 0.00 | < 300 | 10.00 mm (12") an | d > 75 | Millimeters mm (3") | 1.00 Fine S | and | 0.10 < 0.425 mm an | 0.01 nd > 0.075 mm |
| | Cobbles Gravel | 0.00 | < 300 | 10.00 mm (12") an 5 mm and > 4 | d > 75 4.75 m | Millimeters mm (3") m (#4) | 1.00 Fine S | and t | 0.10 < 0.425 mm an < 0.075 and | 0.01 nd > 0.075 mm > 0.005 mm |
| | Cobbles Gravel Coarse Sar | nd | < 300 < 7! < 4.7 | 10.00 mm (12") an 5 mm and > 4 5 mm and > 3 0 mm and > (| d > 75 4.75 m 2.00 m | Millimeters mm (3") m (#4) m (#10) nm (#40) | 1.00 Fine S Sil Cla | and t y uds | 0.10 < 0.425 mm an < 0.075 and < 0.00 < 0.00 | 0.01 nd > 0.075 mm > 0.005 mm 15 mm |
| C M Met | Cobbles Gravel Coarse San edium Sa hod: B | nd | < 300 < 7! < 4.7 < 2.00 Pro | 10.00 mm (12") an 5 mm and > 7 5 mm and > 7 0 mm and > 0 cedure for ob | d > 75 4.75 m 2.00 m 0.425 m otainin | Millimeters mm (3") m (#4) m (#10) nm (#40) g Specimen | 1.00 Fine S Sil Cla Collo Moist | and t y iids Dispersic | 0.10 < 0.425 mm an < 0.075 and < 0.00 < 0.00 on Process: | 0.01 nd > 0.075 mm > 0.005 mm 5 mm 11 mm Dispersant |
| C M Met | Cobbles Gravel Coarse Sar edium Sa hod: B Maxin | nd nd num Pai | < 300 < 7! < 4.7 < 2.00 Pro rticle Size | 10.00 mm (12") an 5 mm and > 4 5 mm and > 6 0 mm and > 0 cedure for of 9.50 mm | d > 75 4.75 m 2.00 m 0.425 m otainin | Millimeters mm (3") m (#4) m (#10) nm (#40) g Specimen | 1.00 Fine S Sil Cla Collo Moist Coarse Sand | iand t y vids Dispersic 14.1% | 0.10 < 0.425 mm an < 0.075 and < 0.00 < 0.00 on Process: Fine San | 0.01 nd > 0.075 mm > 0.005 mm 15 mm 11 mm Dispersant nd 35.6% |
| C M Met | Cobbles Gravel Coarse Sar edium Sa hod: B Maxin | nd nd num Par | < 300 < 7! < 4.7 < 2.00 Pro rticle Size Gravel | 10.00 mm (12") an 5 mm and > 4 5 mm and > 6 0 mm and > 6 cedure for ol 9.50 mm 6.9% | d > 75 4.75 m 2.00 m 0.425 n otainin | Millimeters mm (3") m (#4) m (#10) nm (#40) g Specimen | 1.00 Fine S Sil Cla Collo Moist Coarse Sand Medium Sand | and t y oids Dispersio 14.1% 23.3% | 0.10 < 0.425 mm an < 0.075 and < 0.00 < 0.00 on Process: Fine San Silt & Cla | 0.01 ad > 0.075 mm > 0.005 mm 15 mm 11 mm Dispersant ad 35.6% ay 20.1% |
| C M Met | Cobbles Gravel Coarse Sar edium Sa hod: B Maxin | nd nd num Pai | < 300 < 7! < 4.7 < 2.00 Pro rticle Size Gravel uuid Limit | 10.00 mm (12") an 5 mm and > 4 5 mm and > 0 0 mm and > 0 cedure for ol 9.50 mm 6.9% | d > 75 4.75 m 2.00 m 0.425 n otainin | Millimeters mm (3") m (#4) m (#10) nm (#40) g Specimen | 1.00 Fine S Sil Cla Collo Moist Coarse Sand Medium Sand Plastic Limit | and t y Dispersio 14.1% 23.3% NP | 0.10 < 0.425 mm an < 0.075 and < 0.00 < 0.00 on Process: Fine San Silt & Cla Plastic Inde | 0.01 ad > 0.075 mm > 0.005 mm 5 mm 11 mm Dispersant ad 35.6% ay 20.1% ex NP |
| C M Met | Cobbles Gravel Coarse Sar edium Sa hod: B Maxin | nd nd num Pai | < 300 < 7! < 4.7 < 2.00 Pro Pro ticle Size Gravel Juid Limit | 10.00 mm (12") an 5 mm and > 4 5 mm and > 0 0 mm and > 0 cedure for ol 9.50 mm 6.9% | d > 75 4.75 m 2.00 m 0.425 n otainin | Millimeters mm (3") m (#4) m (#10) nm (#40) g Specimen | 1.00 Fine S Sil Cla Collo Moist Coarse Sand Medium Sand Plastic Limit tural Moisture | and t y oids Dispersio 14.1% 23.3% NP 14.5% | 0.10 < 0.425 mm and < 0.075 and < 0.00 < 0.00 < 0.00 on Process: Fine Sand Silt & Clator Plastic Index | 0.01 ad > 0.075 mm > 0.005 mm 15 mm 11 mm Dispersant ad 35.6% ay 20.1% ex NP |
| C M Met | Cobbles Gravel Coarse Sar edium Sa hod: B Maxin | nd nd Lic | < 300 < 7! < 4.7 < 2.00 Pro rticle Size Gravel quid Limit ences: | 10.00 mm (12") an 5 mm and > 4 5 mm and > 6 0 mm and > (cedure for of 9.50 mm 6.9% | d > 75 4.75 m 2.00 m 0.425 n otainin | Millimeters mm (3") m (#4) m (#10) nm (#40) g Specimen | 1.00 Fine S Sil Cla Collo Moist Coarse Sand Medium Sand Plastic Limit tural Moisture | iand t y iids Dispersio 14.1% 23.3% NP 14.5% | 0.10 < 0.425 mm an < 0.075 and < 0.00 on Process: In Fine San Silt & Cla Plastic Inde | 0.01 ad > 0.075 mm > 0.005 mm 15 mm 11 mm Dispersant ad 35.6% ay 20.1% ex NP |
| C M Met | Cobbles Gravel Coarse Sar edium Sa hod: B Maxin | nd nd num Pai Lic | < 300 < 7! < 4.7 < 2.00 Pro rticle Size Gravel Juid Limit | 10.00 mm (12") an 5 mm and > 4 5 mm and > 6 0 mm and > 0 cedure for ol 9.50 mm 6.9% | d > 75 4.75 m 2.00 m 0.425 m otainin | Millimeters mm (3") m (#4) m (#10) nm (#40) g Specimen | 1.00 Fine S Sil Cla Collo Moist Coarse Sand Medium Sand Plastic Limit tural Moisture | iand t y oids Dispersio 14.1% 23.3% NP 14.5% | 0.10 < 0.425 mm an < 0.075 and < 0.00 < 0.00 on Process: Fine San Silt & Cla Plastic Inde | 0.01 ad > 0.075 mm > 0.005 mm 15 mm 11 mm Dispersant ad 35.6% ay 20.1% ex NP |
| C M Meth Notes / | Cobbles Gravel Coarse Sar edium Sa hod: B Maxin | nd nd Lic | < 300 < 7! < 4.7 < 2.00 Pro rticle Size Gravel Juid Limit | 10.00 mm (12") an 5 mm and > 4 5 mm and > (cedure for ol 9.50 mm 6.9% | d > 75 4.75 m 2.00 m 0.425 m otainin | Millimeters mm (3") m (#4) m (#10) nm (#40) g Specimen Na | 1.00 Fine S Sil Cla Collo Moist Coarse Sand Medium Sand Plastic Limit tural Moisture | and t y oids Dispersio 14.1% 23.3% NP 14.5% | 0.10 < 0.425 mm an < 0.075 and < 0.00 < 0.00 < 0.00 on Process: Fine San Silt & Cla Plastic Inde | 0.01 nd > 0.075 mm > 0.005 mm 15 mm 11 mm Dispersant nd 35.6% ay 20.1% ex NP |

| Frank Morris, P.E. | FRANKP. MORTS. P. | Project Manager | 8/30/21 |
|--------------------------|---|--------------------------------------|---------|
| Technical Responsibility | Signature | Position | Date |
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| | | ASTM D 4318 | XA | ASHTO T 89 | | AASHTO 1 | -90 D | | | |
|-----------|-------------------------------------|-----------------------|----------------|------------------------|-------------|--------------|---|---------------|-----------------|-----------------------------|
| | | S&ME, Inc S | Spartanbur | g: 301 Zir | ma Park D | rive, Sparta | anburg, SC | 29301 | | |
| Project a | #: 2130 |)45 | | | | | Repor | t Date: | 8/30/ | 21 |
| Project I | Name: Bad | Creek Phase 2 | Feasibility | Study Proj | ect | | Tes | t Date: | 8/19/ | 21 |
| Client N | ame: HDR | | | | | | | | | |
| Client A | ddress: 1122 | Lady Street, S | Suite 1100 | Columbia, | South Car | olina 2920 | 01 | | | |
| Borehol | e: B-21-5 | | Log | #: | 135 | | Sample Da [.] | te: | 6/2/21 | |
| Sample | ID: SS-1 | | Тур | be: Sp | lit-spoon | | Dept | th: | 2.6' | |
| Sample | Description: | siltv SAN | D (SM) - ar | av brown v | vhite, coar | se to fine | | | | |
| Type and | Specification | S&ME ID |)# Co | al Date: | Type and | Specificatio | n | S&ME ID # | Cal | Date: |
| Balance | (0.01 g) | 7537 | 1/ | 29/2021 | Grooving | tool | | 14185 | 9/28 | 3/2020 |
| LL Appar | atus | 13859 | 9/1 | 28/2020 | | | | | | |
| Oven | | 7313 | 7/ | 30/2021 | | | | | | |
| Pan : | # | | | | Liquid Limi | t | | | Plastic Lim | it |
| | • | Tare #: | | | | | | | | |
| Α | Tare Weight | | | | | | | | | |
| В | Wet Soil Weigh | t + A | | | | | | | | |
| С | Dry Soil Weight | : + A | | | | | | | | |
| D | Water Weight (| B-C) | | | | | | | | |
| E | Dry Soil Weight | : (C-A) | | | | | | | | |
| F | % Moisture (D/ | E)*100 | | | | | | | | |
| N | | | | | | | | Moisturo C | ontonto do | termined by |
| 11 | | FACTOR | | | | | | A | STM D 22 | 16 |
| | | | | | | | | | | |
| Ave. | Aver | uye | | | | | | One Point I | iquid Lin | nit |
| 4 | ^{10.0} T | | | | | | | Factor | N | Factor |
| | | | | | | | 20 | 0.974 | 26 | 1.005 |
| | | | | | | | 21 | 0.979 | 27 | 1.009 |
| ten | 5.0 | | | | | | 22 | 0.985 | 28 | 1.014 |
| Con | | | | | | | 23 | 0.99 | 29 | 1.018 |
| Ire 3 | 30.0 | | | | | | 24 | 0.995 | 30 | 1.022 |
| istr | | | | | | | 25 | 1.000 | 4 ° - | 5 |
| M | | | | | | | | NP, NON-Pla | | |
| 8 2 | 25.0 | | | | | | | | | |
| | | | | | | | | Plastic L | .imit i | |
| | | | | | | | | Plastic Ir | ndex I | NP |
| 2 | 10 | 15 20 | 25 30 3 | 5 40 | # CD | 100 | | Group Syn | nbol S | SM |
| | | | | | # of Drops | 3 | | Multipoint N | /lethod | ~ |
| | | | | | | | | One-point N | lethod | |
| Wet Pre | | Dry Preparati | on 🗸 | Air Dried | 7 | | % Passin | g the #200 Si | eve: | 20.1% |
| Notes / L | Deviations / Refere | ences: | | | | | | | | |
| | | | | | | | | | | |
| ASTM D 4 | 4318: Liquid Limit | t, Plastic Limit, 8 | & Plastic Inde | ex of Soils | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | <u>Matt Jacob</u> | <u> </u> | <u>8</u> , | /30/21 | | Frank Mc | orris, P.E. | | <u>8/3</u> | <u>0/21</u> |
| | <u>Matt Jacok</u> Technician Nar | <mark>DS</mark> ne | <u>8</u> , | / <u>30/21</u> Date | | Frank Mc | o <mark>rris, P.E.</mark> sponsibility | | <u>8/3</u> D | 8 <mark>0/21</mark> Date |

| Single sieve set | | | | | | ASTM | 1 D 6913 | | | | | | | |
|----------------------|-----------|------------------|----------------------|--------------|----------|-----------|----------------|--------------|----------|--------------|-------------|-----------|--------------------|-------------------|
| | 9 | S&ME, In | ic Sp | bartan | burg: | 301 Zi | ma Park | Driv | ve, Spa | artanb | urg, S | SC 29301 | | |
| Project #: | 21304 | 15 | | | | | | | | | | Re | eport Date: | 8/30/21 |
| Project Name: | Bad Cı | reek Pha | se 2 Fo | easibi | lity Stu | ıdy Proj | ect | | | | | Te | est Date(s): | 8/17 - 8/19/2 |
| Client Name: | HDR | | | | | | | | | | | | | |
| Client Address: | 1122 L | ady Stre | et, Su | ite 11 | 00 Co | lumbia, | South C | aroli | ina 2 | 9201 | | | | |
| Borehole: | B-21-5 | 5 | | | | | Log #: | | | 135 | | Sa | mple Date: | 6/2/21 |
| Sample ID: | SS-2 | | | | | | Type: | | Spl | it-spoo | on | | Depth: | 7.6' |
| Sample Description | on: si | Ity SAND |) (SM) | - bro | wn wh | ite, mec | lium to f | ine | | | | | | |
| 100% | | 1" 3 | /4" | 3/8" | #4 | #1 | 0 # | ŧ20 | #40 | #60 | #100 | #140 #200 | | |
| - | | | - | | | | | | | | | | | |
| 90% | | | | | | | \mathbf{i} | | | | | | | |
| 80% | | | | | | | | | | _ | | | | + |
| ്ല് 70% | | | | | | | | | | | | | | |
| .iis 60% | | | | | | | | | | \mathbf{X} | | | | |
| | | | | | | | | | | | | | | |
| erce | | | | | | | | | | | | | | |
| 40% | | | | | | | | | | | | | | |
| 30% | | | | | | | | | | _ | | | | |
| 20% | | | | | | | | | | | | | | |
| 10% | | | | | | | | | | | | | | |
| 10% | | | | | | | | | | _ | | | | |
| 0% L 100.0 | 0 | | 1 | 10.00 | Mi | llimeters | 1.0 |) | <u> </u> | | | 0.10 | | 0.01 |
| Cobbles | | < 300 n | nm (12 | ") and | > 75 m | ım (3") | | F | ine Sa | nd | | < 0.4 | 25 mm and | > 0.075 mm |
| Gravel | | < 75 | mm an | d > 4. | 75 mm | (#4) | | | Silt | | | < (| 0.075 and > | 0.005 mm |
| Coarse Sand | | < 4.75 | mm ar | nd >2. | 00 mm | (#10) | | | Clay | | | | < 0.005 | mm |
| Medium Sand | | < 2.00 ı | nm an | d > 0.4 | 425 mm | n (#40) | | | Colloid | ds Di | | | < 0.001 | mm |
| Method: B Maximu | m Parti | Proce No Sizo | edure f 2 75 | or obt mm | aining | Specimei | n: Mo Coars | oist e Sa | ind | Dis 6.69 | persic % | on Proces | s: Di Fine Sand | spersant 41 7% |
| Maxima | | Gravel | ۰. <i>۲</i> 3 1 (| 7% | | | Mediur | n Sa | ind | 22.8 | % | | Silt & Clav | 27.8% |
| | Liqui | d Limit | - | | | | Plast | ic Li | mit | NP | | PI | astic Index | NP |
| | - | | | | | | | | | | | | | |
| | | | | | | N | atural M | oist | ure | 15.1 | % | | | |
| Notes / Deviations / | / Referen | ces: | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |

| Frank Morris DE | FRANKP. MORTSR. | Project Manager | 8/20/2 |
|--------------------------|-----------------|-----------------|--------|
| FIGHK WOTTS, P.E. | | Project Manager | 0/30/2 |
| Technical Responsibility | Sianature | Position | Date |



| | | ASTM D 4318 | | ASHTO T 89 | | AASHT | O T 90 | | | | |
|---------------|------------------------------|---------------------|-----------------|-----------------|-----------------|------------|----------|-------------|--------------|------------------|------------|
| | | S&ME, Inc 3 | Spartanburg | : 301 Zim | na Park Dri | ive, Spa | artanbu | urg, SC 29 | 9301 | | |
| Project # | #: 213 | 045 | | | | | | Report [| Date: | 8/30/ | 21 |
| Project N | Name: Bad | Creek Phase 2 | Feasibility S | Study Proje | ct | | | Test [| Date: | 8/19/ | 21 |
| Client N | ame: HDF | २ | | | | | | | | | |
| Client Ad | ddress: 112 | 2 Lady Street, S | Suite 1100 (| Columbia, S | South Card | olina 29 | 9201 | | | | |
| Borehole | e: B-21-5 | | Log # | ¥: | 135 | | Sam | ple Date: | | 6/2/21 | |
| Sample | ID: SS-2 | | Тур | e: Spl | it-spoon | | | Depth: | | 7.6' | |
| Sample | Description: | silty SAN | D (SM) - bro | wn white, | medium to | o fine | | | | | |
| Type and | Specification | S&ME ID |)# Ca | l Date: | Type and S | Specifica | tion | S& | ME ID # | Cal | Date: |
| Balance | (0.01 g) | 7537 | 1/2 | 9/2021 | Grooving t | tool | | | 14185 | 9/28 | 8/2020 |
| LL Appara | atus | 13859 | 9/2 | 8/2020 | | | | | | | |
| Oven Ban t | # | /313 | //3 | 0/2021 | Liquid Limit | | | | | Plactic Lim | :+ |
| Full + | Ŧ | Tare # [.] | | | | | | | | | |
| Δ | Tare Weight | Tare #: | | | | | | | | | |
| B | Wet Soil Weig | ht + A | | <u> </u> | | | | | | | |
| C | Dry Soil Weigh | ht + A | | | | | | | | | |
| | Water Weight | (B-C) | | | | | | | | | |
| F | Dry Soil Weight | $(C - \Delta)$ | | | | | | | | | |
| | % Moisture (D | /F)*100 | | | | | | | | | |
| N | | (2) 100 | | | | | | | Maistura C | antante dat | arminad by |
| | | FACTOR | | | | | | | Moisture Co | STM D 221 | ermined by |
| Δνα | | rage | | | | | | | | - | - |
| 7176. | 7100 | lage | | | | | | (| One Point I | iauid Lim | nit |
| 4 | 0.0 | | | | | | | N | Factor | N | Factor |
| | | | | | | | | 20 | 0.974 | 26 | 1.005 |
| 뉟 3 | 5.0 | | | | | | | 21 | 0.979 | 27 | 1.009 |
| nte | | | | _ | | | | 22 | 0.985 | 28 | 1.014 |
| ں د | | | | | | | | 23 | 0.995 | 30 | 1.022 |
| tir 3 | 0.0 | | | | | | | 25 | 1.000 | | |
| Iois | | | | | | | | N | P, Non-Pla | astic | X |
| 8 2 | 5.0 | | | | | | | | Liquid L | .imit - | |
| • | | | | | | | | | Plastic L | imit 🚺 | NP |
| | | | | | | | | | Plastic Ir | ndex 🚺 | NP |
| 2 | 0.0 | - | + + + | _ _ | <u> </u> | | 100 | (| Group Syn | nbol S | M |
| | 10 | 15 20 | 25 30 35 | 40 | # of Drops | | 100 | Ν | 1ultipoint N | /lethod | 1 |
| | | | | | | | | С | ne-point N | /lethod | |
| Wet Pre | eparation | Dry Preparati | on 🗸 | Air Dried | 1 | | % | 6 Passing t | he #200 Si | eve: | 27.8% |
| Notes / D | eviations / Refe | rences: | | | | | | | | | |
| | | | | | | | | | | | |
| ASTMD | 4318 [.] Liquid Lim | it Plastic Limit & | V Plastic Index | of Soils | | | | | | | |
| AJIMU | | | | 0 5013 | | | | | | | |
| | Matt Jaco | hs | ٨/ | 30/21 | ſ | Frank M | Morrie | PF | | 8/2 | 0/21 |
| | Technician Na | ime | <u>0/</u> | Date | <u>1</u> 7 | Technical | Respons | ibility | | <u>0, 5</u> D | ate |
| | | This report shall | not be reproduc | ed, except in j | full, without t | the writte | en appro | val of S&MI | E, Inc. | | |
| | | | | | | | | | | | |

| | ., | | | | | | | | | | | | 111.5 | |
|----------------------|--------|-----------|---------|----------|---------|-----------|-----------|---------|--------------------|--------------|---------------------|-------------|---------------|-------|
| Single sieve set | | | | | | ASTM | D 6913 | | | | | | | |
| | | S&ME, II | nc Sj | partan | burg: | 301 Zir | na Park D | rive, S | partanb | urg, S | C 2930 ⁻ | 1 | | |
| Project #: | 2130 | 45 | | | | | | | | | Re | eport Date | e: 8/30/ | 21 |
| Project Name: | Bad C | Creek Pha | ase 2 F | easibil | ity Stu | dy Proje | ct | | | | T | est Date(s |): 8/17 - 8/1 | 19/21 |
| Client Name: | HDR | | | | | | | | | | | | | |
| Client Address: | 1122 | Lady Str | eet, Su | ite 110 | 00 Co | lumbia, S | South Car | olina i | 29201 | | | | | |
| Borehole: | B-21- | ·5 | | | | | Log #: | | 135 | | Sa | mple Date | e: 6/2/2 | 21 |
| Sample ID: | SS-3 | | | | | | Туре: | Sp | olit-spoo | on | | Depth | n: 12.6 | j' |
| Sample Description | on: s | ilty SAN | D (SM) |) - gray | / olive | white, m | nedium to | fine w | vith little | e grav | el | | | |
| (| | 1" | 3/4" | 3/8" | #4 | #10 | #20 | #, | 40 #60 | #100 | #140 #200 | | | |
| 100% | + | | 5,74 | | | | *20 | | • | + | • | | | |
| 90% | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| 80% | | | | | | | | | | | | | | |
| ୁ ଜୁ 70% | | | | | | | | | \leftarrow | | | | | |
| iiss 60% | | | | | | | | | $\mathbf{\Lambda}$ | | | | | |
| t Pa | | | | | | _ | | | | | | | | |
| | | | | | | | | | | \mathbf{h} | | | | |
| ਕ <mark>ੇ</mark> 40% | | | | | | | | | | | | | | |
| 20% | | | | | | | | | | | | | | |
| 50% | | | | | | | | | | | | | | |
| 20% | | | | | | | | | | | | | | |
| 10% | | | | | | | | | | | | | | |
| - | | | | | | | | | | | | | | |
| 0% - 100.0 | 0 | | | 10.00 | Mi | limeters | 1.00 | | • | | 0.10 | | 0. | .01 |
| | | | | | L | | | | | | | | | |
| Cobbles | | < 300 | mm (12 | 2") and | > 75 m | m (3") | | Fine S | and | | < 0.4 | 125 mm and | d > 0.075 m | ım |
| Gravel | | < 75 | mm ar | 1d > 4.7 | 75 mm | (#4) | | Sil | t | | < | 0.075 and > | • 0.005 mm | |
| Medium Sand | 1 | < 2.00 | mm an | na > 2.0 | 25 mm | (#10) | | | iy bids | | | < 0.005 | mm | |
| Method: B | | Proc | cedure | for obta | aining | Specimen | : Mois | t | Dis | persio | n Proces | is: D | Dispersant | |
| Maximu | m Part | icle Size | 19.0 | 0 mm | 5 | | Coarse | Sand | 3.0% | % | | Fine Sand | d 45.89 | % |
| | | Gravel | 11 | .4% | | | Medium | Sand | 15.5 | % | | Silt & Cla | y 24.39 | % |
| | Liqu | uid Limit | - | | | | Plastic | Limit | NP |) | PI | lastic Inde | x NP | |

Notes / Deviations / References:

| | FRANKPAURISO | | |
|---------------------------|--------------|------------------------|---------------|
| <u>Frank Morris, P.E.</u> | | <u>Project Manager</u> | <u>8/30/2</u> |
| Technical Responsibility | Sianature | Position | Date |

Natural Moisture

13.7%



| | | ASTM D 4318 | X | AASHTO T | T 89 🗆 A | ASHTO T 90 | | | | |
|---|--|---|-------------|-------------------|-------------------|--|---|---|---|---|
| | | S&ME, Inc | Spartanb | urg: 301 | Zima Park Driv | e, Spartanbı | urg, SC 29 | 9301 | | |
| Project # | : 2130 | 45 | | | | | Report I | Date: | 8/30/ | 21 |
| Project N | lame: Bad (| Creek Phase 2 | 2 Feasibili | ty Study P | roject | | Test I | Date: | 8/19/ | 21 |
| Client Na | ame: HDR | | | <u> </u> | 5 | | | | | |
| Client Ad | dress: 1122 | Lady Street, | Suite 110 | 0 Columb | oia, South Caroli | ina 29201 | _ | | | |
| Borehole | e: B-21-5 | | Lc | oa #: | 135 | Sam | ple Date: | | 6/2/21 | |
| Sample I | D: 55-3 | | T | vne [.] | Split-spoon | 00111 | Depth: | | 12 6' | |
| Sample I | Description [.] | silty SAN | ID (SM) - | grav olive | white medium | to fine with | little gra | vel | 12.0 | |
| Type and | Specification | S&ME II |) # | Cal Date: | Type and Sp | ecification | S8 | ME ID # | Cal | Date: |
| Balance (| 0.01 q) | 7537 | , | 1/29/2021 | Grooving to | ol | | 14185 | 9/28 | /2020 |
| LL Appara | atus | 13859 | Э | 9/28/2020 | | | | | | |
| Oven | | 7313 | , | 7/30/2021 | | | | | | |
| Pan # | ÷ | | | | Liquid Limit | | _ | | Plastic Limi | it |
| | - | Tare #: | | | | | | | | |
| А | Tare Weight | | | | | | | | | |
| В | Wet Soil Weight | t + A | | | | | | | | |
| С | Dry Soil Weight | + A | | | | | | | | |
| D | Water Weight (B | 3-C) | | | | | | | | |
| E | Dry Soil Weight | (C-A) | | | | | | | | |
| F | % Moisture (D/E | E)*100 | | | | | | | | |
| N | # OF DROPS | , | | | | | | Moisturo C | ontonts dat | arminad by |
| 11 | | | | | | | | A | STM D 221 | 6 |
| Avo | | | | | | | | | | |
| Ave. | Avent | Jge | | | | | 1 | One Point I | iquid Lim | it |
| 40 | ^{0.0} T | | | | | | N | Factor | N | Factor |
| | | | | | | | | 0.074 | 20 | 1.005 |
| | | | | | | | 20 | 0.974 | 26 | 1.005 |
| + 2 | | | | | | | 20 21 | 0.974 | 26 | 1.005 |
| tent 35 | 5.0 | | | | | | 20 21 22 | 0.974 0.979 0.985 | 26 27 28 | 1.003 1.009 1.014 |
| Content 35 | 5.0 | | | | | | 20 21 22 23 | 0.979 0.985 0.99 | 26 27 28 29 | 1.003 1.009 1.014 1.018 |
| 35 Tre Content | 5.0 | | | | | | 20 21 22 23 24 25 | 0.979 0.985 0.99 0.995 | 26 27 28 29 30 | 1.003 1.009 1.014 1.018 1.022 |
| oisture Content | 0.0 | | | | | | 20 21 22 23 24 25 | 0.979 0.985 0.99 0.995 1.000 | 26 27 28 29 30 | 1.003 1.009 1.014 1.018 1.022 |
| 6 Moisture Content | 5.0 | | | | | | 20 21 22 23 24 25 N | 0.979 0.985 0.99 0.995 1.000 | 26 27 28 29 30 astic | 1.003 1.009 1.014 1.018 1.022 |
| % Moisture Content 36 | 5.0 | | | | | | 20 21 22 23 24 25 | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pli Liquid L | 26 27 28 29 30 astic .imit - | 1.003 1.009 1.014 1.018 1.022 X |
| % Moisture Content 35 | 5.0 | | | | | | 20 21 22 23 24 25 | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L | 26 27 28 29 30 astic .imit - .imit N | 1.003 1.009 1.014 1.018 1.022 |
| 35 % Moisture Content 25 | 5.0 | | | | | | 20 21 22 23 24 25 | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir | 26 27 28 29 30 astic .imit - .imit N ndex N | 1.003 1.009 1.014 1.018 1.022 X NP NP |
| 35 % Moisture Content 25 | | 5 20 | 25 30 | 35 40 | | | 20 21 22 23 24 25 N | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn | 26 27 28 29 30 astic .imit - .imit M ndex M nbol S | 1.003 1.009 1.014 1.018 1.022 X P IP SM |
| 35 % Moisture Content 20 | | 5 20 | 25 30 | 35 40 | # of Drops | 100 | 20 21 22 23 24 25 N | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N | 26 27 28 29 30 astic .imit - .imit M ndex M nbol S Aethod | 1.003 1.009 1.014 1.018 1.022 ⊠ NP NP SM ✓ |
| 35 % Moisture Content 20 | 5.0 0.0 5.0 0.0 10 10 10 10 10 | 5 20 | 25 30 | 35 40 | # of Drops | | 20 21 22 23 24 25 N | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N Dne-point N | 26 27 28 29 30 astic .imit - .imit M ndex M nbol S Method Aethod | 1.003 1.009 1.014 1.018 1.022 ⊠ → ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |
| 35 30 30 25 20 Wet Pre Notes / De | 5.0 | 5 20 Dry Preparati | 25 30 | 35 40 | # of Drops | 100 | 20 21 22 23 24 25 N (0 (0) 0 6 Passing t | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N One-point N the #200 Sin | 26 27 28 29 30 astic .imit - .imit M ndex M nbol S Aethod Aethod eve: | 1.003 1.009 1.014 1.018 1.022 ⊠ ■ ■ 24.3% |
| Vet Pre Notes / De | 5.0 5.0 5.0 5.0 10 10 1 eviations / Refere | 5 20 Dry Preparati | 25 30 | 35 40 | # of Drops | 100 | 20 21 22 23 24 25 N 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N One-point N | 26 27 28 29 30 astic .imit - .imit M ndex M nbol S Aethod Aethod | 1.003 1.009 1.014 1.018 1.022 ⊠ □ 24.3% |
| Wet Pre Notes / De | 5.0 | 5 20 Dry Preparati | 25 30 | 35 40 | # of Drops | 100 | 20 21 22 23 24 25 N 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N Dne-point N | 26 27 28 29 30 astic .imit - .imit - nbol S Method Aethod | 1.003 1.009 1.014 1.018 1.022 ⊠ □ 24.3% |
| Wet Pre Notes / De ASTM D 4 | 5.0 | 5 20 Dry Preparati | 25 30 | 35 40 Air Drie | d I | 100 | 20 21 22 23 24 25 N 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N Dne-point N the #200 Sid | 26 27 28 29 30 astic .imit - .imit M ndex M nbol S Aethod Aethod | 1.003 1.009 1.014 1.018 1.022 ⊠ NP JP ™ 24.3% |
| Wet Pre Notes / De ASTM D 4 | 5.0 | 5 20 Dry Preparati 20 Plastic Limit, 6 | 25 30 | 35 40 Air Drie | d ✓ | 100 | 20 21 22 23 24 25 N 0 (0 0 6 Passing t | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N Dne-point N | 26 27 28 29 30 astic .imit - .imit - ndex N nbol S Aethod Aethod | 1.003 1.009 1.014 1.018 1.022 ⊠ → ↓ 24.3% |
| Wet Pre Notes / Do | 5.0 5.0 5.0 5.0 10 10 10 1 10 1 1 1 1 1 1 1 1 1 1 1 1 1 | 5 20 Dry Preparati 20 Plastic Limit, 6 | 25 30 | Air Drie | d ✓ | 100 2 2 2 2 3 2 3 3 3 3 3 3 3 3 3 3 3 3 3 | 20 21 22 23 24 25 N 6 Passing t | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N One-point N | 26 27 28 29 30 astic .imit - .imit M ndex M nbol S Aethod Aethod eve: | 1.003 1.009 1.014 1.018 1.022 ⊠ № № № № № № № № |
| Wet Pre Notes / De ASTM D 4 | 5.0 5.0 5.0 5.0 5.0 10 10 1 1 1 1 1 1 1 1 1 1 1 1 1 | 5 20 Dry Preparati 20 Dry Preparati | 25 30 | Air Drie | d ✓ Fr Tec | 100 P rank Morris chnical Response | 20 21 22 23 24 25 N 6 Passing t | 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N Dne-point N | 26 27 28 29 30 astic .imit - .imit M ndex M nbol S Method Method Method Method | 1.003 1.009 1.014 1.018 1.022 ⊠ → ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |

| Single sieve set | | ASTM D 6913 | | | |
|--------------------|-------------------------------------|----------------------|----------------------|---------------|----------------|
| | S&ME, Inc Spartanburg: 3 | 01 Zima Park Driv | ve, Spartanburg, SC | 29301 | |
| Project #: | 213045 | | | Report Date: | 8/30/21 |
| Project Name: | Bad Creek Phase 2 Feasibility Study | / Project | | Test Date(s): | 8/17 - 8/19/21 |
| Client Name: | HDR | | | | |
| Client Address: | 1122 Lady Street, Suite 1100 Colur | nbia, South Carol | ina 29201 | | |
| Borehole: | B-21-5 | Log #: | 135 | Sample Date: | 6/2/21 |
| Sample ID: | SS-4 | Туре: | Split-spoon | Depth: | 17.6' |
| Sample Description | n: silty SAND (SM) - gray olive w | hite, coarse to fine | e with little gravel | | |
| 100% | 1" 3/4" 3/8" #4 | #10 #20 | #40 #60 #100 #1 | 40 #200 | |



3201 Spring Forest Road Raleigh, NC. 27616

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| | AS | STM D 4318 | \boxtimes , | ааѕнто т | 89 🗆 AA | ASHTO T 90 | | | | |
|---|--|-----------------------------|-----------------|-----------|-------------------|--------------|---|---|---|--|
| | S8 | &ME, Inc : | Spartanbui | rg: 301 | Zima Park Drive | , Spartanbu | urg, SC 29 | 9301 | | |
| Project #: | 213045 | | | | | | Report I | Date: | 8/30/2 | 21 |
| Project Nan | me: Bad Cre | eek Phase 2 | Feasibility | Study Pi | oject | | Test I | Date: | 8/19/2 | 21 |
| Client Nam | e: HDR | | | | | | | | | |
| Client Addr | ress: 1122 La | ady Street, S | Suite 1100 | Columb | ia, South Carolin | na 29201 | | | | |
| Borehole: | B-21-5 | | Loc | 1#: | 135 | Sam | ple Date: | | 6/2/21 | |
| Sample ID: | SS-4 | | Ty | pe: | Split-spoon | | Depth: | | 17.6' | |
| Sample Des | scription: | silty SAN | D (SM) - g | ray olive | white, coarse to | fine with li | ttle grave | el | | |
| Type and Spe | ecification | S&ME ID |)# (| Cal Date: | Type and Spe | cification | 58 | ME ID # | Cal | Date: |
| Balance (0.0 |)1 g) | 7537 | 1, | /29/2021 | Grooving too | I | | 14185 | 9/28 | /2020 |
| LL Apparatus | s | 13859 |) 9, | /28/2020 | | | | | | |
| Oven | | 7313 | 7, | /30/2021 | | | | | | |
| Pan # | | T awa #4 | | | Liquid Limit | | | [| Plastic Limi | t |
| | va Maisht | Tare #: | | | | | | | | |
| A la | | ٨ | | | | | | | | |
| B W | et Soil Weight + | A | | | | _ | | | | |
| C Dr | ry Soil Weight + | A | | | | | | | | |
| D Wa | ater Weight (B-C | 2) | | | | | | | | |
| E Dr | ry Soil Weight (C | -A) | | | | | | | | |
| F % | Moisture (D/E)* | 100 | | | | | | | | |
| N # (| OF DROPS | | | | | | | Moisture Co | ontents det | ermined by |
| LL | LL = F * FAG | CTOR | | | | | | A | STM D 221 | 6 |
| Ave. | Average | 2 | | | | | | | | |
| | | | | | | | | | المتربية | i+ |
| 40.0 | | | | | | | | One Point L | liquia Lim | ιι |
| 40.0 | | | | | | \equiv) | N | Factor | N | Factor |
| 40.0 | | | | | | | N 20 21 | 0.974 | 26 | Factor 1.005 |
| 40.0 1 35.0 | | | | | | | N 20 21 22 | 0.974 0.979 0.985 | 26 27 28 | Factor 1.005 1.009 1.014 |
| 40.0 ten 35.0 | | | | | | | N 20 21 22 23 | Factor 0.974 0.979 0.985 0.99 | N 26 27 28 29 | Factor 1.005 1.009 1.014 1.018 |
| 40.0 35.0 9 30.0 | | | | | | | N 20 21 22 23 24 | Factor 0.974 0.979 0.985 0.99 | N 26 27 28 29 30 | Factor 1.005 1.009 1.014 1.018 1.022 |
| 40.0 35.0 30.0 30.0 | | | | | | | N 20 21 22 23 24 25 | Factor 0.974 0.979 0.985 0.99 0.995 1.000 | N 26 27 28 29 30 | Factor 1.005 1.009 1.014 1.018 1.022 |
| 40.0 Woisture Content 30.0 | | | | | | | N 20 21 22 23 24 25 N | Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla | N 26 27 28 29 30 | Factor 1.005 1.014 1.018 1.022 |
| 40.0 35.0 30.0 % 25.0 | | | | | | | N 20 21 22 23 24 25 N | Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Platic Liquid L | N 26 27 28 29 30 | Factor 1.005 1.009 1.014 1.018 1.022 |
| 40.0 35.0 30.0 25.0 | | | | | | | N 20 21 22 23 24 25 N | Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Plate Liquid L Plastic L | N 26 27 28 29 30 astic imit - imit N | Factor 1.005 1.009 1.014 1.018 1.022 |
| 40.0 35.0 30.0 25.0 | | | | | | | N 20 21 22 23 24 25 N | Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In | N 26 27 28 29 30 | Factor 1.005 1.009 1.014 1.018 1.022 ▼ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |
| 40.0 35.0 30.0 % Voisture Content 25.0 20.0 | | | | | | 100 | N 20 21 22 23 24 25 N | Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym | N 26 27 28 29 30 add to the second secon | Factor 1.005 1.009 1.014 1.018 1.022 ▼ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ |
| 40.0 35.0 30.0 25.0 20.0 | | 20 | | 35 40 | # of Drops | 100 | N 20 21 22 23 24 25 N | Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym | N 26 27 28 29 30 | Factor 1.005 1.009 1.014 1.018 1.022 IM IM |
| 40.0 35.0 30.0 25.0 20.0 | | 20 | | | # of Drops | | N 20 21 22 23 24 25 N (((((((((((((| Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M | N 26 27 28 29 30 astic imit adex Aethod Aethod | Factor 1.005 1.009 1.014 1.018 1.022 IX JP M ✓ IX |
| 40.0 40.0 100 100 100 100 100 100 100 | | 20 Dry Preparati | 25 30 3 | 35 40 | # of Drops | | N 20 21 22 23 24 25 N 6 Passing t | Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M Dne-point M the #200 Sid | N 26 27 28 29 30 asstic imit adex Method Aethod ave: | Factor 1.005 1.009 1.014 1.018 1.022 Image: State St |
| 40.0 40.0 40.0 35.0 30.0 30.0 25.0 20.0 Wet Prepar Notes / Device | 10 15 | 20 Dry Preparati | 25 30 3 | Air Dried | # of Drops | 100 | N 20 21 22 23 24 25 N (((((((((((((| Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M Dne-point M the #200 Sid | N 26 27 28 29 30 astic imit adex Aethod Aethod eve: | Factor 1.005 1.009 1.014 1.018 1.022 IX JP JP IA 16.1% |
| 40.0 40.0 100 35.0 30.0 25.0 20.0 Wet Prepar Notes / Device | 10 15 | 20 Dry Preparati | 25 30 3 | 35 40 | # of Drops | | N 20 21 22 23 24 25 N 6 Passing t | Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint N Dne-point N the #200 Sid | N 26 27 28 29 30 astic imit adex Method Aethod ave: | Factor 1.005 1.009 1.014 1.018 1.022 Image: Constraint of the second secon |
| 40.0 40.0 40.0 35.0 30.0 30.0 25.0 20.0 Wet Prepar Notes / Device ASTM D 4318 | 10 15 ration [[ations / Reference 8: Liquid Limit. P | 20 Dry Preparati res: | 25 30 3 | Air Dried | # of Drops | 100 | N 20 21 22 23 24 25 N (((((((((((((| Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M Dne-point M | N 26 27 28 29 30 astic imit adex Aethod Aethod eve: | Factor 1.005 1.009 1.014 1.018 1.022 IX JP JP IA 16.1% |
| 40.0 40.0 35.0 30.0 30.0 25.0 20.0 Wet Prepar Notes / Device ASTM D 4318 | Image: state of the state of t | 20 Dry Preparati res: | 25 30 3 | Air Dried | # of Drops | | N 20 21 22 23 24 25 N 6 Passing t | Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M One-point M the #200 Sid | N 26 27 28 29 30 add to the serve: | Factor 1.005 1.009 1.014 1.018 1.022 Image: Constraint of the second secon |
| 40.0 40.0 40.0 35.0 30.0 25.0 20.0 Wet Prepar Notes / Device ASTM D 4318 | 10 15 ration 15 8: Liquid Limit, P Matt Jacobs | 20 Dry Preparati | 25 30 3 0 | Air Dried | # of Drops | 100 | N 20 21 22 23 24 25 N 6 Passing t | Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M Dne-point M the #200 Sid | N 26 27 28 29 30 astic imit Index Ind | Factor 1.005 1.009 1.014 1.018 1.022 Image: State of the state of th |
| 40.0 100 100 100 100 100 100 100 | 10 15 ration 10 15 rations / Reference 8: Liquid Limit, P Matt Jacobs Technician Name | 20 Dry Preparati | 25 30 3 on 🖌 | Air Dried | # of Drops | 100 % | N 20 21 22 23 24 25 N (0 (0 (0 (0 (0 (0 (0 (0 (0 (0 | Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic In Group Sym Aultipoint M One-point M the #200 Sid | N 26 27 28 29 30 astic imit adex Method Aethod ave: N | Factor 1.005 1.009 1.014 1.018 1.022 IX JP JP IA 16.1% 0/21 ate |

| Single sieve set | | | | ASTI | M D 6913 | | | |
|------------------|------------|---------------|-----------|--------------|--------------|-----------------|-------------------|----------------|
| | S& | ME, Inc Sp | partanbu | urg: 301 Z | ima Park Dri | ve, Spartanburg | J, SC 29301 | |
| Project #: | 213045 | | | | | | Report Date: | 8/30/21 |
| Project Name: | Bad Cree | ek Phase 2 F | easibilit | y Study Pro | ject | | Test Date(s): | 8/17 - 8/19/21 |
| Client Name: | HDR | | | | | | | |
| Client Address: | 1122 Lac | dy Street, Su | ite 1100 |) Columbia | , South Caro | ina 29201 | | |
| Borehole: | B-21-5 | | | | Log #: | 135 | Sample Date: | 6/2/21 |
| Sample ID: | SS-6 | | | | Туре: | Split-spoon | Depth: | 27.6' |
| Sample Descript | ion: silty | SAND (SM) | - brow | n olive whit | e, medium to | o fine | | |
| | | 1" 2/4" | 3 /0" | <i>#4 #</i> | 10 #20 | #40 #60 #1 | 00 #140 #200 | |
| 100% | | 1 3/4 | | *4 * | 10 #20 + | *40 *00 *1 | ◆ ◆ ↓ ↓ ◆ ↓ ↓ ↓ ↓ | |
| 00% | | | | | | | | |
| 90% | | | | | | | | |
| 80% | | | | | | | | |
| <u>8</u> 70% | | | | | | | | |
| sing 10% | | | | | | | | |
| Pas 90% | | | | | | | | |
| 50% | | | | | | | | |
| erc | | | | | | | \mathbf{x} | |
| 40% | | | | | | | | |
| 30% | | | | | | | | |
| 2001 | | | | | | | | |
| 20% | | | | | | | | |
| 10% | | | | | | | | |
| 0% | | | | | | | | |
| 100. | 00 | | 10.00 | Millimeters | 1.00 | • | 0.10 | 0.01 |

| | - | | | | | | |
|--------------------------|--------------------------------|---|---------------------------------------|----------------------------|--|----------------------------------|--|
| Cobbles | < 300 m | nm (12") and > 75 mm (3") | Fine Sa | ind | < 0.425 mm and > 0.075 mm | | |
| Gravel | < 75 i | mm and > 4.75 mm (#4) | Silt | | < 0.075 and > | > 0.005 mm | |
| Coarse Sand | < 4.75 | mm and >2.00 mm (#10) | Clay | , | < 0.005 | 5 mm | |
| Medium Sand | < 2.00 r | mm and > 0.425 mm (#40) | Colloid | ds | < 0.001 | l mm | |
| | | | | | | | |
| Method: B | Proce | edure for obtaining Specimer | : Moist | Dispersio | on Process: D | Dispersant | |
| Method: B Maximum Par | Proce rticle Size | edure for obtaining Specimer 9.50 mm | : Moist Coarse Sand | Dispersio 8.8% | n Process: D Fine San | Dispersant d 42.1% | |
| Method: B Maximum Par | Proce rticle Size Gravel | edure for obtaining Specimer 9.50 mm 1.2% | : Moist Coarse Sand Medium Sand | Dispersio 8.8% 20.6% | n Process: D Fine San Silt & Cla | Dispersant d 42.1% y 27.3% | |

Natural Moisture

21.3%

Notes / Deviations / References:

| Frank Morris P F | FRANKP. MERTSIZ. | Project Manager | 8/30/21 |
|--------------------------|---|---------------------------------------|---------|
| TTATIK MOTTS, F.L. | | <u>FTOJECT Manager</u> | 0/30/21 |
| Technical Responsibility | Signature | Position | Date |
| This report she | all not be reproduced, except in full, withou | It the written approval of S&ME, Inc. | |

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| | Q |
| 111 | _ |
| | - |

| | | ASTM D 4318 | | ASHTO T a | 89 🗆 A | ASHTO T 90 | | | | |
|--|--|--|---|-----------|------------------|---|--|--|---|--|
| | | S&ME, Inc 9 | Spartanburg | g: 301 Z | Zima Park Drive | e, Spartanbu | urg, SC 29 | 9301 | | |
| Project # | <i>t</i> : 213 | 045 | | | | | Report I | Date: | 8/30/ | 21 |
| Project N | Name: Bad | Creek Phase 2 | Feasibility S | Study Pro | oject | | Test I | Date: | 8/19/ | 21 |
| Client Na | ame: HDF | र | | | • | | | | | |
| Client Ac | ddress: 112 | 2 Lady Street, S | Suite 1100 | Columbia | a, South Carolir | na 29201 | - | | | |
| Borehole | e: B-21-5 | , | Loa | #: | 135 | Sam | ple Date: | | 6/2/21 | |
| Sample I | ID: 55-6 | | Tvn | e. (| Split-spoon | | Depth [.] | | 27.6' | |
| Sample I | Description [.] | silty SAN | D (SM) - bro | own olive | white mediur | n to fine | Deptil | | 27.0 | |
| Type and | Specification | S&ME ID | D # Ca | l Date: | Type and Spe | cification | S& | ME ID # | Cal | Date: |
| Balance (| (0.01 q) | 7537 | 1/2 | 29/2021 | Grooving too | bl | | 14185 | 9/28 | /2020 |
| LL Appara | atus | 13859 | 9/2 | 28/2020 | | | | | | |
| Oven | | 7313 | 7/3 | 30/2021 | | | | | | |
| Pan # | ŧ | | | | Liquid Limit | | | | Plastic Limi | it |
| | | Tare #: | | | | | | | | |
| А | Tare Weight | | | | | | | | | |
| В | Wet Soil Weigh | nt + A | | | | | | | | |
| С | Dry Soil Weigh | t + A | | | | | | | | |
| D | Water Weight | (B-C) | | | | | | | | |
| F | Dry Soil Weigh | t (C-Δ) | | | | | | | | |
| | % Moisturo (D | /E)*100 | | | | | | | | |
| F | | (1) 100 | | | | | | | | |
| IN | # OF DROPS | | | | | | | Moisture C | ontents det | rermined by |
| LL | LL = F * | FACTOR | | | | | | A | ISTM D 221 | 0 |
| A1/0 | A | | | | | | | | | |
| Ave. | Ave | rage | | | | | I | | | • |
| Ave. | 0.0 T | rage | | | | | | One Point I | Liquid Lim | nit Fastar |
| 40e. | | | | | | | N | One Point I Factor | Liquid Lim | Factor |
| Ave. 40 | | | | | | | N 20 21 | One Point I Factor 0.974 0.979 | Liquid Lim N 26 27 | nit Factor 1.005 1.009 |
| Ave. 44 | 0.0 5.0 | | | | | | N 20 21 22 | One Point I Factor 0.974 0.979 0.985 | Liquid Lim 26 27 28 | it Factor 1.005 1.009 1.014 |
| Ave. 40 | 5.0 Ave | | | | | | N 20 21 22 23 | One Point I Factor 0.974 0.979 0.985 0.99 | Liquid Lim 26 27 28 29 | iit Factor 1.005 1.009 1.014 1.018 |
| Ave. | | | | | | | N 20 21 22 23 24 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 | Liquid Lim N 26 27 28 29 30 | nit Factor 1.005 1.009 1.014 1.018 1.022 |
| Ave. | | | | | | | N 20 21 22 23 24 25 | One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 | Liquid Lim N 26 27 28 29 30 | iit Factor 1.005 1.009 1.014 1.018 1.022 |
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| Ave. 44 33 34 34 34 25 24 24 24 24 24 24 24 24 24 24 24 24 24 | 0.0 | Its 20 | 25 30 35 | Air Dried | # of Drops | 100 | N 20 21 22 23 24 25 N (((((((((((((| One Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 IP, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Aultipoint N Dne-point N he #200 Sid | Liquid Lim N 26 27 28 29 30 astic .imit . .imit . .imit . Method Aethod Aethod | iit Factor 1.005 1.009 1.014 1.018 1.022 ▼ NP NP SM 27.3% |
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|----------|-------------------------------------|------|---------|----------|-----------|-----------|-------------|-----------|-------------|--------------|--------------|-------|----------------|
| Surgie s | leve sel | | S&M | IF Inc - | Snartan | hura: | 301 7ima | Park Driv | e Snartan | hura SC | 29301 | | |
| Project | #· | 213(|)45 | ie, inc. | Spartam | burg. | Sor Zinia | | e, opurturi | burg, se | Report D |)ate: | 8/30/21 |
| Project | ["] . Name [.] | Bad | Creek | Phase 2 | Feasibil | itv Stuc | lv Proiect | | | | Test Dat | e(s) | 8/17 - 8/19/21 |
| Client N | Jame: | HDR | ereek | | | ity otac | ly i loject | | | | i cot Dut | 0(5). | -, -, -, |
| Client A | ddress: | 1122 | Lady | Street, | Suite 110 | 00 Colu | umbia, Sou | th Caroli | na 29201 | | | | |
| Boreho | le: | B-21 | -5 | | | | Log | g #: | 135 | | Sample D |)ate: | 6/2/21 |
| Sample | ID: | SS-1 | 0 | | | | Ту | pe: | Split-sp | oon | De | pth: | 47.6' |
| Sample | Description | on: | silty S | AND (SI | M) - gray | / olive v | vhite, med | ium to fi | ne | | | | |
| | | | | | | | | | | | | | |
| | 100% 🗖 | | | 1" 3/4" | 3/8" | #4 | #10 | #20 | #40 #6 | 0 #100 # | 140 #200 | | |
| | - | | | | | | | | | | | | |
| | 90% | | | | | | | | | | | | |
| | 80% | | | | | | | | | | | | |
| %) | 70% | | | | | | | | | | | | |
| sing | 70% | | | | | | | | | | | | |
| Pas | 60% | | | | | | | | | . | | _ | |
| ent | 50% | | | | | | | | | \mathbf{X} | | | |
| Perc | | | | | | | | | | | | + | |
| | 40% | | | | | | | | | | | | |
| | 30% | | | | | | | | | | \mathbb{N} | _ | |
| | 20% | | | | | | | | | | | | |
| | 20% | | | | | | | | | | | | |
| | 10% | | | | | | | | | | | + | + |
| | 0% | | | | | | | | | | | | |

| 0% | 10.00 | Aillimeters 1.00 | • | 0.10 | 0.01 |
|-------------|-------------------------|------------------|--------------|------------------|------------|
| Cobbles | < 300 mm (12") and > 75 | mm (3") | Fine Sand | < 0.425 mm and | > 0.075 mm |
| Gravel | < 75 mm and > 4.75 mr | m (#4) | Silt | < 0.075 and > | 0.005 mm |
| Coarse Sand | < 4.75 mm and >2.00 mr | m (#10) | Clay | < 0.005 | mm |
| Medium Sand | < 2.00 mm and > 0.425 m | nm (#40) | Colloids | < 0.001 | mm |
| Method: B | Procedure for obtaining | g Specimen: Mo | ist Disper | sion Process: Di | spersant |
| Maximum Pai | rticle Size 9.50 mm | Coars | e Sand 9.2% | Fine Sand | 43.1% |
| | Gravel 4.3% | Mediun | n Sand 17.4% | Silt & Clay | 26.1% |
| Liq | quid Limit | Plasti | c Limit NP | Plastic Index | NP |

14.4%

Notes / Deviations / References:



Natural Moisture



| | ASTM D 4318 | 🗵 AASHTO | T 89 🔲 🗛 | SHTO T 90 | | | | |
|--|---------------------|---|-------------------------------|-----------------------------------|--|--|---|---|
| | S&ME, Inc Sp | partanburg: 301 | Zima Park Drive, | Spartanbu | urg, SC 29 | 9301 | | |
| Project #: 2 ⁻ | 13045 | - | | | Report [| Date: | 8/30/ | 21 |
| Project Name: Ba | ad Creek Phase 2 F | easibility Study P | Project | | Test I | Date: | 8/19/ | 21 |
| Client Name: H | DR | , , | 5 | | | | | |
| Client Address: 1 | 122 Lady Street, Su | uite 1100 Columb | oia, South Carolina | a 29201 | | | | |
| Borehole: B-21-5 |) | Log #: | 135 | Sam | ple Date: | | 6/2/21 | |
| Sample ID: SS-10 | | Type: | Split-spoon | | Depth: | | 47.6' | |
| Sample Description: | silty SAND | (SM) - gray olive | white, medium to | o fine | | | | |
| Type and Specification | S&ME ID # | # Cal Date: | Type and Spec | ification | S& | ME ID # | Cal | Date: |
| Balance (0.01 g) | 7537 | 1/29/2021 | Grooving tool | | | 14185 | 9/28 | /2020 |
| LL Apparatus | 13859 | 9/28/2020 | | | | | | |
| Oven | 7313 | 7/30/2021 | | | | | | |
| Pan # | _ | | Liquid Limit | | | F | Plastic Lim | it |
| | Tare #: | | | | | | | |
| A Tare Weight | | | | | | | | |
| B Wet Soil We | ight + A | | | | | | | |
| C Dry Soil Wei | ght + A | | | | | | | |
| D Water Weigł | nt (B-C) | | | | | | | |
| E Dry Soil Wei | ght (C-A) | | | | | | | |
| F % Moisture | (D/E)*100 | | | | | | | |
| N # OF DROPS | | | | | | Moisture Co | ontents det | ermined hy |
| | * FACTOR | | | | | AS | STM D 221 | 6 |
| | | | | | | | | |
| $\Delta V P$ Δ | vernae | | | | | | | |
| Ave. A | verage | | | | (| One Point I | iauid Lim | nit |
| 40.0 A | verage | | | | (N | One Point L Factor | iquid Lim N | it Factor |
| 40.0 | | | | | (N 20 | One Point L Factor 0.974 | iquid Lim N 26 | nit Factor 1.005 |
| | | | | | N 20 21 | One Point L Factor 0.974 0.979 | iquid Lim N 26 27 | it Factor 1.005 1.009 |
| 40.0 40.0 10 35.0 | | | | | N 20 21 22 | One Point L Factor 0.974 0.979 0.985 | iquid Lim N 26 27 28 | it Factor 1.005 1.009 1.014 |
| 40.0 40.0 35.0 | | | | | N 20 21 22 23 | Dne Point L Factor 0.974 0.979 0.985 0.99 | iquid Lim N 26 27 28 29 20 | it Factor 1.005 1.009 1.014 1.018 |
| 40.0 40.0 35.0 30.0 | | | | | N 20 21 22 23 24 25 | Dne Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 | iquid Lim N 26 27 28 29 30 | it Factor 1.005 1.009 1.014 1.018 1.022 |
| 40.0 40.0 35.0 30.0 | | | | | N 20 21 22 23 24 25 | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 | iquid Lim N 26 27 28 29 30 | Factor 1.005 1.009 1.014 1.018 1.022 |
| 40.0 40.0 35.0 30.0 | | | | | N 20 21 22 23 24 25 N | Dne Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla | iquid Lim N 26 27 28 29 30 stic | iit Factor 1.005 1.009 1.014 1.018 1.022 X |
| 40.0 40.0 35.0 30.0 25.0 | | | | | N 20 21 22 23 24 25 N | Dne Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L | iquid Lim N 26 27 28 29 30 stic imit | init Factor 1.005 1.009 1.014 1.018 1.022 ▼ |
| 40.0 40.0 35.0 30.0 25.0 | verage | | | | N 20 21 22 23 24 25 N | Dne Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L | iquid Lim N 26 27 28 29 30 istic imit imit | init Factor 1.005 1.009 1.014 1.018 1.022 ▼ ▼ |
| 40.0 40.0 35.0 30.0 25.0 20.0 | verage | | | | N 20 21 22 23 24 25 N | Dne Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In | iquid Lim N 26 27 28 29 30 stic imit imit dex | init Factor 1.005 1.009 1.014 1.018 1.022 ▼ ▼ NP NP |
| 40.0 40.0 35.0 30.0 25.0 20.0 10 | | 5 30 35 40 | | | N 20 21 22 23 24 25 N | Dne Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym | iquid Lim N 26 27 28 29 30 stic imit imit dex N bol S | it Factor 1.005 1.009 1.014 1.018 1.022 X V V N D |
| 40.0 40.0 35.0 30.0 25.0 20.0 10 | 15 20 2: | 5 30 35 40 | # of Drops | 100 | N 20 21 22 23 24 25 N | Dne Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym Multipoint M | iquid Lim N 26 27 28 29 30 istic imit imit dex N bol S 1ethod | init Factor 1.005 1.009 1.014 1.018 1.022 ▼ NP NP NP M |
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| Ave. A 40.0 40.0 40.0 40.0 35.0 30.0 30.0 30.0 25.0 25.0 20.0 10 | verage | 5 30 35 40 | # of Drops | | N 20 21 22 23 24 25 N 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | Dne Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym fultipoint M Ine-point M he #200 Sie | iquid Lim N 26 27 28 29 30 astic imit imit dex N bol S N thool S N thool S N S S S S S S S S S S S S S | init Factor 1.005 1.009 1.014 1.018 1.022 ⊠ № № № № № № № № |
| Ave. A 40.0 40.0 35.0 30.0 25.0 20.0 10 Wet Preparation Notes / Deviations / Re | verage | 5 30 35 40 | # of Drops | | N 20 21 22 23 24 25 N (C 6 Passing t | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym fultipoint M one-point M he #200 Sie | iquid Lim N 26 27 28 29 30 astic imit - imit | nit Factor 1.005 1.009 1.014 1.018 1.022 ▼ ▼ NP NP SM 26.1% |
| Ave. A 40.0 40.0 35.0 30.0 25.0 20.0 10 Wet Preparation Notes / Deviations / Re | verage | 5 30 35 40 | # of Drops | | N 20 21 22 23 24 25 N 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym fultipoint M Ine-point M he #200 Sie | iquid Lim N 26 27 28 29 30 stic imit imit dex N bol S lethod lethod eve: | itit Factor 1.005 1.009 1.014 1.018 1.022 |
| Ave. A 40.0 40.0 35.0 30.0 30.0 25.0 20.0 10 Wet Preparation Notes / Deviations / Re ASTM D 4318: Liquid Li | verage | 5 30 35 40 Plastic Index of Soil | # of Drops | | N 20 21 22 23 24 25 N 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym fultipoint N one-point N he #200 Sie | iquid Lim 26 27 28 29 30 astic imit - imit - | init Factor 1.005 1.009 1.014 1.018 1.022 ▼ ▼ NP NP SM 26.1% |
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| Ave. A 40.0 40.0 35.0 30.0 25.0 20.0 10 Wet Preparation Notes / Deviations / Re ASTM D 4318: Liquid Li Matt Jac Technician | verage | Image: Second state of sold Image: Second state of state of sold Image: Second state of state of sold Image: Second state of sold Image: Second state of state of state of sold Image: Second state of state of sold Image: Second state of state of state of sold Image: Second state of state of sold Image: Second state of state of sold Image: Second state of state of state of sold Image: Second state of state of sold Image: Second state of state of state of sold Image: Second state of state of sold <t< td=""><td># of Drops # of Drops s</td><td>100 mk Morris nical Respons</td><td>N 20 21 22 23 24 25 N C C C C C C C C C C C C C</td><td>One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym Multipoint M he #200 Sie</td><td>iquid Lim N 26 27 28 29 30 isstic imit fi dex fi hbol S lethod lethod lethod lethod 29 30 S 10 S 10 10 10 10 10 10 10 10 10 10</td><td>nit Factor 1.005 1.009 1.014 1.018 1.022 ▼ ▼ ■ 26.1% 0/21 ate</td></t<> | # of Drops # of Drops s | 100 mk Morris nical Respons | N 20 21 22 23 24 25 N C C C C C C C C C C C C C | One Point L Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic In Group Sym Multipoint M he #200 Sie | iquid Lim N 26 27 28 29 30 isstic imit fi dex fi hbol S lethod lethod lethod lethod 29 30 S 10 S 10 10 10 10 10 10 10 10 10 10 | nit Factor 1.005 1.009 1.014 1.018 1.022 ▼ ▼ ■ 26.1% 0/21 ate |

| Single sieve set ASTM D 6913 Project #: 213045 Report Date: 8/30/21 Project Name: Bad Creek Phase 2 Feasibility Study Project Test Date(s): 8/17 - 8/20/21 Client Name: HDR Test Date(s): 8/17 - 8/20/21 Client Name: HDR Test Date(s): 8/17 - 8/20/21 Borehole: B-21-5 Log #: 135 Sample Date: 6/2/21 Sample ID: SS-17 Type: Split-spoon Depth: 3.2.6' Sample Description: silty SAND (SM) - gray olive white, medium to fine Total and the provide of the total and total and the provide of the total and to | | | | | | | | | | | | | | | | | | | | | |
|--|---------------------|-----------|-------|-----------|-----------------|-------------------------|------------|-------|----------|--------|----------|------------|----------|--------------------|--------------|--------------|------|-----------------|-------------|-----------------|--------|
| S&ME, Inc Spartanburg: 301 Zima Park Drive, Spartanburg, SC 29301 Project #: 213045 Report Date: 8/30/21 Troject Mame: Bad Creek Phase 2 Feasibility Study Project Test Date(s): 8/17 - 8/20/21 Client Name: HDR Test Date(s): 8/17 - 8/20/21 Client Address: 1122 Lady Street, Suite 1100 Columbia, South Carolina 29201 Sample Date: 6/2/21 Borehole: B-21-5 Log #: 135 Sample Date: 6/2/21 Sample Description: silty SAND (SM) - gray olive white, medium to fine Type: Split-spoon Depth: 32.6' Sample Description: silty SAND (SM) - gray olive white, medium to fine Total addression Total addressio | Single sieve set | | | | | | | | AS | TM E | 0 6913 | | | | | | | | | | |
| Project #: 213045 Report Date: 8/30/21 Project Name: Bad Creek Phase 2 Feasibility Study Project Test Date(s): 8/17 - 8/20/21 Client Address: 1122 Lady Street, Suite 1100 Columbia, South Carolina 29201 Borehole: B-21-5 Log #: 135 Sample Date: 6/2/21 Sample ID: SS-17 Type: Split-spoon Depth: 32.6' Sample Description: silty SAND (SM) - gray olive white, medium to fine | | | S&I | ME, In | c S | part | anb | urg: | 301 | Zim | a Park I | Drive | e, Spa | irtanbi | urg, S | C 29 | 301 | | | | |
| Project Name: Bad Creek Phase 2 Feasibility Study Project Test Date(s): &/17 - &/20/21 Client Name: HDR Client Address: 1122 Lady Street, Suite 1100 Columbia, South Carolina 29201 Borehole: B-21-5 Log #: 135 Sample Date: 6/2/21 Sample Description: silty SAND (SM) - gray olive white, medium to fine 100% 00% 00% 00% 00% 00% 00% 00% 00% 00% | Project #: | 213 | 045 | | | | | - | | | | | - | | - | | Re | port | : Date: | 8/30 | /21 |
| Client Name: HDR Client Address: 1122 Lady Street, Suite 1100 Columbia, South Carolina 29201 Borehole: B-21-5 Log #: 135 Sample Date: 6/2/21 Sample ID: SS-17 Type: Split-spoon Depth: 32.6' Sample Description: silty SAND (SM) - gray olive white, medium to fine 100% 00% 00% 00% 00% 00% 00% 00% 00% 00% | Project Name: | Bad | Cree | k Phas | se 2 F | easi | bilit | y St | udy Pr | ojec | t | | | | | | Te | st D | ate(s): | 8/17 - 8 | /20/21 |
| Client Address: 1122 Lady Street, Suite 1100 Columbia, South Carolina 29201 Borehole: B-21-5 Log #: 135 Sample Date: 6/2/21 Sample Description: silty SAND (SM) - gray olive white, medium to fine 100% 00% 10.00 11 3/4" 3/4" 410 420 440 450 410 420 400 410 420 420 420 420 420 420 420 420 420 42 | Client Name: | HDR | | | | | | , | , | 5 | | | | | | | | | () | | |
| Borehole: B-21-5 Log #: 135 Sample Date: 6/2/21 Sample Description: silty SAND (SM) - gray olive white, medium to fine 100% 00% 11 3/4" 3/4" 44 #10 #20 #40 #60 #100 #140 #200 100% 00% 00% 00% 00% 00% 00% 00% 00% 00% | Client Address: | 1122 | 2 Lad | y Stre | et, Sı | uite ' | 1100 |) Co | olumb | ia, So | outh Ca | rolir | ia 29 | 201 | | | | | | | |
| Sample ID: SS-17 Type: Split-spoon Depth: 32.6' Sample Description: silty SAND (SM) - gray olive white, medium to fine | Borehole: | B-21 | -5 | | | | | | | L | .og #: | | | 135 | | | San | nple | Date: | 6/2/ | /21 |
| Sample Description: silty SAND (SM) - gray olive white, medium to fine | Sample ID: | SS-1 | 7 | | | | | | | ٦ | Гуре: | | Spli | t-spoc | n | | | [| Depth: | 32. | 6' |
| Image: constraint of the second se | Sample Description | on: | silty | SAND |) (SM |) - g | ray | olive | e white | e, me | edium t | o fin | e | | | | | | | | |
| Image: 1 * 3/4" 3/8" M4 #10 #20 #40 #60 #10 #220 90% | | | | | | | | | | | | | | | | | | | | | |
| 90% 90% 80% 70% 70% 60% 60% 50% 60% 50% 60% 50% 60% 60% 50% 60% 60% 60% 50% 60% 60% 60% 50% 60% 60% 60% 50% 60% 60% 6 | 100% | | | 1" 3/ | • | 3/8' | | #4 | | #10 | #2 | :0 | #40 | #60 | #100 | #140 # | ¥200 | | | | _ |
| 90% 80% 70% 70% 60% 90% 60% 60% 90% 60% 90% 90% 60% 90% 90% 60% 90% 90% 60% 90% 90% 60% 90% 90% 60% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 90% 9 | - | +++ | | | | | | - | | | | | | _ | | | | | | | |
| 80% 70% 70% 60% 70% 60% 70% 60% 70% 60% 70% 60% 70% 60% 70% 60% 70% 60% 70% 60% 70% 60% 70% 60% 70% 70% 70% 60% 70% 7 | 90% | | | | | | | | | | | | | | | | | | | | |
| 70% 70% 60% 60% 50% 60% 40% 60% 30% 60% 20% 60% 10% 60% 0% 60% 0% 60% 10% 60% | 80% | | | | | | | | | _ | | | | | | | | _ | | | - |
| 10% 1 | 3 70% | | | | | | | | | | | | | $\mathbf{\lambda}$ | | | | | | | |
| 60% 6 | sing - | +++ | | | | | | | | _ | | | | | | | | | | | - |
| 50% | Pas 60% | | | | | | | | | | | | | | \mathbf{h} | | | | | | |
| 40% 4 | 50% | | | | | | | | | _ | | | | | | | | | | | |
| 40% 30% 30% 4 | ber 10% | | | | | | | | | _ | | | | | | \mathbf{H} | | | | | |
| 30% 0 | 40% | | | | | | | | | | | | | | | N | | | | | |
| 20% 0% <t< td=""><td>30%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<> | 30% | | | | | | | | | | | | | | | | | | | | |
| $\begin{array}{c c c c c c c c c c c c c c c c c c c $ | 20% | | | | | | | | | | | | | | | | | | | | - |
| Note that the second se | 10% | | | | | | | | | | | | | | | | | | | | |
| 0%100.0010.00Millimeters1.000.100.01Cobbles< 300 mm (12") and > 75 mm (3")Fine Sand< 0.425 mm and > 0.075 mmGravel< 75 mm and > 4.75 mm (#4)Silt< 0.075 and > 0.005 mmCoarse Sand< 4.75 mm and > 2.00 mm (#10)Clay< 0.005 mm | | | | | | | | | | _ | | | | _ | | | | | | | - |
| Cobbles< 300 mm (12") and > 75 mm (3")Fine Sand< 0.425 mm and > 0.075 mmGravel< 75 mm and > 4.75 mm (#4)Silt< 0.075 and > 0.005 mmCoarse Sand< 4.75 mm and > 2.00 mm (#10)Clay< 0.005 mm | 0% – | | | | | 10.00 | | | illimate | | 1 00 | | | | | 0 10 | | | | | 0.01 |
| $\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$ | 100.0 | | | | | 10.00 | | | mmete | :15 | 1.00 | | | | | 0.10 | | | | | 0.01 |
| Gravel < 75 mm and > 4.75 mm (#4) Silt < 0.075 and > 0.005 mm Coarse Sand < 4.75 mm and > 2.00 mm (#10) Clay < 0.005 mm Medium Sand < 2.00 mm and > 0.425 mm (#40) Colloids < $< 0.001 mm$ Method: B Procedure for obtaining Specimen: Moist Dispersion Process: Dispersant Maximum Particle Size 4.75 mm Coarse Sand 2.9% Fine Sand 51.8% Gravel 0.4% Medium Sand 15.1% Silt & Clay 29.8% | Cobbles | | < | 300 m | nm (12 | 2") ar | nd > | 75 r | nm (3" |) | | Fir | ne Sar | nd | | < | 0.42 | 25 m | m and > | > 0.075 | mm |
| Coarse Sand < 4.75 mm and >2.00 mm (#10) Clay < 0.005 mm Medium Sand < 2.00 mm and > 0.425 mm (#40) Colloids < 0.001 mm Method: B Procedure for obtaining Specimen: Moist Dispersion Process: Dispersant Maximum Particle Size 4.75 mm Coarse Sand 2.9% Fine Sand 51.8% Gravel 0.4% Medium Sand 15.1% Silt & Clay 29.8% | Gravel | | | < 75 ı | mm ai | nd > | 4.75 | 5 mm | n (#4) | | | | Silt | | | | < 0. | .075 | and > 0 |).005 mr | n |
| Medium Sand< 2.00 mm and > 0.425 mm (#40)Colloids< 0.001 mmMethod:BProcedure for obtaining Specimen:MoistDispersion Process:DispersantMaximum Particle Size4.75 mmCoarse Sand2.9%Fine Sand51.8%Gravel0.4%Medium Sand15.1%Silt & Clay29.8% | Coarse Sand | | | < 4.75 | mm a | nd > | 2.00 |) mm | n (#10) | | | | Clay | | | | | < | 0.005 n | nm | |
| Method: B Procedure for obtaining specimen: Moist Dispersion Process: Dispersant Maximum Particle Size 4.75 mm Coarse Sand 2.9% Fine Sand 51.8% Gravel 0.4% Medium Sand 15.1% Silt & Clay 29.8% | Medium Sand | 1 | < | : 2.00 r | nm ar | nd > | 0.42 | 5 mr | n (#40) |) | N/- | C | olloid | S Dia | | | | < | 0.001 n | nm | |
| Gravel 0.4% Medium Sand 15.1% Silt & Clay 29.8% | Method: B Maximu | ım Dar | ticlo | Proce | aure 17 | tor o 5 mr | obtai n | ning | Specir | nen: | | ist Sor | d | DIS 2 Q0 | persio 4 | n Pro | cess | : Find | Dis Sand | persant 51 9 | 20/ |
| Graver 0.470 Internation 13.170 Silt & Clay 23.070 | ΙνιαλίΠΙΟ | iiii F di | C. | - Size | ۰. ۱ | ۱۱۱۱ د ۸% | | | | N | Modium | , Sal | nd nd | ر د. ع 15 10 | 0 % | | c | i ine Sil+ 9 | | 20.9 | 2% |
| Liquid Limit 27 Plastic Limit 27 Plastic Index NP | | Liq | uid L | imit | Ú. | . ⊶ ⁄₀ 27 | | | | ľ | Plastic | Lim | nit | 27 | /0 | | Pla | istic | Index | 29.0 N | P |
| Natural Maintura 10.20/ | | | | | | | | | | Nat | | | ro | 10.20 | 0/ | | | | | | |
| Natural Moisture 19.5% | Notes / Deviations | / Refer | ences | | | | | | | INdl | | ภรเน | ie | 19.5 | /0 | | | | | | |

Frank Morris, P.E.Frank Morris, P.E.Project Manager8/30/21Technical ResponsibilitySignaturePositionDateThis report shall not be reproduced, except in full, without the written approval of S&ME, Inc.



| | | ASTM D 4318 | \mathbf{X} | AASHTO | T 89 🗆 |] AAS | 5НТО Т 90 | | | | |
|--|---|--|-----------------------------|-------------------|------------|-----------|-----------------------|--|---|--|--|
| | : | S&ME, Inc | Spartanb | urg: 301 | Zima Par | k Drive, | Spartanbu | urg, SC 29 | 301 | | |
| Project # | #: 21304 | 45 | | | | | | Report D | Date: | 8/30/2 | 21 |
| Project I | Name: Bad C | Creek Phase 2 | Feasibili | ty Study P | Project | | | Test D | Date: | 8/27/2 | 21 |
| Client N | ame: HDR | | | , , | 5 | | | | | | |
| Client A | ddress: 1122 | Lady Street, | Suite 110 | 0 Columb | oia, South | Carolina | 29201 | | | | |
| Borehol | e: B-21-5 | , | Lo | og #: | 135 | | Sam | ple Date: | | 6/2/21 | |
| Sample | ID: SS-17 | | T | vpe: | Split-spc | on | | Depth: | | 32.6' | |
| Sample | Description: | silty SAN | D (SM) - | gray olive | white, m | edium to | fine | | | | |
| Type and | Specification | S&ME IE |)# | Cal Date: | Туре | and Speci | ification | S& | ME ID # | Cal I | Date: |
| Balance | (0.01 g) | 7537 | | 1/29/2021 | Groov | ving tool | | | 14185 | 9/28, | /2020 |
| LL Appar | atus | 13859 |) | 9/28/2020 | | | | | | | |
| Oven | | 7313 | | 7/30/2021 | | | | | | | |
| Pan # | # | | | | Liquid | Limit | 1 | | | Plastic Limi | t |
| | | Tare #: | P-4 | P-5 | P-6 | | | | 12 | 13 | |
| A | Tare Weight | | 16.60 | 16.58 | 15.97 | | | | 11.17 | 12.10 | |
| В | Wet Soil Weight | + A | 40.99 | 42.56 | 40.20 | | | | 17.27 | 18.39 | |
| С | Dry Soil Weight | + A | 36.01 | 37.08 | 34.97 | | | | 15.95 | 17.05 | |
| D | Water Weight (B | 6-C) | 4.98 | 5.48 | 5.23 | | | | 1.32 | 1.34 | |
| E | Dry Soil Weight | (C-A) | 19.41 | 20.50 | 19.00 | | | | 4.78 | 4.95 | |
| F | % Moisture (D/E |)*100 | 25.7% | 26.7% | 27.5% | | | | 27.6% | 27.1% | |
| N | # OF DROPS | | 32 | 25 | 18 | | | | Moisture C | ontents dete | ermined by |
| LL | LL = F * F | ACTOR | | | | | | | A | STM D 221 | 6 |
| Ave. | Avera | ige | | <u> </u> | | | <u> </u> | | | 27.4% | |
| | | | | | | | | | | | it |
| | 7.0 | | | | | | | (| Jne Point I | Liquia Lim | it. |
| | 37.0 | | | | | | ⊣) | N | Factor | Liquid Lim N | Factor |
| | 37.0 | | | | | | | N 20 | Factor | Liquid Lim N 26 | Factor 1.005 |
| िंच ा 3 | 37.0 | | | | | | | N 20 21 | Factor 0.974 0.979 | 26 27 | Factor 1.005 1.009 |
| e utent | 32.0 | | | | | | | N 20 21 22 23 | Factor 0.974 0.979 0.985 | N 26 27 28 29 | Factor 1.005 1.009 1.014 |
| e Content | 32.0 | | | | | | | N 20 21 22 23 24 | Factor 0.974 0.979 0.985 0.99 | N 26 27 28 29 30 | Factor 1.005 1.009 1.014 1.018 1.022 |
| ture Content | 37.0 32.0 27.0 | | | | | | | N 20 21 22 23 24 25 | Factor 0.974 0.979 0.985 0.99 0.995 1.000 | N 26 27 28 29 30 | Factor 1.005 1.009 1.014 1.018 1.022 |
| To the Content State Sta | 37.0 32.0 27.0 | | | | | | | N 20 21 22 23 24 25 N | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla | N 26 27 28 29 30 astic | Factor 1.005 1.009 1.014 1.018 1.022 |
| % Moisture Content | | | | | | | | N 20 21 22 23 24 25 N | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L | N 26 27 28 29 30 | Factor 1.005 1.009 1.014 1.018 1.022 ⊠ 7 |
| % Moisture Content | 37.0 32.0 27.0 22.0 | | | | | | | N 20 21 22 23 24 25 N | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Platic Liquid Plastic | N 26 27 28 29 30 | Factor 1.005 1.009 1.014 1.018 1.022 ▼ 7 7 |
| % Moisture Content | 37.0 32.0 27.0 22.0 | | | | | | | N 20 21 22 23 24 25 N | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic Ir | N 26 27 28 29 30 astic .imit 2 .imit 2 ndex N | Factor 1.005 1.009 1.014 1.018 1.022 |
| c Moisture Content | | | | | | | | N 20 21 22 23 24 25 N | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Platic L Plastic L Plastic Ir Oroup Syn | Induction Line Line Line Line Line Line Line Lin | Factor 1.005 1.009 1.014 1.018 1.022 X 7 7 IP M |
| % Moisture Content | | 5 20 | 25 30 | 35 40 | # of D | | 100 | N 20 21 22 23 24 25 N (C M | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic Ir Group Syn | Arrient Content of Con | Factor 1.005 1.009 1.014 1.018 1.022 |
| 2 2 2 1 | | 5 20 | 25 30 | 35 40 | | | 100 | N 20 21 22 23 24 25 N C C M | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Jultipoint N ne-point N | Induid Lim N 26 27 28 29 30 Astic imit 2 imit 2 imit 2 Method Aethod Aethod | Factor 1.005 1.009 1.014 1.018 1.022 |
| 2 % Moisture Content | 27.0 27.0 27.0 27.0 22.0 10 10 10 10 | 5 20 | 25 30 | 35 40 | # of D | | 100 | N 20 21 22 23 24 25 N C C M C C C C C C C C C C C C C | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Platic L Plastic L Plastic Ir Group Syn Jultipoint N ne-point N he #200 Side | Arthodd Arthodd Ar | Factor 1.005 1.009 1.014 1.018 1.022 |
| 2 % Moisture Content | 37.0 32.0 27.0 27.0 27.0 27.0 27.0 10 11 22.0 10 11 Deviations / Refere | 5 20 Dry Preparati | 25 30 | 35 40 | # of D | | 100 | N 20 21 22 23 24 25 N 0 6 Passing to | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Plastic L Plastic Ir Group Syn Jultipoint N ne-point N he #200 Sid | Artic Carlor Car | Factor 1.005 1.009 1.014 1.018 1.022 |
| 2 % Moisture Content | 32.0 | 5 20 Dry Preparati | 25 30 | 35 40 | # of D | Props | 100 | N 20 21 22 23 24 25 N C C C C C C C C C C C C C | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Jultipoint N ne-point N he #200 Side | Induid Lim N 26 27 28 29 30 astic imit 2 imit 2 imit 2 Method Aethod eve: | Factor 1.005 1.009 1.014 1.018 1.022 |
| 2 % Moisture Content | 32.0 | 5 20 Dry Preparati | 25 30 | 35 40 | # of D | | 100 | N 20 21 22 23 24 25 N C C M O 6 Passing t | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Platic L Plastic L Plastic Ir Group Syn Iultipoint N he #200 Sid | Acthod Acthod Acthod Acthod Acthod Acthod Acthod Acthod | Factor 1.005 1.009 1.014 1.018 1.022 |
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| 3 Woisture Content Notes / D | 37.0 | 5 20 Dry Preparati nces: | 25 30 on 27 30 | 35 40 | # of D | | | N 20 21 22 23 24 25 N C C M O 6 Passing t | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Platic L Plastic L Plastic Ir Group Syn Iultipoint N he #200 Sid | Index Method Aethod Reference | Factor 1.005 1.009 1.014 1.018 1.022 |
| Weit Pre Notes / D ASTM D | 37.0 | 5 20 Dry Preparati nces: Plastic Limit, 8 | 25 30 on 2 Plastic Ir | 35 40 Air Drie | # of D | | 100 P | N 20 21 22 23 24 25 N 6 Passing to 6 Passing to | Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Platic L Plastic Ir Group Syn Jultipoint N ne-point N he #200 Side | Index N 26 27 28 29 30 astic imit 2 imit 2 imit 2 Method Aethod Aethod Aethod | Factor 1.005 1.009 1.014 1.018 1.022 |
| 2 % Moisture Content Notes / D | 27.0 27.0 27.0 27.0 27.0 22.0 10 11 12 12 12 12 12 12 12 12 12 | 5 20 Dry Preparati nces: Plastic Limit, & | 25 30 | 35 40 Air Drie | # of D | Props | 100 9 hk Morris | N 20 21 22 23 24 25 N 6 Passing t 6 Passing t | Just Point I Factor 0.974 0.979 0.985 0.99 0.995 1.000 P, Non-Pla Liquid L Plastic L Plastic Ir Group Syn Jultipoint N he #200 Size | Induid Lim N 26 27 28 29 30 astic imit 2 imit 2 imit 2 Method Aethod Aethod Aethod Aethod | Factor 1.005 1.009 1.014 1.018 1.022 I I I I I I I I I I I I I |

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|------------------|----------|-----------|----------------|------------|-----------|------------|----------|---------|---------------------------------------|-----------|----------------|
| Single sieve set | | | | | ASTM D | 6913 | | | | | |
| | | S&ME, I | nc Spartan | burg: 3 | 301 Zima | Park Driv | e, Spart | anburg, | SC 29301 | | |
| Project #: | 2130 |)45 | | | | | | | Repor | rt Date: | 8/30/21 |
| Project Name: | Bad | Creek Pha | ase 2 Feasibi | lity Study | y Project | | | | Test [| Date(s): | 8/17 - 8/20/21 |
| Client Name: | HDR | | | | | | | | | | |
| Client Address: | 1122 | Lady Str | eet, Suite 11 | 00 Colu | mbia, So | uth Caroli | na 2920 | 01 | | | |
| Borehole: | B-21 | -5 | | | Lo | g #: | 13 | 35 | Sampl | e Date: | 6/2/21 |
| Sample ID: | SS-1 | 8 | | | Ту | /pe: | Split-s | spoon | | Depth: | 37.6' |
| Sample Descript | tion: | silty SAN | D (SM) - gra | y olive w | hite, meo | dium to fi | ne | | | | |
| (| | 1" | 3/4" 3/8" | #4 | #10 | #20 | #40 | #60 #10 | 0 #140 #200 | | |
| 100% | ┏┌╷╇┌┬╌┩ | ·── | | | | • | | • | • • • • • • • • • • • • • • • • • • • | | |
| 90% | | | | | | | | | | | |
| 5078 | | | | | | | | | | | |
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| 20% | | | | | | | | | | | |
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| 10% | | | | | | | | | | | |
| 0% | | | | | | | | | | | |
| 100 | .00 | | 10.00 | Millin | meters | 1.00 | | | 0.10 | | 0.01 |
| Cobbles | | < 300 | mm (12") and | > 75 mm | n (3") | F | ne Sand | | < 0.425 r | nm and : | > 0.075 mm |
| Gravel | | < 75 | mm and > 4. | 75 mm (# | ±4) | | Silt | | < 0.07 | 5 and > (|).005 mm |
| Coarse San | d | < 4.7 | 5 mm and >2. | 00 mm (# | ±10) | | Clay | | | < 0.005 n | nm |
| Medium Sar | nd | < 2.00 | mm and > 0.4 | 425 mm (# | #40) | (| Colloids | | | < 0.001 n | nm |
| Method: B | | Proc | edure for obt | aining Sp | ecimen: | Moist | | Dispers | sion Process: | Dis | persant |

 Frank Morris, P.E.
 Project Manager
 8/30/21

 Technical Responsibility
 Signature
 Position
 Date

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Coarse Sand

Plastic Limit

Medium Sand

Natural Moisture

4.4%

15.3%

27

18.7%

Maximum Particle Size

Notes / Deviations / References:

Gravel

Liquid Limit

9.50 mm

2.3%

27

3201 Spring Forest Road Raleigh, NC. 27616 Fine Sand

Silt & Clay

Plastic Index

48.4%

29.7%

NΡ



| | | ASTM D 4318 | X | AASHTO | T 89 🛛 | ⊐ AAS | SHTO T 90 | | | | |
|-----------|-------------------|----------------------|--------------|--------------|------------|------------|--------------|-------------|--------------|--------------|------------|
| | | S&ME, Inc | Spartanb | urg: 301 | Zima Pa | rk Drive, | Spartanbu | urg, SC 29 | 301 | | |
| Project # | #: 213 | 045 | | | | | | Report D | Date: | 8/30/2 | 21 |
| Project N | Name: Bad | Creek Phase 2 | 2 Feasibili | ity Study F | Project | | | Test D | Date: | 8/27/2 | 21 |
| Client N | ame: HDF | २ | | | | | | | | | |
| Client Ad | ddress: 112 | 2 Lady Street, | Suite 110 | 0 Columb | oia, South | n Carolina | 29201 | | | | |
| Borehole | e: B-21-5 | | Lo | og #: | 135 | | Sam | ple Date: | | 6/2/21 | |
| Sample | ID: SS-18 | | 1 | Гуре: | Split-sp | oon | | Depth: | | 37.6' | |
| Sample | Description: | silty SAN | D (SM) - | gray olive | white, m | edium to | fine | • | | | |
| Type and | Specification | S&ME IE |) # | Cal Date: | Туре | and Speci | fication | S& | ME ID # | Cal I | Date: |
| Balance | (0.01 g) | 7537 | | 1/29/2021 | Groo | oving tool | | | 14185 | 9/28 | /2020 |
| LL Appara | atus | 13859 | 9 | 9/28/2020 | | | | | | | |
| Oven | | 7313 | 1 | 7/30/2021 | | | | | | | 1 |
| Pan # | # | Taua #1 | 0.4 | | Liquic | d Limit | 1 | | 17 | Plastic Limi | t |
| • | Taua Mainht | Tare #: | Q-4 | Q-5 | Q-6 | | | | 12.12 | 12.12 | |
| A | Tare Weight | | 16.67 | 16.82 | 16.80 | | | | 12.12 | 12.12 | |
| В | Wet Soil Weigh | nt + A | 40.54 | 41.26 | 40.37 | | | | 19.67 | 19.35 | |
| C | Dry Soil Weigh | it + A | 35.65 | 36.02 | 35.21 | | | | 18.07 | 17.83 | |
| D | Water Weight | (B-C) | 4.89 | 5.24 | 5.16 | | | | 1.60 | 1.52 | |
| E | Dry Soil Weigh | it (C-A) | 18.98 | 19.20 | 18.41 | | | | 5.95 | 5.71 | |
| F | % Moisture (D, | /E)*100 | 25.8% | 27.3% | 28.0% | | | | 26.9% | 26.6% | |
| Ν | # OF DROPS | | 35 | 21 | 15 | | | | Moisture C | ontents det | ermined by |
| LL | LL = F * | FACTOR | | | | | | | Д | STM D 221 | 6 |
| Ave. | Ave | rage | | | | | | | | 26.8% | |
| 3 | 7.0 T | | | | | | | (| One Point | Liquid Lim | it _ |
| - | | | | | | | | N 20 | Factor | N 20 | Factor |
| | | | | | | | | 20 | 0.974 | 26 | 1.005 |
| ti 3 | 2.0 | | | | | | | 21 | 0.985 | 28 | 1.003 |
| oute | | | | | | | | 23 | 0.99 | 29 | 1.018 |
| Ŭ | | | | | | | | 24 | 0.995 | 30 | 1.022 |
| | 7.0 | | | | | | | 25 | 1.000 | | |
| lois | | | | | | | | N | P, Non-Pl | astic | X |
| N N N | | | | | | | | | Liquid I | imit 2 | 7 |
| | .2.0 | | | | | | | | Plastic I | imit 2 | 7 |
| | | | | | | | | | | | . / ID |
| 1 | 7.0 | | | | | | | | | | |
| 1 | 10 | 15 20 | 25 30 | 35 40 | | · · · | 100 | | sroup Syn | | M |
| | | | | | # 01 1 | brops | | N | Iultipoint N | /lethod | 1 |
| | | | | A' D ' | 1 [1] | | | 0 | ne-point N | lethod | |
| Wet Pre | | Dry Preparati | ion 🗸 | Air Drie | ed 🗸 | | % | 6 Passing t | he #200 Si | eve: | 29.7% |
| Notes / D | evialions / Refer | rences. | | | | | | | | | |
| | | | | | | | | | | | |
| ASTM D 4 | 4318: Liauid Lim | it, Plastic Limit. a | & Plastic II | ndex of Soil | S | | | | | | |
| | | ., | | 5,000 | - | | | | | | |
| | Matt Jaco | hs | | 8/30/21 | | Fran | nk Morris | PF | | 8/3 | 0/21 |
| | Technician Na | ime | | Date | | Techn | ical Respons | ibility | | <u>0, 0</u> | ate |

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| Single s | sieve set | | | | | | | ASTM | D 6913 | 3 | | | | | | | | | |
|----------|---------------|--------------|-------|----------|----------|----------------|------------|----------|-----------------|--------|---------|--------|--------|--------|-----|-------|-------|-----------|--------|
| | | | S&I | ME, Inc. | - Spa | rtan | burg: | 301 Zi | ma Parl | k Driv | e, Spar | tanb | urg, S | SC 293 | 301 | | | | |
| Project | #: | 213 | 045 | | | | | | | | | | | | Rep | ort [| Date: | 8/30, | /21 |
| Project | Name: | Bad | Cree | k Phase | e 2 Fea | sibil | ity Stu | dy Proje | ect | | | | | | Tes | t Dat | e(s): | 8/17 - 8/ | /20/21 |
| Client N | Name: | HDF | 2 | | | | | | | | | | | | | | | | |
| Client A | Address: | 1122 | 2 Lad | y Stree | t, Suite | e 11(| 00 Col | umbia, | South (| Caroli | na 292 | 201 | | | | | | | |
| Boreho | ole: | B-2 1 | 1-5 | | | | | | Log #: | | 1 | 35 | | | Sam | ple [| Date: | 6/2/ | 21 |
| Sample | e ID: | SS-2 | 21 | | | | | | Type: | | Split | -spoc | on | | | De | epth: | 52.6 | 6' |
| Sample | e Descripti | on: | silty | clayey | SAND | (SC- | -SM) - | tan bro | wn whit | te, me | edium | to fin | е | | | | | | |
| | | | | 1. 2/4 | | (0" | <i># 4</i> | | • | #20 | #40 | #60 | #100 | #140 # | 200 | | | | |
| | 100% F | • | •• | 1 3/4 | 3 | /8 | #4 | #1 | U | #20 | #40 | #80 | #100 | #140 # | 200 | 1 1 | | | - I |
| | - | | | | | | | | | | | | | | | | - | + | - |
| | 90% | | | | | | | | $\overline{\ }$ | | | | | | | | | | |
| | 80% | | | | | | | | | | | | | | | | | | - 1 |
| %) | 70% | | | | | | | | | | | | | | | | | _ | |
| sing | 10% | | | | | | | | | | | | | | | | _ | <u> </u> | - 1 |
| Pas | 60% | | | | | | | | | | | | | | | | | + | - |
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| erc | | | | | | | | | | | | | | | | | _ | + | - |
| | 40% | | | | | | | | | | | | | | | | | | |
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| | | | | | | | - | | • | | | | | | | | | | |

| | | | | | | | | _ |
|-------------|------------|-----------------------------|---------------|-----------|-------------|-----------|----------|---|
| Cobbles | < 300 n | nm (12") and > 75 mm (3") | Fine Sa | and | < 0.425 mr | n and > | 0.075 mm | |
| Gravel | < 75 | mm and > 4.75 mm (#4) | Silt | | < 0.075 a | and > 0.0 | 005 mm | |
| Coarse Sand | < 4.75 | mm and >2.00 mm (#10) | Clay | 0.005 mr | n | | | |
| Medium Sand | < 2.00 ı | mm and > 0.425 mm (#40) | Colloi | ids | < | 0.001 mr | n | |
| Method: B | Proce | edure for obtaining Specime | en: Moist | Dispersic | on Process: | Disp | ersant | |
| Maximum Par | ticle Size | 19.00 mm | Coarse Sand | 6.3% | Fine | Sand | 37.5% | |
| | Gravel | 3.3% | Medium Sand | 17.0% | Silt & | ι Clay | 36.0% | |
| Liq | uid Limit | 27 | Plastic Limit | 22 | Plastic | Index | 5 | |

Natural Moisture

17.6%

Notes / Deviations / References:

| Frank Morris P F | FRANKP. MERTSR. | Project Manager | 8/30/21 |
|--------------------------|---|---------------------------------------|---------|
| | | <u>FIQECEManager</u> | 0/30/21 |
| Technical Responsibility | Signature | Position | Date |
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| | AS | STM D 4318 | X | AASHTO | <i>T 89</i> C | I AAS | бНТО Т 90 | | | | |
|---------------------------------------|---|-----------------|--------------|--------------------------------|---------------|-------------|-----------|-------------|--------------|----------------|-------------|
| | S8 | §ME, Inc | Spartanb | urg: 301 | l Zima Pai | rk Drive, S | Spartanbu | urg, SC 29 | 9301 | | |
| Project # | #: 213045 | , | | | | | | Report [| Date: | 8/30/2 | 21 |
| Project I | Name: Bad Cre | eek Phase 2 | 2 Feasibili | ty Study F | Project | | | Test [| Date: | 8/27/2 | 21 |
| Client N | ame: HDR | | | | | | | | | | |
| Client A | ddress: 1122 La | ady Street, | Suite 110 | 0 Colum | oia, South | Carolina | 29201 | | | | |
| Borehole | e: B-21-5 | | Lo | og #: | 135 | | Sam | ple Date: | | 6/2/21 | |
| Sample | ID: SS-21 | | Т | ype: | Split-spo | oon | | Depth: | | 52.6' | |
| Sample | Description: | silty claye | ey SAND | (SC-SM) - | tan brow | n white, | medium t | o fine | | | |
| Type and | Specification | S&ME IL |) # | Cal Date: | Туре | and Speci | fication | S& | ME ID # | Cal | Date: |
| Balance | (0.01 g) | 7537 | | 1/29/2021 | Groo | ving tool | | | 14185 | 9/28 | /2020 |
| LL Appar | atus | 13859 | 9 | 9/28/2020 | | | | | | | |
| Oven | | 7313 | | 7/30/2021 | | | | | | | |
| Pan a | # | T aua #4 | | УГ | Liquid | Limit | 1 | | 20 | Plastic Limi | t |
| | Tara Waisht | Tare #: | 1C 00 | 1C 72 | Υ-6 15.02 | | | | 20 | 21 | |
| A | | | 16.80 | 16.72 | 15.92 | | | | 12.12 | 12.07 | |
| В | Wet Soil Weight + | A | 41.57 | 41.12 | 40.25 | | | | 18.84 | 18.66 | |
| C | Dry Soil Weight + | A | 36.47 | 35.93 | 34.89 | | | | 17.65 | 17.48 | |
| D | Water Weight (B-C | C) | 5.10 | 5.19 | 5.36 | | | | 1.19 | 1.18 | |
| E | Dry Soil Weight (C | A) | 19.67 | 19.21 | 18.97 | | | | 5.53 | 5.41 | |
| F | % Moisture (D/E)* | 100 | 25.9% | 27.0% | 28.3% | | | | 21.5% | 21.8% | |
| Ν | # OF DROPS | | 34 | 24 | 16 | | | | Moisture C | ontents det | ermined by |
| LL | LL = F * FAG | CTOR | | | | | | | A | STM D 221 | 6 |
| Ave. | Average | ę | | | | | | | | 21.7% | |
| 3 | 57.0 T | | | | | | | (| One Point | Liquid Lim | it I e i |
| | | | | | | | | N | 0.974 | N 26 | 1 005 |
| | | | | | | | | 21 | 0.979 | 27 | 1.009 |
| tent 3 | 32.0 | | | | | | | 22 | 0.985 | 28 | 1.014 |
| Cont | | | | | | | | 23 | 0.99 | 29 | 1.018 |
| l l l l l l l l l l l l l l l l l l l | .7.0 | | | | | | | 24 | 0.995 | 30 | 1.022 |
| istu | | | | ◄ | | | | 25 | 1.000 | | _ |
| W | | | | | | | | 1 | NP, NON-P | | 1 |
| ≥ 2 | 22.0 | | | | | | | | Diactic I | imit 2 | .7 |
| | | | | | | | | | | | 5 |
| 1 | 7.0 | | | | | | | (| | nhol SC | 5 _CM |
| | 10 15 | 20 | 25 30 | 35 40 | # of I | Drops | 100 | | Jultinoint N | Aethod | |
| | | | | | | in ops | | C C | ne-point N | /lethod | |
| Wet Pre | eparation [| Drv Preparat | ion 🗸 | Air Drie | ed 🗸 | | 9 | 6 Passina t | he #200 Si | eve: | 36.0% |
| Notes / D | Deviations / Reference | ces: | | | | | | <u> </u> | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| ASTM D 4 | | | | | | | | | | | |
| | 4318: Liquid Limit, P | lastic Limit, a | & Plastic Ir | ndex of Soil | 's | | | | | | |
| | 4318: Liquid Limit, P | lastic Limit, d | & Plastic Ir | ndex of Soil | s | | | | | | |
| | 4318: Liquid Limit, P <u>Matt Jacobs</u> | lastic Limit, d | & Plastic Ir | ndex of Soil <u>8/30/21</u> | 's | Fran | nk Morris | , P.E. | | <u>8/3</u> | <u>0/21</u> |

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Appendix H

Rock Core Sample Laboratory Testing Results

Not Included - Available Upon Request

Appendix I

HDR Downhole Data Stereonets

Not Included - Available Upon Request

Attachment 3

Attachment 3 – Lower Reservoir CFD Flow Modeling Report

FX

Bad Creek II Power Complex Feasibility Study

Volume 5: Lower Reservoir CFD Flow Modeling Report

Salem, South Carolina September 1, 2022





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Contents

| 1 | Exec | cutive Su | ummary | 1 |
|---|-------|----------------|---|----------|
| 2 | Intro | duction. | | 2 |
| 3 | CFD | Model [| Development | 2 |
| | 3.1 | Model | Description | 2 |
| | | 3.1.1 | Modeling Approach | 2 |
| | 3.2 | Model | Geometry | 3 |
| | | 3.2.1 3.2.2 | Existing I/O Structure and Lake Jocassee Proposed I/O Structure | 3 6 |
| | 3.3 | Mesh | Development | 10 |
| | | 3.3.1 3.3.2 | Existing Configuration Proposed Configuration | 10 10 |
| | 3.4 | Model | Scenarios | 10 |
| | | 3.4.1 3.4.2 | Model Scenarios Boundary Conditions | 10 12 |
| | 3.5 | Model | Evaluation | 13 |
| | | 3.5.1 | Flux Surfaces | 13 |
| | | 3.5.2 | Monitoring Points | 13 |
| | 3.6 | Evalua | ation Criteria | 13 |
| | | 3.6.1 | Model Verification Criteria | 13 |
| | | 3.6.2 | Generation Scenario Criteria | 13 |
| | | 3.6.3 | Pumping Scenario Criteria | 13 14 |
| | - | 0.0.4 | | 14 |
| 4 | Resu | ults | | 14 |
| | 4.1 | Existin | ng Bad Creek Configuration and Model Verification - Cases 1 & 2 | 14 |
| | 4.2 | Propos | sed Configuration - Cases 3 through 5 (Turbine Mode) | 19 |
| | | 4.2.1 | Case 3: Lake Jocassee Normal Full Reservoir Elevation 1,110 ft msl | 19 |
| | | 4.2.2 | Case 4: Lake Jocassee Normal Minimum Reservoir Elevation 1,080 ft msl | 29 |
| | | 4.2.3 | msl | 38 |
| | 43 | Propos | sed Configuration - Cases 6 through 8 (Pump Mode) | 48 |
| | 4.0 | 4.3.1 | Case 6: Lake Jocassee Normal Full Reservoir Elevation 1 110 ft msl | 48 |
| | | 4.3.2 | Case 7: Lake Jocassee Normal Minimum Reservoir Elevation 1,080 ft msl | 58 |
| | | 4.3.3 | Case 8: Lake Jocassee Intermediate Reservoir Elevation 1,096 ft msl | 67 |
| | 4.4 | Constr | ruction Configuration - Cases 9 through 12 Generation and Pump Modes | 77 |
| | | 4.4.1 | Case 9: Lake Jocassee Normal Full Reservoir Elevation 1,110 ft msl - | |
| | | | Generation | 77 |
| | | 4.4.2 | Case 10: Lake Jocassee Normal Minimum Reservoir Elevation 1080 ft msl - | 05 |
| | | 443 | Generation Case 11: Lake Jocassee Normal Full Reservoir Elevation 1 110 ft msl - | ชว |
| | | | Pumping | 92 |
| | | | | |

| | 4.4.4 Case 12: Lake Jocassee Normal Minimum Reservoir Elevation 1,080 ft r | | nsl - | |
|---|--|---------|-------|--|
| | | Pumping | 100 | |
| 5 | Conclusion | | 107 | |
| 6 | References | | 108 | |

Tables

| able 1. Simulation Conditions |
|-------------------------------|
|-------------------------------|

Figures

| Figure 1. Existing I/O Structure and Lake Jocassee Bathymetry | 4 |
|--|----|
| Figure 2. Existing I/O Structure and Lake Jocassee Bathymetry- Jocassee Lake Level 1,080 ft msl | 5 |
| Figure 3. Existing I/O Structure and Lake Jocassee Bathymetry - Jocassee Lake Level 1,110 ft msl | 5 |
| Figure 4. Existing I/O Structure Geometry and Lake Jocassee Bathymetry - detailed rendering of structure | 6 |
| Figure 5. Existing and Proposed I/O Structure and Lake Jocassee Topography | 7 |
| Figure 6. Existing and Proposed I/O and Lake Jocassee Bathymetry - Jocassee Lake Level 1,080 ft msl | 8 |
| Figure 7. Proposed I/O Structure and Lake Jocassee Bathymetry - Jocassee Lake Level 1,110 ft msl | 8 |
| Figure 8. Proposed I/O Structure Geometry and Lake Jocassee Bathymetry – detailed rendering of structure | 9 |
| Figure 9. General Flow Pattern Comparison - CFD Model Case 1 Results vs ARL Physical Model Results - Lake Jocassee Normal Full Reservoir: 1,110 ft msl | 15 |
| Figure 10. East Bank Velocity and Flow Pattern Comparison - CFD Model Case 1 Results vs ARL Physical Model Results - Lake Jocassee Normal Full Reservoir: 1,110 ft msl | 16 |
| Figure 11. General Flow Pattern Comparison - CFD Model Case 2 Results vs ARL Physical Model Results - Lake Jocassee Normal Minimum Reservoir: 1,080 ft msl | 17 |
| Figure 12. East Bank Velocity and Flow Pattern Comparison - CFD Model Case 2 Results vs ARL Physical Model Results - Lake Jocassee Normal Minimum Reservoir: 1,080 ft msl | 18 |
| Figure 13. Case 3 (generation - maximum reservoir elevation) Velocity Streamlines at Normal Full Pool Elevation | 20 |
| Figure 14. Case 3 (generation - maximum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl | 21 |
| Figure 15. Case 3 (generation - maximum reservoir elevation) Velocity Vectors at Elevation 1,050 ft | 22 |
| Figure 16. Case 3 (generation - maximum reservoir elevation) Velocity Vectors at Elevation 1,080 ft | 23 |

| Figure 17. Case 3 (generation - maximum reservoir elevation) Velocity Vectors at Elevation 1,11 ft msl | 0 24 |
|--|---------|
| Figure 18. Case 3 (generation - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 25 |
| Figure 19. Case 3 (generation - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 26 |
| Figure 20. Case 3 (generation - maximum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors | 27 |
| Figure 21. Case 3 (generation - maximum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors | 28 |
| Figure 22. Case 4 (generation - minimum reservoir elevation) Velocity Streamlines under Norma Minimum Reservoir Elevation | l 30 |
| Figure 23. Case 4 (generation - minimum reservoir elevation) Velocity Vectors at Elevation 1,04 ft msl |) 31 |
| Figure 24. Case 4 (generation - minimum reservoir elevation) Velocity Vectors at Elevation 1,05 ft msl |) 32 |
| Figure 25. Case 4 (generation - minimum reservoir elevation) Velocity Vectors at Elevation 1,08 ft msl |) 33 |
| Figure 26. Case 4 (generation - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | |
| Figure 27. Case 4 (generation - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | |
| Figure 28. Case 4 (generation - minimum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors | |
| Figure 29. Case 4 (generation - minimum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors | |
| Figure 30. Case 5 (generation - intermediate reservoir elevation) Velocity Streamlines under Normal Minimum Reservoir Elevation | 39 |
| Figure 31. Case 5 (generation - intermediate reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl | 40 |
| Figure 32. Case 5 (generation - intermediate reservoir elevation) Velocity Vectors at Elevation 1,050 ft msl | 41 |
| Figure 33. Case 5 (generation - intermediate reservoir elevation) Velocity Vectors at Elevation 1,080 ft msl | |
| Figure 34. Case 5 (generation – intermediate reservoir elevation) Velocity Vectors at Elevation 1,096 ft msl | |
| Figure 35. Case 5 (generation - intermediate reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | |
| Figure 36. Case 5 (generation - intermediate reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | |
| Figure 37. Case 5 (generation - intermediate reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors | |
| Figure 38. Case 5 (generation - intermediate reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors | 47 |

| Figure 39. Case 6 (pumping - maximum reservoir elevation) Velocity Streamlines at Normal Full Pool Elevation | 49 |
|---|----|
| Figure 40. Case 6 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl | 50 |
| Figure 41. Case 6 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,050 ft | 51 |
| Figure 42. Case 6 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,080 ft | 52 |
| Figure 43. Case 6 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,110 ft msl | 53 |
| Figure 44. Case 6 (pumping - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 54 |
| Figure 45. Case 6 (pumping - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 55 |
| Figure 46. Case 6 (pumping - maximum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors | 56 |
| Figure 47. Case 6 (pumping - maximum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors | 57 |
| Figure 48. Case 7 (pumping - minimum reservoir elevation) Velocity Streamlines under Normal Minimum Reservoir Elevation | 59 |
| Figure 49. Case 7 (pumping - minimum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl | 60 |
| Figure 50. Case 7 (pumping - minimum reservoir elevation) Velocity Vectors at Elevation 1,050 ft msl | 61 |
| Figure 51. Case 7 (pumping - minimum reservoir elevation) Velocity Vectors at Elevation 1,080 ft msl | 62 |
| Figure 52. Case 7 (pumping - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 63 |
| Figure 53. Case 7 (pumping - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 64 |
| Figure 54. Case 7 (pumping - minimum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors | 65 |
| Figure 55. Case 7 (pumping - minimum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors | 66 |
| Figure 56. Case 8 (pumping - intermediate reservoir elevation) Velocity Streamlines at Normal Full Pool Elevation | 68 |
| Figure 57. Case 8 (pumping - intermediate reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl | 69 |
| Figure 58. Case 8 (pumping - intermediate reservoir elevation) Velocity Vectors at Elevation 1,050 ft | 70 |
| Figure 59. Case 8 (pumping - intermediate reservoir elevation) Velocity Vectors at Elevation 1,080 ft | 71 |
| Figure 60. Case 8 (pumping - intermediate reservoir elevation) Velocity Vectors at Elevation 1,096 ft msl | 72 |
| Figure 61. Case 8 (pumping - intermediate reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 73 |

| Figure 62. Case 8 (pumping - intermediate reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 74 |
|---|----|
| Figure 63. Case 8 (pumping - intermediate reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors | 75 |
| Figure 64. Case 8 (pumping - intermediate reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors | 76 |
| Figure 65. Case 9 (generating - maximum reservoir elevation) Velocity Streamlines at Normal Full Pool Elevation | 78 |
| Figure 66. Case 9 (generating - maximum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl | 79 |
| Figure 67. Case 9 (generating - maximum reservoir elevation) Velocity Vectors at Elevation 1,050 ft | 80 |
| Figure 68. Case 9 (generating - maximum reservoir elevation) Velocity Vectors at Elevation 1,080 ft | 81 |
| Figure 69. Case 9 (generating - maximum reservoir elevation) Velocity Vectors at Elevation 1,110 ft msl | 82 |
| Figure 70. Case 9 (generating - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 83 |
| Figure 71. Case 9 (generating - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 84 |
| Figure 72. Case 10 (generating - minimum reservoir elevation) Velocity Streamlines at Normal Full Pool Elevation | 86 |
| Figure 73. Case 10 (generating - minimum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl | 87 |
| Figure 74. Case 10 (generating - minimum reservoir elevation) Velocity Vectors at Elevation 1,050 ft | 88 |
| Figure 75. Case 10 (generating - minimum reservoir elevation) Velocity Vectors at Elevation 1,080 ft | 89 |
| Figure 76. Case 10 (generating - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 90 |
| Figure 77. Case 10 (generating - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 91 |
| Figure 78. Case 11 (pumping - maximum reservoir elevation) Velocity Streamlines at Normal Full Pool Elevation | 93 |
| Figure 79. Case 11 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl | 94 |
| Figure 80. Case 11 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,050 ft | 95 |
| Figure 81. Case 11 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,080 ft | 96 |
| Figure 82. Case 11 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,110 ft msl | 97 |
| Figure 83. Case 11 (pumping - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 98 |

| Figure 84. Case 11 (pumping - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 99 |
|---|-----|
| Figure 85. Case 12 (pumping - minimum reservoir elevation) Velocity Streamlines at Normal Minimum Pool Elevation | 101 |
| Figure 86. Case 12 (pumping - minimum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl | 102 |
| Figure 87. Case 12 (pumping - minimum reservoir elevation) Velocity Vectors at Elevation 1,050 ft | 103 |
| Figure 88. Case 12 (pumping - minimum reservoir elevation) Velocity Vectors at Elevation 1,080 ft | 104 |
| Figure 89. Case 12 (pumping - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 105 |
| Figure 90. Case 12 (pumping - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors | 106 |

Acronyms and Abbreviations

| 3D | three dimensional |
|--------------|--|
| ARL | Alden Research Laboratory |
| Bad Creek | Bad Creek Pumped Storage Station |
| Bad Creek II | Proposed Bad Creek II Power Complex |
| CFD | computational fluid dynamics |
| cfs | cubic feet per second |
| ft | feet/foot |
| ft msl | feet above mean sea level |
| fps | feet per second |
| I/O | Inlet/Outlet |
| URANS | Unsteady Reynolds Averaged-Navier Stokes |
| WSE | water surface elevation |
| | |

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1 Executive Summary

As a component of the Duke Energy Carolinas, LLC (Duke Energy) Bad Creek II Power Complex (Bad Creek II) Feasibility Study scope, HDR developed a Computational Fluid Dynamic (CFD) model to quantify and evaluate potential hydraulic impacts within the Whitewater River cove of Lake Jocassee to establish velocity and flow patterns along the channel and near the east bank of the cove opposite of the discharge structure. Model simulations were carried out assuming the existing Bad Creek Pumped Storage Station (Bad Creek) and the proposed Bad Creek II were operating both simultaneously and independently under several scenarios. The modeling utilized Lake Jocassee bathymetry and the existing and proposed Bad Creek II inlet/outlet (I/O) structures to evaluate velocities and flow patterns within the Whitewater River cove to assess operational impacts. Simulations were run at elevations of 1,110 feet (ft) above mean sea level (msl) (i.e., normal full pool elevation) and 1,080 ft msl (minimum normal elevation) to calibrate the CFD model velocities and flow patterns to the 1986 physical model results reported by Alden Research Laboratory (ARL) (Larsen and White 1986) assuming the same discharge flows modeled by ARL. Bad Creek is currently undergoing upgrades to the pump-turbine units. Upgraded operations at Bad Creek as well as proposed Bad Creek II operations (and I/O structure operations) were subsequently added to the model.

Unit operations in both the turbine and pump mode were simulated with the existing and proposed structures at reservoir levels 1,110 ft msl, 1,096 ft msl, and 1,080 ft msl. The elevation of 1,096 ft msl was selected as an intermediate lake elevation operating scenario for the following reasons:

- 1. The surface water elevation threshold for implementation of protective operational measures to minimize fish entrainment is 1,099 ft msl.
- 2. The surface water elevation below which fish entrainment becomes elevated at Bad Creek and historically occurs less than 22 percent of the time is 1,096 ft msl.

Model results indicate that velocities produced by full generation from the existing project at the upper and lower reservoir levels are similar to the velocities physically modeled in 1986. Additional discharge from proposed Bad Creek II operations creates a concentrated area of high velocity flows extending downstream to the existing Bad Creek I/O structure. This effect is more pronounced at lower reservoir levels. The concentrated area of high velocity flow does not impact the east (i.e., opposite) bank of the Whitewater River cove, which is predominantly bedrock. Additional scenarios to simulate pumping operations were performed and showed distinct flow patterns specific to each I/O structure. Expansion of the existing submerged weir downstream of the I/O structure is planned during the construction of Bad Creek II; velocities in the water column above the expanded submerged weir increased as the flow depth decreased. Velocities along the eastern bank near the expanded weir were higher when compared to the simulations using existing weir.

2 Introduction

The existing Bad Creek Pumped Storage Station (Bad Creek) is part of a Duke Energy Carolinas, LLC (Duke Energy) operated system of two pumped storage stations near Salem, South Carolina. Bad Creek utilizes the Bad Creek Reservoir as the upper pool and Lake Jocassee as the lower pool. Downstream of Bad Creek is the Jocassee Pumped Storage Station, which uses Lake Jocassee as the upper pool and Lake Keowee as the lower pool.

Duke Energy is studying the viability of constructing a second pumped storage plant at Bad Creek to increase generation and pump capacity while also supporting Duke Energy's commitment to expanding intermittent renewable energy generation sources and reduce carbon dioxide emissions and achieve net-zero by 2050 (Duke Energy 2020). The proposed second powerhouse, Bad Creek II Power Complex (Bad Creek II), would operate similar to the existing Bad Creek station, using the Bad Creek Reservoir as the upper pool and Lake Jocassee as the lower pool.

As part of the Bad Creek II Feasibility Study authorized by Duke Energy, HDR Engineering, Inc. (HDR) developed a three-dimensional Computational Fluid Dynamic (CFD) model for lower reservoir modeling to complement the Upper and Lower Reservoir Operational Impact Studies. The Lower Reservoir CFD flow model supports the evaluation of a second additional inlet/outlet (I/O) structure and the potential associated impacts to the Whitewater River cove of Lake Jocassee.

The CFD modeling framework included a calibration phase (phase I) focused on replicating the existing dominant flow and velocity patterns predicted by the Alden Research Laboratory (ARL) physical model (Larsen and White 1986), followed by phase II, which focused on evaluating the velocity and flow pattern impacts of the proposed second I/O structure at two reservoir elevations - 1,110 feet (ft) and 1,080 ft above mean sea level (msl). The second phase utilized discharge flows based on the soon to be uprated Bad Creek units, plus the assumed discharge from the conceptualized Bad Creek II project.

This report describes these simulations and the results presented provide a preliminary analysis for the Feasibility Study. Additional data or modifications to the model can be provided to support future studies.

3 CFD Model Development

3.1 Model Description

FLOW-3D is developed and supported by Flow Science, Inc. (Flow Science 2014) and is a commercially available computational model capable of solving three-dimensional (3D) Unsteady Reynolds Averaged-Navier Stokes (URANS) equations. The software utilizes a Volume of Fluid method to calculate the free surface within the model domain (Hirt and Nichols 1981). The software package contains the meshing module (pre-processor), solver, and post-processor.

3.1.1 Modeling Approach

The FLOW-3D software solves fully URANS equations on structured grids and the governing equations used in the model are provided in the FLOW-3D user's guide (Flow Science 2014). Model-

fitted meshes were developed for the existing Bad Creek I/O structure/reservoir and for the proposed Bad Creek II I/O structure/reservoir. A known water surface elevation (WSE) was applied to the reservoir meshes based on data supplied by Duke Energy.

PRESSURE SOLVER OPTIONS

Two numerical schemes are available for the pressure solver module with multiple options (i.e., explicit, and implicit). Within the implicit solver, limited compressibility models can be toggled to relax the constraints of the pressure solver for cases where solution stability is an issue. The explicit solver allows for improved accuracy of the solution, though it results in longer computational time (Hirt 2000). The explicit pressure solver was applied in the Bad Creek II CFD modeling effort.

TURBULENCE MODELS

Various one-equation (Prandtl Mixing Length and Turbulent Energy Model) and two-equation (k-e, kw, and Renormalized Group) turbulence modules are available in FLOW-3D (Yakhot and Orszag 1986). The Renormalized Group model was selected for the Lower Reservoir CFD flow modeling study based on anticipated flow patterns in the Whitewater River cove. Additionally, the Renormalized Group model is robust enough to handle the anticipated increased turbulence in the Whitewater River cove as a result of a second I/O structure.

MODEL LIMITATIONS

As with all numerical models, the CFD model is limited in the results it can accurately produce. Some hydrodynamic features are not accurately modeled with the selected solver and turbulence closure models and recirculation patterns and vortices are approximate in size and strength; however, the selected features used to produce the results for this study are considered appropriate for the intended use of the model results.

3.2 Model Geometry

3.2.1 Existing I/O Structure and Lake Jocassee

The topography and bathymetry for the model was adapted from existing AutoCAD files and exported to a stereolithography file. Figure 1 shows the existing I/O structure and Lake Jocassee bathymetry. Figure 2 and Figure 3 show the geometry, bathymetry, and the Lake Jocassee reservoir level initial conditions of 1,110 ft and 1,080 ft msl used as initial conditions in the model, respectively. Figure 4 shows a detailed rendering of the existing I/O structure and bifurcated tunnels.



Figure 1. Existing I/O Structure and Lake Jocassee Bathymetry



Figure 2. Existing I/O Structure and Lake Jocassee Bathymetry- Jocassee Lake Level 1,080 ft msl



Figure 3. Existing I/O Structure and Lake Jocassee Bathymetry - Jocassee Lake Level 1,110 ft msl



Figure 4. Existing I/O Structure Geometry and Lake Jocassee Bathymetry - detailed rendering of structure

3.2.2 Proposed I/O Structure

The existing geometry and topography were expanded, adding the geometry for the proposed I/O structure to the model. Figure 5 shows the existing and proposed I/O structure and Lake Jocassee bathymetry. Figure 6 and Figure 7 show the bathymetry and the Lake Jocassee reservoir level initial conditions of 1,110 ft and 1,080 ft msl used as initial conditions in the CFD model, respectively. Figure 8 shows a detailed rendering of the proposed I/O structure and bifurcated tunnels.



Figure 5. Existing and Proposed I/O Structure and Lake Jocassee Topography



Figure 6. Existing and Proposed I/O and Lake Jocassee Bathymetry - Jocassee Lake Level 1,080 ft msl



Figure 7. Proposed I/O Structure and Lake Jocassee Bathymetry - Jocassee Lake Level 1,110 ft msl



Figure 8. Proposed I/O Structure Geometry and Lake Jocassee Bathymetry – detailed rendering of structure

3.3 Mesh Development

The CFD model determines flow field throughout the volume of water in discrete sections. A computational mesh is used to discretize the solution within the domain. FLOW-3D requires the computational mesh to be comprised of orthogonal elements (faces align with the x, y, or z direction). The model topography and features were translated to represent significant features with fewer elements.

3.3.1 Existing Configuration

The computational mesh block used for the existing Bad Creek configuration was 4-ft by 4-ft by 4-ft (length by width by height). The block was modified in the vertical direction +/- 8 ft from the anticipated free surface elevation (i.e., 1,110 ft or 1,080 ft msl) to help resolve the free surface and aid with the computational runtime. Mesh planes were added in the horizontal direction to align the computational mesh with important project features such as the I/O structure.

3.3.2 Proposed Configuration

The computational mesh for the proposed Bad Creek II powerhouse was largely unchanged from the existing configuration. The mesh block remained 4-ft by 4-ft by 4-ft (length by width by height) and contained the vertical modification in the vicinity of the free surface. Additional mesh planes were added to align the mesh with the proposed I/O structure.

3.4 Model Scenarios

3.4.1 Model Scenarios

Model simulations were run until the monitored flow (see Section 3.5 for description of methods used to monitor the model simulations) converged with the target flow; Table 1 lists the model scenarios. Three categories of simulations were performed: generation, pumping, and construction. Cases (i.e., simulations) 1 and 2 are verification of model parameters and performance. Cases 3, 4, and 5 evaluate the hydraulic interactions between the existing and proposed I/O structures in the turbine (or generation) mode. The hydraulic interactions of the existing and proposed I/O structures during pump back were evaluated in Cases 6, 7, and 8. Cases 9 through 12 represent mid construction operations of the existing powerhouse in both the pump and turbine mode after the rock spoil from construction of Bad Creek II has been placed in the reservoir.

| Simulation | Reservoir WSE (ft msl) | Flow (cfs) | Notes |
|--------------------------|------------------------------|--|---|
| Case 1 (Turbine Mode) | 1,110 | Unit 1: 4,000 Unit 2: 4,000 Unit 3: 4,000 Unit 4: 4,000 | Existing I/O structure configuration, Lake Jocassee at normal full reservoir elevation. Original ARL unit characteristics. |
| Case 2 (Turbine Mode) | 1,080 | Unit 1: 4,000 Unit 2: 4,000 Unit 3: 4,000 Unit 4: 4,000 | Existing I/O structure configuration, Lake Jocassee at normal minimum reservoir elevation. Original ARL unit characteristics |

 Table 1. Simulation Conditions

| Simulation | Reservoir WSE (ft msl) | Flow (cfs) | Notes |
|--------------------------|------------------------------|---|--|
| Case 3 (Turbine Mode) | 1,110 | Unit 1: 4,940 Unit 2: 4,940 Unit 3: 4,940 Unit 4: 4,940 Unit 5: 4,860 Unit 6: 4,860 Unit 7: 4,860 Unit 8: 4,860 | Proposed I/O structure configuration, Lake Jocassee at normal full reservoir elevation during generation. Units 1-4 belong to the existing I/O structure and 5-8 belong to the proposed I/O structure. Units 1-4 reflect upgraded unit characteristics. |
| Case 4 (Turbine Mode) | 1,080 | Unit 1: 4,940 Unit 2: 4,940 Unit 3: 4,940 Unit 4: 4,940 Unit 5: 4,860 Unit 6: 4,860 Unit 6: 4,860 Unit 7: 4,860 Unit 8: 4,860 | Proposed I/O structure configuration, Lake Jocassee at normal minimum reservoir elevation during generation. Units 1-4 belong to the existing I/O structure and 5-8 belong to the proposed I/O structure. Units 1-4 reflect upgraded unit characteristics. |
| Case 5 (Turbine Mode) | 1,096 | Unit 1: 4,940 Unit 2: 4,940 Unit 3: 4,940 Unit 4: 4,940 Unit 5: 4,860 Unit 6: 4,860 Unit 7: 4,860 Unit 8: 4,860 | Proposed I/O structure configuration, Lake Jocassee at assumed intermediate reservoir elevation during generation. Units 1-4 belong to the existing I/O structure and 5-8 belong to the proposed I/O structure. Units 1-4 reflect upgraded unit characteristics. |
| Case 6 (Pump Mode) | 1,110 | Unit 1: 4,060 Unit 2: 4,060 Unit 3: 4,060 Unit 4: 4,060 Unit 5: 4,120 Unit 6: 4,120 Unit 7: 4,120 Unit 8: 4,120 | Proposed I/O structure configuration, Lake Jocassee at normal maximum reservoir elevation during pumping. Units 1-4 belong to the existing I/O structure and 5-8 belong to the proposed I/O structure. Units 1-4 reflect upgraded unit characteristics. |
| Case 7 (Pump Mode) | 1,080 | Unit 1: 4,060 Unit 2: 4,060 Unit 3: 4,060 Unit 4: 4,060 Unit 5: 4,120 Unit 6: 4,120 Unit 7: 4,120 Unit 8: 4,120 | Proposed I/O structure configuration, Lake Jocassee at normal minimum reservoir elevation during pumping. Units 1-4 belong to the existing I/O structure and 5-8 belong to the proposed I/O structure. Units 1-4 reflect upgraded unit characteristics. |
| Case 8 (Pump Mode) | 1,096 | Unit 1: 4,060 Unit 2: 4,060 Unit 3: 4,060 Unit 4: 4,060 Unit 5: 4,120 Unit 6: 4,120 Unit 7: 4,120 Unit 8: 4,120 | Proposed I/O structure configuration, Lake Jocassee at assumed intermediate reservoir elevation during pumping. Units 1-4 belong to the existing I/O structure and 5-8 belong to the proposed I/O structure. Units 1-4 reflect upgraded unit characteristics. |
| Case 9 (Turbine Mode) | 1,110 | Unit 1: 4,940 Unit 2: 4,940 Unit 3: 4,940 Unit 4: 4,940 Unit 5: 0 Unit 5: 0 Unit 6: 0 Unit 7: 0 Unit 8: 0 | Proposed I/O structure configuration, Lake Jocassee at normal full reservoir elevation during generation. Units 1-4 belong to the existing I/O structure and 5-8 belong to the proposed I/O structure. Units 1-4 reflect upgraded unit characteristics. |

| Simulation | Reservoir WSE (ft msl) | Flow (cfs) | Notes |
|---------------------------|------------------------------|---|--|
| Case 10 (Turbine Mode) | 1,080 | Unit 1: 4,940 Unit 2: 4,940 Unit 3: 4,940 Unit 4: 4,940 Unit 5: 0 Unit 5: 0 Unit 6: 0 Unit 7: 0 Unit 8: 0 | Proposed I/O structure configuration, Lake Jocassee at normal minimum reservoir elevation during generation. Units 1-4 belong to the existing I/O structure and 5-8 belong to the proposed I/O structure. Units 1-4 reflect upgraded unit characteristics. |
| Case 11 Pump Mode) | 1,110 | Unit 1: 4,060 Unit 2: 4,060 Unit 3: 4,060 Unit 4: 4,060 Unit 5: 0 Unit 5: 0 Unit 6: 0 Unit 7: 0 Unit 8: 0 | Proposed I/O structure configuration, Lake Jocassee at normal minimum reservoir elevation during pumping. Units 1-4 belong to the existing I/O structure and 5-8 belong to the proposed I/O structure. Units 1-4 reflect upgraded unit characteristics. |
| Case 12 (Pump Mode) | 1,080 | Unit 1: 4,060 Unit 2: 4,060 Unit 3: 4,060 Unit 4: 4,060 Unit 5: 0 Unit 5: 0 Unit 6: 0 Unit 7: 0 Unit 8: 0 | Proposed I/O structure configuration, Lake Jocassee at normal minimum reservoir elevation during pumping. Units 1-4 belong to the existing I/O structure and 5-8 belong to the proposed I/O structure. Units 1-4 reflect upgraded unit characteristics. |

Note: cfs = cubic feet per second

3.4.2 Boundary Conditions

Boundary conditions for the CFD model were applied through multiple boundary types. Boundary condition definitions were consistent between the existing and proposed configurations. Boundary types for the CFD model are briefly described in the subsections that follow.

MASS-MOMENTUM SOURCES

Mass-momentum sources were used to define the I/O structure discharge tunnels. The source allows flow to be added or removed from the model domain.

OUTFLOW BOUNDARY

The outflow boundary was applied to the downstream limit of the model. This boundary allows pressure to be balanced through the model. A hydrostatic pressure condition was applied at the outflow and set to the target reservoir water surface elevation of 1,110 or 1,080 ft msl for the normal full and normal minimum Lake Jocassee levels, respectively.

BOUNDARY-TYPE WALL

The boundary-type wall applied the no-slip condition at the outer boundary of the mesh blocks as well as a zero velocity condition normal to the boundary.

3.5 Model Evaluation

Analysis of completed model runs focused on the flow patterns and velocities. Multiple methods were used to monitor the progress of the model during the simulation. This section highlights the methods used to evaluate the model during the simulation and in post-processing. Flux surfaces and monitoring points provided data during the simulations.

3.5.1 Flux Surfaces

Flux surfaces were used to monitor the volumetric flow through the I/O tunnels and near the model outlet. The flux surfaces were vertical planes placed at specific locations in the CFD model. The surfaces were monitored for mass/volume balance of flow through the model.

3.5.2 Monitoring Points

Monitoring points were placed within the model to gather point data in Lake Jocassee during model simulations. Modeled velocities and water surface elevations were actively monitored during the simulation to determine if the model reached a reportable solution.

3.6 Evaluation Criteria

The three categories (generation, pumping, and construction) of simulation were evaluated using several different criteria. The details of the evaluation are listed below.

3.6.1 Model Verification Criteria

The CFD model assumptions and performance were compared against previous physical model results. The exact location and orientation of the physical model data were not explicitly detailed in the documentation (Larsen and White 1986), so a qualitative analysis was performed to verify the model could replicate the general flow patterns and velocity magnitude of the physical model study.

3.6.2 Generation Scenario Criteria

The focus of the generation simulations was the hydraulic impact along the east bank of Lake Jocassee. A specific velocity threshold or criteria was not established for potential bank erosion or recreational flows in the Whitewater River cove. The east bank velocities were compared to the verification simulations and existing site knowledge to determine potential hydraulic impacts.

3.6.3 Pumping Scenario Criteria

The flow patterns and velocities in the Whitewater River cove and near the proposed I/O structure were qualitatively evaluated. The velocity magnitude north of the submerged weir was identified as a potential concern and maximum values were reported in this area. The hydraulic approach conditions for the proposed I/O structure were analyzed for hydraulic efficiency and distribution of approaching flow.

3.6.4 Construction Scenarios Criteria

The flow patterns and velocities in the Whitewater River cove and near the expanded weir structure were qualitatively evaluated. The velocity magnitude north of the submerged weir was identified as a potential concern and maximum values were reported in this area. The hydraulic approach conditions for the existing I/O structure were analyzed for hydraulic efficiency and distribution of approaching flow. Simulations for only the proposed structure were not performed as the initial hydraulics did not indicate the hydraulics Lake Jocassee would not produce hydraulic variables in excess of previously simulated flows.

4 Results

The hydraulics for both the existing and proposed I/O structures were simulated to target outflow convergence to establish flow and velocity patterns for the Whitewater River cove channel and east bank velocity analysis.

4.1 Existing Bad Creek Configuration and Model Verification - Cases 1 & 2

The CFD model was verified against the ARL physical model (Larsen and White 1986) using Cases 1 and 2 (see Table 3-1). Flow patterns and bank line velocities were described by the physical model. Figure 9 through Figure 12 shows the comparison between CFD model and physical model flow patterns and east bank velocities for the reservoir at the normal full pool (i.e., 1,110 ft msl) and normal minimum (i.e., 1,080 ft msl) reservoir levels at Lake Jocassee, respectively. The model showed a reasonable comparison to the physical modeled data. While the existing I/O structure outflow predicted by the physical model is higher than that predicted by the CFD model resulting in more recirculation (which in turn has a more pronounced effect on the flow pattern), the overall flow patterns predicted by the physical model, including major patterns of recirculation and velocity magnitudes, are captured in the CFD model. This was noted in both the normal minimum and normal full Lake Jocassee elevation scenarios.

East bank velocities along the I/O structure centerline predicted by the physical model range between about 0.5 feet per second (fps) and 2.25 fps at reservoir level 1,110 ft msl. At the minimum normal reservoir elevation of 1,080 ft msl, the velocities are slightly lower ranging from 0.5 fps to 1.3 fps. As shown on Figure 10 and Figure 12, similar bank velocities were also captured by the CFD model. For the purposes of this study, it is assumed the velocities measured in the ARL physical model are representative of the existing east bank conditions. The point velocities shown in the physical model results were reproduced by the flow simulated in the CFD model. To HDR's knowledge, flows from the existing structure have not caused erosion along the east bank.



Figure 9. General Flow Pattern Comparison - CFD Model Case 1 Results vs ARL Physical Model Results - Lake Jocassee Normal Full Reservoir: 1,110 ft msl



Figure 10. East Bank Velocity and Flow Pattern Comparison - CFD Model Case 1 Results vs ARL Physical Model Results - Lake Jocassee Normal Full Reservoir: 1,110 ft msl



Figure 11. General Flow Pattern Comparison - CFD Model Case 2 Results vs ARL Physical Model Results - Lake Jocassee Normal Minimum Reservoir: 1,080 ft msl





Figure 12. East Bank Velocity and Flow Pattern Comparison - CFD Model Case 2 Results vs ARL Physical Model Results - Lake Jocassee Normal Minimum Reservoir: 1,080 ft msl

4.2 Proposed Configuration - Cases 3 through 5 (Turbine Mode)

After model verification (see Section 4.1), the proposed Bad Creek II I/O structure configuration was modeled for both reservoir elevations and assuming full generation at both I/O structures (combined 39,200 cubic feet per second [cfs]) to determine impacts to the channel and east bank of the Lake Jocassee Whitewater River cove. Turbine flows for the uprated Bad Creek units were used in these scenarios.

4.2.1 Case 3: Lake Jocassee Normal Full Reservoir Elevation 1,110 ft msl

Results of the proposed configuration at normal full reservoir elevation are presented on Figure 13 through Figure 21. Figure 13 shows the plan view of the streamlines at normal full pool elevation. Flow from the proposed I/O structure forces flow from the existing I/O structure to the center of the reservoir, lowering the velocities along the east bank.

Figure 14 through Figure 17 show slices of the velocity vectors at four elevations within the water column: 1,040 ft msl, 1,050 ft msl, 1,080 ft msl, and at the surface (i.e., 1,110 ft msl). The flow patterns at each depth are relatively similar throughout the water column. The water velocities within the concentrated flows from the I/O structures increase with depth.

The effect of adding the proposed I/O structure to the model is distinct; the area of high velocity along the east bank moved approximately 600 ft to the north and velocity peaks at approximately 2.5 fps. Recirculation patterns were reduced in size as the velocity flow from the proposed I/O structure forced more of the flow to the center of the channel. The peak magnitude of the velocity along the east bank was approximately equal to the velocities measured in the ARL physical model. The change in location of the peak velocities should not affect bank conditions/erosion assuming the geology of the east bank is consistent upstream (i.e., north) of the existing structure (i.e., predominantly bedrock).

Figure 18 through Figure 21 show model slices of velocity vectors and magnitudes through the two existing and two proposed I/O structure tunnels centerlines, respectively (note that these figures represent a cross-sectional view across the Whitewater River channel (i.e., a view from west to east looking downstream from the I/O structure). These slices show peak velocities on the east bank below 2.5 fps along tunnel centerlines.







Figure 14. Case 3 (generation - maximum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl



Figure 15. Case 3 (generation - maximum reservoir elevation) Velocity Vectors at Elevation 1,050 ft



Figure 16. Case 3 (generation - maximum reservoir elevation) Velocity Vectors at Elevation 1,080 ft



Figure 17. Case 3 (generation - maximum reservoir elevation) Velocity Vectors at Elevation 1,110 ft msl



Figure 18. Case 3 (generation - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 19. Case 3 (generation - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 20. Case 3 (generation - maximum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 21. Case 3 (generation - maximum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors

4.2.2 Case 4: Lake Jocassee Normal Minimum Reservoir Elevation 1,080 ft msl

Figure 22 shows the plan view of streamlines from the normal minimum reservoir elevation scenario (Case 4). Flow patterns are similar to the full reservoir configuration, with increased velocities throughout, which would be expected.

Figure 23 through Figure 25 shows velocity vector slices at elevations 1,040 ft, 1,050 ft, and at the surface (1,080 ft), respectively. The lower Lake Jocassee level increases the effect of the concentrated flow from the I/O structures. Surface velocities exceed 5.0 fps, while flow along the east bank peaks at approximately 3.5 fps in the same location as Case 3 (existing I/O centerline). East bank velocities within the water column reach 5.0 fps approximately 500 ft upstream (i.e., north) of the existing I/O structure centerline. Surface velocities along the entire east bank peak at approximately 3.5 fps. The peak magnitude of the velocity along the east bank was approximately equal to the velocities measured in the ARL physical model. The change in location of the peak velocities should not affect bank conditions/erosion assuming the geology of the east bank is consistent upstream (i.e., north) of the existing structure (i.e., predominantly bedrock).

Figure 26 and Figure 29 show slices of velocity vectors and magnitudes through the two existing and two proposed I/O structure tunnels' centerlines, respectively. As in Case 3, these slices show velocities on the east bank below 2.5 fps along tunnel centerlines.



Figure 22. Case 4 (generation - minimum reservoir elevation) Velocity Streamlines under Normal Minimum Reservoir Elevation



Figure 23. Case 4 (generation - minimum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl



Figure 24. Case 4 (generation - minimum reservoir elevation) Velocity Vectors at Elevation 1,050 ft msl



Figure 25. Case 4 (generation - minimum reservoir elevation) Velocity Vectors at Elevation 1,080 ft msl







Figure 27. Case 4 (generation - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 28. Case 4 (generation - minimum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors


Figure 29. Case 4 (generation - minimum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors

4.2.3 Case 5: Lake Jocassee Assumed Intermediate Reservoir Elevation 1,096 ft msl

Figure 30 shows the plan view of streamlines from the intermediate reservoir elevation scenario (Case 5). Flow patterns are similar to the full reservoir configuration, with increased velocities throughout, which would be expected.

Figure 31 through Figure 34 shows velocity vector slices at elevations 1,040 ft, 1,050 ft, 1,080 ft, and at the surface (1,096 ft), respectively. The lower Lake Jocassee level increases the effect of the concentrated flow from the I/O structures. Surface velocities exceed 5.0 fps, while flow along the east bank peaks at approximately 3.5 fps in the same location as Case 3 (existing I/O centerline). East bank velocities within the water column reach 5.0 fps approximately 500 ft upstream (north) of the existing I/O structure centerline. Surface velocities along the entire east bank peak at approximately 3.5 fps. The peak magnitude of the velocity along the east bank was approximately equal to the velocities measured in the ARL physical model. The change in location of the peak velocities should not affect bank conditions/erosion assuming the geology of the east bank is consistent upstream (i.e., north) of the existing structure (i.e., predominantly bedrock).

Figure 35 and Figure 37 show slices of velocity vectors and magnitudes through the two existing and two proposed I/O structure tunnels' centerlines, respectively. As in Case 3, these slices show velocities on the east bank below 2.5 fps along tunnel centerlines.



Figure 30. Case 5 (generation - intermediate reservoir elevation) Velocity Streamlines under Normal Minimum Reservoir Elevation



Figure 31. Case 5 (generation - intermediate reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl



Figure 32. Case 5 (generation - intermediate reservoir elevation) Velocity Vectors at Elevation 1,050 ft msl



Figure 33. Case 5 (generation - intermediate reservoir elevation) Velocity Vectors at Elevation 1,080 ft msl



Figure 34. Case 5 (generation – intermediate reservoir elevation) Velocity Vectors at Elevation 1,096 ft msl



Figure 35. Case 5 (generation - intermediate reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 36. Case 5 (generation - intermediate reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 37. Case 5 (generation - intermediate reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 38. Case 5 (generation - intermediate reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors

4.3 Proposed Configuration - Cases 6 through 8 (Pump Mode)

The proposed Bad Creek II I/O structure configuration was modeled for both reservoir elevations and assuming full pumping at both I/O structures (combined 32,720 cfs) to determine impacts to the channel and east bank of the Lake Jocassee Whitewater River cove and hydraulic approach to the proposed I/O structure.

4.3.1 Case 6: Lake Jocassee Normal Full Reservoir Elevation 1,110 ft msl

Results of the proposed configuration at normal full reservoir elevation are presented on Figure 39 through Figure 47. Figure 39 shows the plan view of the streamlines. Flow from the proposed I/O structure approaches from the east bank, while flow entering the existing I/O structure approaches from the west bank. Velocities increase upstream of the I/O structures but were lower than velocities in the generation simulations.

Figure 40 through Figure 43 show slices of the velocity vectors at four elevations within the water column: 1,040 ft msl, 1,050 ft msl, 1,080 ft msl, and at the surface (i.e., 1,110 ft msl). The flow patterns at each depth are relatively similar throughout the water column. The water velocities near the submerged weir were less than 2.0 fps.

Figure 44 through Figure 47 show model slices of velocity vectors and magnitudes through the two existing and two proposed I/O structure tunnels centerlines, respectively. These slices show velocities on the east bank below 2.5 fps along tunnel centerlines.







Figure 40. Case 6 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl











Figure 43. Case 6 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,110 ft msl



Figure 44. Case 6 (pumping - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 45. Case 6 (pumping - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 46. Case 6 (pumping - maximum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 47. Case 6 (pumping - maximum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors

4.3.2 Case 7: Lake Jocassee Normal Minimum Reservoir Elevation 1,080 ft msl

Figure 48 shows the plan view of streamlines from the normal minimum reservoir elevation scenario (Case 7). Flow patterns are similar to the full reservoir configuration, with increased velocities throughout, which would be expected.

Figure 49 through Figure 51 show velocity vector slices at elevations 1,040 ft, 1,050 ft, and at the surface, respectively. The lower Lake Jocassee level increases the effect of the concentrated flow from the I/O structures. Surface velocities approach 5.0 fps near the submerged weir while flow along the east bank was less than 2.0 fps.

Figure 52 and Figure 55 show slices of velocity vectors and magnitudes through the two existing and two proposed I/O structure tunnels' centerlines, respectively. As in Case 6, these slices show velocities on the east bank below 2.5 fps along tunnel centerlines.



Figure 48. Case 7 (pumping - minimum reservoir elevation) Velocity Streamlines under Normal Minimum Reservoir Elevation



Figure 49. Case 7 (pumping - minimum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl



Figure 50. Case 7 (pumping - minimum reservoir elevation) Velocity Vectors at Elevation 1,050 ft msl



Figure 51. Case 7 (pumping - minimum reservoir elevation) Velocity Vectors at Elevation 1,080 ft msl



Figure 52. Case 7 (pumping - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 53. Case 7 (pumping - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 54. Case 7 (pumping - minimum reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors





4.3.3 Case 8: Lake Jocassee Intermediate Reservoir Elevation 1,096 ft msl

Results of the proposed configuration at normal full reservoir elevation are presented on Figure 56 through Figure 64. Figure 56 shows the plan view of the streamlines. Flow from the proposed I/O structure approaches from the east bank, while flow entering the existing I/O structure approaches from the west bank. Velocities increase upstream of the I/O structures but are lower than velocities in the generation simulations.

Figure 57 through Figure 60 show slices of the velocity vectors at four elevations within the water column: 1,040 ft msl, 1,050 ft msl, 1,080 ft msl, and at the surface (i.e., 1,110 ft msl). The flow patterns at each depth are relatively similar throughout the water column. The water velocities near the submerged weir are less than 2.0 fps.

Figure 61 through Figure 63 show model slices of velocity vectors and magnitudes through the two existing and two proposed I/O structure tunnels centerlines, respectively. These slices show velocities on the east bank below 2.5 fps along tunnel centerlines.







Figure 57. Case 8 (pumping - intermediate reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl



Figure 58. Case 8 (pumping - intermediate reservoir elevation) Velocity Vectors at Elevation 1,050 ft



Figure 59. Case 8 (pumping - intermediate reservoir elevation) Velocity Vectors at Elevation 1,080 ft



Figure 60. Case 8 (pumping - intermediate reservoir elevation) Velocity Vectors at Elevation 1,096 ft msl


Figure 61. Case 8 (pumping - intermediate reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 62. Case 8 (pumping - intermediate reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 63. Case 8 (pumping - intermediate reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 64. Case 8 (pumping - intermediate reservoir elevation) Slices through Proposed I/O Structure Tunnel Centerlines - Velocity Vectors

4.4 Construction Configuration - Cases 9 through 12 Generation and Pump Modes

Additional simulations were performed to evaluate the hydraulic conditions after the placement of the rock spoil (i.e., construction configuration) near the existing submerged weir. The construction configuration was modeled for both reservoir elevations and assuming full generation and pumping at the existing structure I/O structures (19,760 cfs [generation] or 16,240 cfs [pumping]). The analysis was carried out to determine impacts near the submerged weir and the hydraulic approach to the existing I/O structure.

4.4.1 Case 9: Lake Jocassee Normal Full Reservoir Elevation 1,110 ft msl - Generation

Results of the construction configuration at normal full reservoir elevation are presented on Figure 65 through Figure 71. Figure 65 shows the plan view of the streamlines. Flow from the existing I/O structure creates multiple large, low velocity areas of recirculation as flows extend into the reservoir. Velocities increase upstream of submerged weir but were less than 2.0 fps.

Figure 66 through Figure 69 show slices of the velocity vectors at four elevations within the water column: 1,040 ft msl, 1,050 ft msl, 1,080 ft msl, and at the surface (i.e., 1,110 ft msl). The flow patterns at each depth are relatively similar throughout the water column. The water velocities near the submerged weir were less than 2.0 fps.

Figure 70 and Figure 71 show model slices of velocity vectors and magnitudes through the two existing I/O structure tunnels centerlines. These slices show velocities on the east bank below 1.5 fps along tunnel centerlines.







Figure 66. Case 9 (generating - maximum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl



Figure 67. Case 9 (generating - maximum reservoir elevation) Velocity Vectors at Elevation 1,050 ft



Figure 68. Case 9 (generating - maximum reservoir elevation) Velocity Vectors at Elevation 1,080 ft



Figure 69. Case 9 (generating - maximum reservoir elevation) Velocity Vectors at Elevation 1,110 ft msl



Figure 70. Case 9 (generating - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 71. Case 9 (generating - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors

4.4.2 Case 10: Lake Jocassee Normal Minimum Reservoir Elevation 1080 ft msl - Generation

Results of the construction configuration at normal minimum reservoir elevation are presented on Figure 72 through Figure 77. Figure 72 shows the plan view of the streamlines. Velocities are higher near the submerged weir due to the decreased depth.

Figure 73 through Figure 75 show slices of the velocity vectors at four elevations within the water column: 1,040 ft msl, 1,050 ft msl, and at the surface (i.e., 1,080 ft msl). The flow patterns at each depth are relatively similar throughout the water column. The water velocities near the submerged weir were less than 2.5 fps.

Figure 76 and Figure 77 show model slices of velocity vectors and magnitudes through the two existing I/O structure tunnels centerlines. These slices show velocities on the east bank below 2.5 fps along tunnel centerlines.







Figure 73. Case 10 (generating - minimum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl



Figure 74. Case 10 (generating - minimum reservoir elevation) Velocity Vectors at Elevation 1,050 ft



Figure 75. Case 10 (generating - minimum reservoir elevation) Velocity Vectors at Elevation 1,080 ft



Figure 76. Case 10 (generating - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 77. Case 10 (generating - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors

4.4.3 Case 11: Lake Jocassee Normal Full Reservoir Elevation 1,110 ft msl - Pumping

Results of the construction configuration and pumping at normal full reservoir elevation are presented on Figure 78 through Figure 84. Figure 78 shows the plan view of the streamlines. Velocities increase as flow approaches the existing I/O structure.

Figure 79 through Figure 82 show slices of the velocity vectors at four elevations within the water column: 1,040 ft msl, 1,050 ft msl, 1,080 ft msl, and at the surface (i.e., 1,110 ft msl). The flow patterns at each depth are relatively similar throughout the water column. The water velocities near the submerged weir were less than 1.5 fps.

Figure 83 and Figure 84 show model slices of velocity vectors and magnitudes through the two existing I/O structure tunnels centerlines. These slices show velocities on the east bank below 2.5 fps along tunnel centerlines.







Figure 79. Case 11 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl



Figure 80. Case 11 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,050 ft



Figure 81. Case 11 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,080 ft



Figure 82. Case 11 (pumping - maximum reservoir elevation) Velocity Vectors at Elevation 1,110 ft msl



Figure 83. Case 11 (pumping - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 84. Case 11 (pumping - maximum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors

4.4.4 Case 12: Lake Jocassee Normal Minimum Reservoir Elevation 1,080 ft msl - Pumping

Results of the construction configuration at normal full reservoir elevation are presented on Figure 85 through Figure 90. Figure 85 shows the plan view of the streamlines. Velocities increase upstream of the I/O structures but were lower than velocities in the generation simulations.

Figure 86 through Figure 87 show slices of the velocity vectors at four elevations within the water column: 1,040 ft msl, 1,050 ft msl, and at the surface (i.e., 1,080 ft msl). The flow patterns at each depth are relatively similar throughout the water column. The water velocities near the submerged weir were less than 3.5 fps.

Figure 89 and Figure 90 show model slices of velocity vectors and magnitudes through the two existing I/O structure tunnels centerlines. These slices show velocities on the east bank below 1.0 fps along tunnel centerlines.







Figure 86. Case 12 (pumping - minimum reservoir elevation) Velocity Vectors at Elevation 1,040 ft msl



Figure 87. Case 12 (pumping - minimum reservoir elevation) Velocity Vectors at Elevation 1,050 ft







Figure 89. Case 12 (pumping - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors



Figure 90. Case 12 (pumping - minimum reservoir elevation) Slices through Existing I/O Structure Tunnel Centerlines - Velocity Vectors

5 Conclusion

A lower reservoir CFD flow model was developed for the existing Bad Creek and proposed Bad Creek II and I/O structure configurations.

The CFD model was verified by comparing flow and velocity patterns from Cases 1 and 2 against the ARL 1986 physical model results (Larsen and White 1986), which utilized the original Bad Creek turbine flows. Flow patterns predicted by the CFD model existing configuration (16,000 cfs) reasonably replicated the physical model results and velocities at the east bank of the Whitewater River cove opposite of the I/O structures and along the I/O structure centerline for both cases.

The proposed Bad Creek II I/O structure was added to the model and six additional scenarios were run. Cases 3 through 5 provide results for each assumed Lake Jocassee water surface elevation. These cases increased the total flow generating flow from 16,000 cfs to 39,560 cfs assuming both I/O structures were discharging maximum flow and utilizing the uprated Bad Creek turbine flows. Cases 6 through 8 focused on the pumping operations at the three reservoir elevations.

During generation, velocity and flow patterns were analyzed throughout the water column and along the east bank opposite of the I/O structures. The proposed I/O structure had a distinct effect on both velocity flow and patterns, and this effect was more prominent at the lower reservoir elevation (Case 4). The concentrated flow from the proposed I/O structure reduced the size of recirculation patterns and directed flow from the existing I/O structure towards the center of the Whitewater River channel. This effect reduced the existing Bad Creek region of high velocity along the east bank but created a new region of high velocity approximately 600 ft upstream (i.e., north). Peak velocities along the east bank were less than 3.5 fps for Cases 3 through 5.

The pumping operations shows distinct flow paths for each I/O structure. Along the east bank, water flows north and enters the proposed I/O structure. Flow along the west bank enters the existing I/O structure. Increased velocities and non-direct flow were shown in the approach to the proposed I/O structure. The simulated flow patterns may lead to uneven loading of the tunnels and ineffective flow areas. The maximum velocity near the submerged weir was 3.5 fps (Case 12) shown during the minimum reservoir pumping operations.

The peak velocities for the proposed Bad Creek II I/O configuration along the east bank do not exceed the modeled velocities shown in the existing Bad Creek configuration at Lake Jocassee elevation 1,110 ft msl. The proposed Bad Creek II I/O configuration predicted minor increases to peak velocities along the east bank when compared to the existing Bad Creek modeled velocities. The location of the peak velocities is spatially closer to the proposed Bad Creek II I/O structure and similar in magnitude to the physical model simulation results (Larsen and White 1986).

The results of this preliminary study indicate that the additional generation flows resulting from Bad Creek II (in combination with the Bad Creek Station) do not appear to increase the potential for erosion along the east/opposite bank of the Whitewater River cove in Lake Jocassee, assuming the geology is consistent along the bank (i.e., predominantly bedrock). The modeled velocities were approximately equivalent to the physical model study velocities, which are representative of the existing conditions. To HDR's knowledge, flow from the existing configuration and operations have not resulted in erosion along the east bank and velocities are within the general range from the

proposed configuration. For a preliminary desktop evaluation regarding potential environmental impacts, please refer to the Feasibility Study Report, Volume 6 – Environmental Studies Report.

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