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October 17, 2008

**BROWN & MITCHELL, INC.**

521 34<sup>th</sup> Street  
Gulfport, MS 39507

**ATTENTION:** Mr. Steve Cook

**SUBJECT:** Report of Subsurface Investigation and Preliminary Geotechnical Evaluation  
Proposed S11 Tradition Wastewater Treatment Facility  
Biloxi, Mississippi  
SESI Project M08-557

Dear Mr. Cook:

**Southern Earth Sciences, Inc** has completed the subsurface exploration and preliminary engineering evaluation for the above referenced project. This report describes our field-testing techniques, includes data obtained during the investigation, and presents our preliminary soil related recommendations with regard to site preparation and support for the proposed structures.

**SITE DESCRIPTION**

The site is located near Biloxi, Mississippi, approximately eight (8) miles north of Interstate 10, one (1) mile south of Highway 605 and two (2) miles west of Highway 67. At the time of our investigation, limited clearing had been performed, removing the majority of small trees and underbrush. With exception to an existing steel frame structure located near the northwest corner of the site, the remainder of the site was wooded and did not appear to have been previously developed. The general topography of the site sloped northwestward toward Tiger Creek. According to the provided topographic survey, existing elevations across the site range approximately from elevation (EL) +70 to EL +100 (Mean Sea Level - MSL).

**PROJECT INFORMATION**

Based on the provided conceptual plans and profiles, it is our understanding the project will consist of the following major structures:

1. **Head Works Section** - Approximate 60' x 60' component containing numerous below grade tanks, a bar screen, grit chamber and associated influent channels and piping. Design high water level is planned to be around EL +94. Bottom of the tank basin is planned to be around EL +88, approximately 5 feet below the original ground surface. Bottom of the grit chamber is planned to be around EL +79, approximately 14 feet below the original ground surface.

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2. **Aeration Basin** - Approximate 165' x 110' structure with design high and low water levels of around EL +90 and EL +88, respectively. The basin bottom is planned to be around EL +75, approximately 18 feet below the original ground surface.
3. **Clarifiers** - Two (2) approximate 80' diameter clarifier tanks with a design water level of around EL +85. The clarifier bottoms will be around EL +70, approximately 15 feet below the original ground surface.
4. **Chlorine Disinfection/De-chlorination Basin** - Approximate 40' x 45' structure with design high and low water levels of around EL +78 and EL +76, respectively. The basin bottom is planned to be around EL +68, approximately 9 feet below the original ground surface.
5. **Chlorine Storage Structure** - Approximate 15' x 45' steel or masonry structure to be supported within a few feet of existing grade utilizing a conventional shallow footing/concrete slab on grade foundation system.
6. **Post Aeration Basin** - Approximate 25' x 40' structure with design high and low water levels of around EL +76 and EL +73, respectively. The basin bottom is planned to be around EL +70, approximately 10 feet below the original ground surface.
7. **Maintenance Building** - Approximate 35' x 60' single-story steel or masonry structure to be supported within a few feet of existing grade utilizing a conventional shallow footing/concrete slab on grade foundation system.
8. **Administration Building** - Approximate 40' x 30' single-story structure of steel or masonry construction to be supported within a few feet of existing grade utilizing a conventional shallow footing/concrete slab on grade foundation system.
9. **Miscellaneous Structures/Components** - Aerobic Digester #2, Sludge Dewatering - no detailed structural loading or grading information was available for these structures at the writing of this report. We have assumed that the water/sludge storage elevations will not exceed a couple feet above the original ground surface grade and that foundation elements supporting these structures will be bearing within a few feet of original grade.
10. **Aggregate Surfacing** – Project roadways will be aggregate surfaced.

### **FIELD INVESTIGATION**

A total of ten (10) Cone Penetrometer Test (CPT) soundings, four (4) conventional soil borings with Standard Penetration Tests (SPTs) and thirteen (13) manual auger borings were performed within the proposed structure and roadway areas. Locations of the soil borings and CPT soundings were determined in the field by Brown and Mitchell survey crews. Locations of the auger borings within the roadways were determined in the field by SESI personnel. A Test Location Plan denoting the approximate location of the borings and soundings is attached in **Appendix A**.

Cone Penetrometer Test soundings were advanced to depths ranging from approximately 20 to 100 feet below the existing ground surface using a track-mounted Hogentogler 20-ton electronic CPT rig. Cone Penetrometer Testing was conducted in accordance with ASTM D-5778. CPT Log sheets graphically showing the cone tip resistance, friction, equivalent N-value and interpreted soil type at each sounding location are included in **Appendix C**. Soil classifications were interpreted from methods recommended by Robertson and Campanella. Correlations between Cone Resistance values and Standard Penetration testing "N" values were performed according to the methods developed by Robertson, Campanella and Wightman. The soil types and stratigraphy shown on the CPT Log sheets are based upon material parameters measured and evaluated as the cone is advanced.

SPT soil borings were advanced to depths ranging from 25 to 75 feet using both flight auger and rotary wash drilling techniques and a track mounted BK-51 drill rig. Soil sampling and penetration testing were performed in accordance with ASTM Specification D 1586. At regular intervals during the process, drill rods were removed and soil samples were obtained with a standard 1.4-inch I.D., 2-inch O.D. split tube sampler. Soil boring logs, graphically showing the soil descriptions, boring depths, and penetration resistances are included in **Appendix B**. Representative portions of each soil sample obtained during the investigation were transported to our laboratory where they were examined by an engineer and classified in accordance with the Unified Soil Classification System.

**Undisturbed Sampling:** Split tube samples obtained during penetration testing are suitable for visual examination and classification tests, but are not sufficiently intact for quantitative laboratory testing. During the drilling process, undisturbed samples were obtained by forcing a section of a 3-inch O.D., 16-gauge, steel tubing into the soil at the desired sampling levels. This sampling procedure is described by ASTM Specification D 1587. The tubes, together with the encased soil, were carefully removed from the ground, made airtight and transported to the laboratory. The locations and depths of the undisturbed sample are shown on the appropriate Soil Boring Log in **Appendix B**.

### **LABORATORY INVESTIGATION**

Laboratory work consisted of physical examination and general strength and classification testing of samples obtained during the soil test boring operation. Evaluations of these samples, in conjunction with laboratory results, have been used to estimate soil characteristics. The results of the laboratory tests are presented on the appropriate Soil Boring Log, as well as on the Laboratory Test Results Sheet in **Appendix C**.

**Moisture Content Determinations:** Twenty-seven (27) samples were selected for water content determination. In the laboratory, each sample was weighed, dried and its moisture content computed in accordance with ASTM D 2216.

**No. 200 Washes:** Twenty-seven (27) No. 200 washes were performed to determine the percent sand and relative percentage of silt and clay of the selected samples. These tests were performed according to ASTM D 1140.

**Soil Plasticity Tests (Atterberg Limits Tests):** Thirteen (13) representative samples were selected for Atterberg Limits testing to determine the plasticity characteristics of the soil. The Plastic Index (PI) is representative of this characteristic and is bracketed by the Liquid Limit (LL) and the Plastic Limit (PL). The LL is the moisture content at which the soil will flow as a heavy viscous fluid and is determined in accordance with ASTM D 4318.

**Consolidation Testing:** A single section from an undisturbed sample was extruded from its sampling tube for consolidation testing. Sections were trimmed into a disc 2.5 inches in diameter, placed in a steel ring 0.75 inches thick and sandwiched between porous stones. Specimens were then subjected to incrementally increasing vertical loads and the resulting deformations measured with a micrometer dial gauge.

**Unconfined Compression Tests:** A single section from an undisturbed sample was extruded from its sampling tube for unconfined compressive strength determination. The sample was trimmed to a diameter of 1.4-inches then placed in the testing device. Incrementally increasing vertical loads were applied until the sample exhibited shear failure.

## **SUBSURFACE CONDITIONS**

Subsurface conditions encountered across the site are variable with loose to medium density silty and clayey sands within the southern portion of the project area and medium to stiff silty and sandy clay with intermediate sand substrata within the northern portion of the site. Detailed descriptions of soils encountered at each test location are shown on the appropriate CPT Sounding Log or Soil Boring Log included in **Appendix B**.

At the time of our investigation, measured ground water depths ranged from approximately 5 to 19 feet below the existing ground surface. Upon removal of the CPT rods, collapse of soundings CPT-2 and CPT-6 at shallower depths indicates that perched groundwater conditions may be encountered within a couple feet of the existing ground surface at these locations. Variance in measured groundwater depths can be attributed to changes in elevation and the presence of low permeability cohesive materials creating perched water conditions. All reference to depth is made with respect to the existing ground surface at the time the fieldwork was performed. Fluctuations in the level of groundwater will occur due to variances in rainfall, elevation, drainage, types of soil present and other factors not evident at the time measurements were made. Design drawings, specifications and construction planning should accommodate such possibilities of variation. Groundwater levels should be verified prior to construction.

## **SEISMIC CONSIDERATIONS**

### ***Seismic Site Class***

Correlation of subsurface conditions encountered with Table 1613.5.2 of the 2006 Edition of the International Building Code (IBC) indicates that this site would best be categorized as **Site Class E**.

### ***Site Coefficients***

In accordance with Section 1613.5 of the IBC, design parameters were calculated for an earthquake having a 2% probability of exceedence in a 50-year period. The results of these calculations, expressed as a percent of the gravitational force (g) are as follows:

#### ***Five-Percent Damped Design Spectral Response Acceleration Parameters***

Short Periods (0.2 sec)	$S_{DS} = 2.05\%g$
1-Second Periods	$S_{D1} = 12.5\%g$

## **FOUNDATION CONSIDERATIONS**

Our preliminary evaluation of foundation conditions has been based on the project information previously described in this report and subsurface data obtained during the investigation. In evaluating the soil test borings and CPT soundings, we have used empirical correlations previously established between foundation stability and the characteristics for soils similar to those encountered at the referenced site.

In general, beneath a layer of topsoil and surficial organics, soils encountered within the investigated depth consisted of firm silty and clayey sand and medium to firm silty and sandy clay. With proper site preparation and construction practice, these reasonably firm insitu materials will be suitable for support of the proposed buildings, basins and tanks at the desired elevations utilizing conventional shallow foundations. Construction of the major tank and basin structures at the elevations indicated on the provided hydraulic profile will result in significant excavation below existing grade and consequent "unloading" of the supporting insitu soils near foundation bearing elevation. Resulting settlement of below grade tank and basin components are expected to be minimal.

While the insitu soils present at this site are generally suitable for foundation support in their present condition, it should be considered that measured groundwater depths at the time of our investigation were well above the proposed bottom elevations of several of the major tank and basin structures. If groundwater conditions at the time of construction are consistent with those encountered at the time of our investigation, extensive dewatering/groundwater diversion, mitigation of saturated soil conditions and possible shoring of deep excavations will be required to successfully construct the proposed tank and basin structures at the planned elevations.

We caution that once disturbed, the cohesive materials present across the majority of the site within depths to be influenced by construction will be moisture sensitive. Weather/moisture related time delays and construction difficulties associated with poorly drained cohesive soils and perched water conditions should be expected. To promote drainage and provide separation from the onsite cohesive materials during construction, placement of at least 12 inches of imported granular fill material is recommended beneath all foundation elements. Site preparation and foundation recommendations are outlined below.

#### **Head Works Section, Aeration Basin, Clarifiers, Post Aeration and Chlorination Basins**

Based on our experience with similar projects, we have assumed that these below grade structures will be comprised of approximate 12" thick cast-in-place concrete walls and 18" to 24" inch thick foundation slabs. Design tank bottom (foundation bearing) elevations range from approximately 5 to 18 feet below existing site grade. Design high water levels are planned to range from approximately 1 foot above original grade to approximately 5 feet below existing grade. Measured groundwater levels range from approximately 5 feet below foundation bearing elevation within the Head Works section of the facility to approximately 15 feet above foundation bearing elevation within the western and central portion of the Aeration Basin. Detailed information for each of the referenced components is presented in the project information section of this report. Net loading of supporting soils beneath these structures (resulting from removal of the insitu soils and the addition of the combined weight of water and structural elements) are estimated to range approximately from -100 to -600 psf, depending on original site grade, final foundation elevation and design water levels. Foundation and site preparation suggestions are outlined below.

The initial step in site preparation for each of these structures should be the excavation of all materials to a depth of at least 1 foot below foundation bearing elevation, maintaining excavation side slopes at approximately 2.5 to 1 (horizontal to vertical) or flatter. In areas where excavations are expected to extend more than a few feet below the measured groundwater level, shoring may be necessary during construction to prevent unstable side slopes. The full depth excavation should extend laterally to at least three (3) feet beyond the perimeter of the foundation area or to a distance sufficient to construct a temporary, shallow perimeter sump. The sump should consist of a narrow sand or gravel filled trench constructed at least 2 feet from the edge of the foundation. To accumulate groundwater and facilitate its removal during construction, the

bottom of the sump should remain approximately 1 foot below foundation bearing elevation. In excavations where groundwater is not present, sump construction will not be necessary.

Upon establishment of an effective drainage system, the excavation bottoms should be leveled as much as practical, removing any loose or disturbed soils deposited during the excavation process. To promote drainage and provide a stable working platform at foundation bearing elevation, we recommend placement of at least one (1) foot of manually compacted open graded aggregate similar to ASTM C-33, Size No. 57 or 67.

Once foundations have been constructed, fill soils placed adjacent to the vertical tank walls should consist of "clean" sand with less than about 15% of the soil's particles (by weight) passing the No. 200 mesh sieve. This material should be compacted in 8-inch loose lifts to at least 95 percent of the soils Modified Proctor maximum dry density as determined by ASTM D 1557, Method "A". In place density tests should be made at frequent intervals to measure the effectiveness of the compaction operations. Care should be taken to avoid damage to the adjacent tank structure during compaction efforts.

Settlement of foundation elements constructed according to the above recommendations and supporting the assumed loads at the planned elevations are expected to be within typically accepted limits. Again, it should be considered that no detailed structural loading information was available at the writing of this report. We will be available to perform a detailed settlement evaluation once actual structural loads are developed.

### **Chlorine Storage, Maintenance and Administration Buildings**

As indicated on the provided conceptual drawings, three individual, slab-on-grade structures are planned for the facility. The combined area of these single story, steel or masonry structures is approximately 4,000 ft<sup>2</sup>. Although no grading information was available at the writing of this report, Finished Floor Elevation (FFE) of each of the structures is assumed to be within a few feet of existing grade. For purposes of this report, maximum column, wall and floor loads have been assumed to be on the order of approximately 25 kips, 4 kips/lf and 200 psf, respectively.

Based on our experience with similar site conditions, effective drainage, including ditching and positive grading, should be established during the initial stages of development and modified as necessary during construction. Once drainage is established, the initial step in site preparation should be the complete removal of all topsoil and surficial organics (to include complete tree root systems) extending to at least 5 feet outside the construction area. **Upon removal of all topsoil and organic material, excavations should extend to approximately 2 feet below original grade or to 1 foot below foundation bearing elevation, whichever is deeper. Excavations should be continued as necessary to ensure the complete removal of all excessively soft, loose or otherwise unsuitable material. Although actual excavation depths will be dependent on final grades, foundation bearing elevations and soil conditions at the time of construction, excavations across the majority of the site are anticipated to average**

**between 1 and 2 feet below the existing ground surface.** All cohesive and organic containing materials excavated from this site should be wasted and not reused as structural fill. With proper handling and moisture conditioning, excavated sandy materials may be reused as structural. As isolated areas of weak soils will likely be encountered during a grading project of this magnitude, provisions should be made to account for additional undercut quantities. Since the lateral and vertical extent will vary, we recommend the entire excavation and backfilling operation be observed by an experienced soils technician under the direct supervision of the registered project geotechnical engineer of record.

Upon completion of the excavations as outlined above, exposed surfaces should be proof rolled with a large static roller to seat the disturbed soils and to identify areas of poor soils. Care should be taken to ensure that any soft or excessively yielding areas are undercut to firmer materials and backfilled with well-compacted fill.

Fill soils placed to achieve finished grade should be of a sandy nature with less than about 30 percent of the soil particles (by weight) passing the No. 200 mesh sieve and should have a liquid limit of less than 25. Fill soils should be compacted in 8-inch loose lifts to at least 95 percent of the soils Modified Proctor maximum dry density as determined by ASTM D 1557, Method "A". In place density tests should be made at frequent intervals to measure the effectiveness of the compaction operations.

Shallow foundation elements should be placed at a minimum depth of 18-inches and may be designed for an allowable soil bearing pressure of up to 2000 psf. Minimum footing widths of 18 and 24 inches for strip and isolated (column) footings, respectively, should be observed. Additional undercutting below footings may be required depending on grades and soil conditions at the time of construction. The bottom of all footing excavations should be observed by an experienced soil technician and compacted to the requirements as previously described.

Settlements of properly constructed foundation elements supporting the assumed loads are estimated to be less than 1 inch. Significant differential settlement is not anticipated. Once actual loading and grading information is developed, we will be available to perform a detailed settlement evaluation.

#### **Miscellaneous Structures/Components - Aerobic Digester #2 and Sludge Dewatering**

No detailed structural loading or grading information was available for these structures at the writing of this report. Based on our assumption that the water/sludge storage elevations will not exceed a couple feet above the original ground surface grade and that foundation elements supporting these structures will be bearing within a few feet of original grade, the site preparation and foundation recommendations outlined above in the Chlorine Storage, Maintenance and Administration Building section will be applicable for these structures. At your request, once construction plans and detailed loading information is developed, we will be

available to provide specific foundation and site preparation recommendations for each of these structures.

### **PROJECT ROADWAYS**

Auger borings made in the locations of the plant roadways and entrance road indicated surface soils to be mostly silty and clayey sands which will support aggregate surfacing. Isolated areas of poor soils could be encountered and should be planned for. These would most likely be in the areas of the very loose sand deposits which have created the "sand traps" on the entrance road and may be difficult to improve. Once cleared of surface organics, roadways should be cut and filled to final subgrade elevation and compacted to 100 percent of the soils standard proctor maximum dry density prior to surfacing. Project roadways should be graded and designed for ditches to intercept surface water flow and not allow water to stand in the roadbed. No equipment details or traffic loading information was available at the writing of this report but 7 inches of aggregate surfacing would be considered typical. Local preference of crushed limestone, gravel or crushed concrete meeting 825, 610 or similar grading would be acceptable for surfacing. We will refine thickness recommendations once loadings are known. To increase the service life of the roadways and reduce maintenance, you may consider utilizing a geotextile separation fabric similar to MIRIFI 140 N at the soil/aggregate interface.

### **CONSTRUCTION NOTES**

#### ***Groundwater***

It should be emphasized that groundwater will be encountered during excavations at this site. Considerations should be made to compensate for additional costs associated with performing site work and construction operations below or in close proximity to the water table. Dewatering and potential shoring of deep excavations should be anticipated.

#### ***Compensation for Buoyant (Uplift) Forces***

If it is anticipated that the tanks/basins may be emptied during the service life of the facility, design measures should be taken (i.e. additional structural reinforcement or hydrostatic pressure relief valves) to resist buoyant (uplift) forces that would be generated in areas where the tank bottom elevation is below the static groundwater table.

#### ***Moisture Control***

Again, we caution that the cohesive soils at this site will be adversely affected by moisture. Moisture control of both the in-place natural soils and fill materials will be critical and will likely drive the project schedule. We recommend that you plan your construction activities such that these soils are exposed for the least possible amount of time during construction operations. Preparation of the subgrade in short sections may be practical, since inclement weather cannot be predicted. During periods of wet weather, use of rubber-tired equipment within the building and pavement areas should be minimized, as the shearing action of the tires will have a softening effect on clayey soils at shallow depths. Additional undercutting of natural cohesive soils

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exposed to rainfall may be required if adequate precautions are not taken by the contractor. It should be considered that additional imported fill or stone/gravel might be necessary near finished grade for on-site construction traverse.

**GENERAL COMMENTS**

While the soil borings and CPT soundings are representative of subsurface conditions at their respective locations and vertical reaches, local variations characteristic of the subsurface materials of the region are anticipated and may be encountered. The delineation between soil types shown on the logs is approximate and the description represents our interpretation of subsurface conditions at the designated boring location and on the particular date tested.

As the project geotechnical engineer of record that developed the foundation design recommendations, please be aware that we cannot accept responsibility for the performance of the foundation system if we are not afforded the opportunity to confirm that our recommendations have been followed. Accordingly, we recommend that Southern Earth Sciences, Inc. be retained on this project to perform observation and field-testing services during the construction phase of the foundation system.

Professional judgments on design alternatives and criteria are presented in this report. These are based partly on our evaluations of technical information gathered, partly on our understanding of the characteristics of the project being planned, and partly on our general experience with subsurface conditions in the area. We do not guarantee performance of the project in any respect, only that our engineering works and judgments rendered meet the standard of care of our profession.

This report is exclusively for the use and benefit of the addressee(s) identified on the first page of this report and is not for the use or benefit of, nor may it be relied upon by any other person or entity. The contents of this report may not be quoted in whole or in part or distributed to any person or entity other than the addressee(s) hereof without, in each case, the advance written consent of the undersigned.

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We appreciate the opportunity to serve you on this project. If you have any questions or if we may be of further assistance, please call at your convenience.

Very truly yours,

**SOUTHERN EARTH SCIENCES, INC.**



Matt Coaker  
Staff Engineer



Lewis Copeland, Jr., P.E.  
Registered, Mississippi 13312

MC/LCjr/bb

Attachments