

March 17, 2009

W.G. Yates & Sons Construction  
115 Main Street  
Biloxi, Mississippi 39530

Attn: Mr. Cam Roberds

Re: Supplemental Geotechnical Engineering Recommendations  
Proposed Ancillary Structures  
at the New Armed Forces Retirement Home (AFRH)  
U. S. Highway 90  
Gulfport, Mississippi  
PSI File Number 254-95030

Dear Mr. Roberds:

Professional Service Industries, Inc. (PSI) is pleased to present additional geotechnical engineering recommendations for the ancillary structures at the above referenced project site. PSI previously performed a subsurface exploration at the referenced project site and issued a geotechnical engineering report for the above referenced project (PSI Report No. 254-75059-1, dated July 3, 2007). That report contained general recommendations for deep foundation system for a multiple-story building as well as shallow foundation system consisting of isolated spread footings to support lightly loaded structures.

Based on the recent information provided by Mr. Howard Rice (Project Executive of W. G. Yates and Sons Construction) and Mr. Daryl Artz (A.I.A. of URS), we understand that current plan includes construction of various structures such as Fuel storage tanks, water storage tank for fire suppression, propane tank, and a generator platform. Therefore, PSI has been asked to provide supplemental recommendations which were not covered under the original scope of services.

The following Table presents the type and size of structure that will be constructed at various locations across the site along with their anticipated service loads:

<b>Structure Type</b>	<b>Capacity</b>	<b>Size</b>	<b>Structural Loads</b>
Fire Water Tank	65,000 gallons	Dia. 26 ft Height 18 ft	Tank+water=738 kips Buoyancy Net Uplift = 148 kips
Fuel Oil Tanks	25,000 gallons	Dia. 10 ft Length 47 ft	Tank+fuel+conc. pier=274 kips Buoyancy Net Uplift= 176 kips
Propane Tank	9,600 gallons	Dia. 9.25 ft Length 40 ft	Tank+propane+conc. pier=92 kips Buoyancy Net Uplift= 100 kips
Generator Elevated Platform	--	20 ft by 20 ft	Interior Concrete Column= 124 kips Interior Steel Column= 74 kips

Detailed grading information was not available at the time this report was prepared. However, it is assumed that about two (2) to three (3) feet of compacted structural fill will be needed to achieve the design grades. Considering the subsurface soil conditions and the magnitude of the structural loads, the proposed fire water tank may be supported on a ring-wall foundation system. The fuel oil tanks and propane tank and a guard booth can be supported on isolated spread footing or mat foundation, provided the site preparation recommendations are followed.

Details related to site preparation, bearing capacity, settlement, and other construction considerations are included in subsequent sections of the report. Our recommendations are based on the subsurface information obtained from the previously drilled borings.

**Ring-Wall Foundation**

Based on the field data and laboratory test results, the tanks can be supported on a ring-wall foundation bearing in the compacted structural fill or natural soils. Tank foundation systems bearing at least three (3) feet below finished grade may be sized to support a maximum net allowable bearing pressure of 2,500 psf. This allowable bearing pressure will have a factor of safety of at least three (3) with respect to the ultimate bearing capacity of the soils.

Although the near-surface soils encountered at the tank location are generally fair relative to bearing quality, the near surface loose sands as well as occasional layers of organic silts will experience some settlement that is induced by the tank structural loads. It was assumed that sandy and silty layers will undergo immediate, elastic settlement in response to additional loading (This elastic settlement is expected to occur during construction). However, the clay layers encountered at depths of about 27 to 32 feet will undergo consolidation settlement. Long-term consolidation settlement within compressible (clay) layers was calculated using classical (Terzaghi) one-dimensional consolidation theory and the Bousinnesq solution for distributing stresses beneath footings. A settlement analysis was performed to estimate the long term and short term settlements the tank foundation will experience during, and post-construction. Based

on our analysis, we estimate that the tank will experience a total settlement on the order of one (1) inch at the center and about three-quarter ( $\frac{3}{4}$ ) inch at the circumference. Furthermore, it is anticipated that approximately 75 percent of the total settlement at the center, about three-quarter ( $\frac{3}{4}$ ) inch which primarily consists of immediate or elastic settlement, could occur during the primary-staged load testing of the tank.

The foundation for the proposed tank must consist of a reinforced concrete ring-wall and compacted sand pad foundation system. Under such a ring-wall foundation system, the water load will be supported on a compacted sand-leveling pad surrounded by a reinforced concrete ring-wall which will support the weight of the tank shell and confine the sand pad.

A minimum footing width of twenty-four (24) inches is recommended for the ring-wall foundation. The footing must be steel-reinforced to resist the hoop stresses imposed by the water load bearing on the sand fill. We recommend using at least a twelve (12) inch thick sand pad with a minimum surface slope of 1 inch per 10 feet. The sand pad should consist of clean sand with no more than ten (10) percent fines passing the No.200 sieve. Furthermore, the sand must be underlain by a minimum of twelve (12) inches of compacted low plasticity structural fill.

The ring-wall excavation must be observed by the geotechnical engineer prior to steel or concrete placement to verify the foundation materials are not loosened or otherwise disturbed during the excavation process or impacted by weather conditions. Soft or loose soils encountered in the foundation area should be removed and replaced with compacted structural fill. The sand pad and underlying structural fill should be placed in loose lifts of no more than eight (8) inches, and compacted in accordance with the compaction criteria presented in the "Site Preparation" section of the report.

A moisture barrier must be placed beneath the tank bottom and around the sand pad to control corrosion. This may consist of either fiberglass impregnated asphaltic tank padding or oiled sand. A four (4) to six (6) inch thick pad of oiled sand (or similar barrier material) will be adequate for this purpose. This oiled sand pad should be prepared by mixing in place medium to fine sand with road oil or cut-back asphalt in a mechanical mixer or the sand may be treated in-place using proper equipment and methods.

The hydrostatic uplift pressure could be resisted by the weight of the tank and fluid, the backfill material that will be placed on the base of the ring-wall beyond the perimeter of the tank shell and the weight of the foundation. The concrete weight for the base can be assumed to be 150 pcf and the backfill soil can be assumed to weigh 115 pcf.

### **Stage Loading**

Stage loading of the proposed tank is recommended during hydro-testing to avoid sudden shock loading and to induce much of the anticipated elastic settlement and to thereby reduce post-construction consolidation settlement.

It is recommended that for stage loading, the tank be loaded to 1/3 of the working load (which results in about six (6) feet of water being placed initially in the Fire Water Tank). This load should be maintained for approximately 3 days or until the settlement has diminished to a small amount (approximately 1/8 inch per 24 hour period). Following this loading increment and assuming no unusual occurrences, the load can be increased in increments to the safe unit load or full height of the water in the tank. The unit weight of water is considered to be 62.4 pcf. The time period for each load increment should be about 3 days (minimum). The tank settlement must be monitored after placing each load increment to verify that the tank settlement is dissipating with each load increment and the tank is stable prior to placement in service.

### **Shallow Foundation Recommendations**

Foundations for lightly loaded structures can be supported on conventional spread footings. Spread footings should be founded a minimum of 24 inches below the finish grade and can be designed for an allowable bearing pressures of 2,500 psf provided they bear in compacted sandy subgrade soils or structural fill. The allowable bearing capacity can be increased by 1/3 for transient loads. Minimum dimensions of 24 inches for spread footings should be used for design to minimize the possibility of a local bearing failure.

The uplift resistance of shallow spread footings formed in open excavations should be limited to the weight of the foundation concrete and the soil above it. For preliminary design purposes, the uplift resistance can be computed by using a total unit weight of 115 pcf for the structural fill placed and compacted above the footing and a unit weight of 150 pcf for the concrete. Concrete reinforcing steel should be properly sized to resist uplift forces. We recommend that a factor of safety of at least 1.5 be used when determining the allowable uplift resistance of spread footings.

Soil resistance to horizontal forces is developed by lateral earth pressures acting on the face of the footing and by friction or adhesion on the footing base. We recommend that the ultimate passive pressure be computed for spread footings below grade using the following equation:

$$P_p = 350 H \text{ (Sand)}$$

Where  $P_p$  is the lateral soil resistance in psf (pounds per square foot) and H is the depth in feet. The top foot of passive resistance at foundations should be neglected unless the ground surface around the footing is covered by concrete or pavement.

The resistance to sliding of spread footing bearing in structural fill or compacted subgrade can be computed by multiplying the footing base contact area by a sliding friction factor of 0.35. Spread footings should also be sized to resist overturning due to moment forces. Concrete reinforcing steel should be properly sized to resist horizontal and moment forces.

### **Mat Foundation**

As an alternative, mat foundation bearing in the structural fill or natural soils can be utilized for support of the proposed structures. The thickness of the mat and the bearing depth should be determined by the structural engineer to resist uplift and overturning loads. The proposed mat could be designed for an allowable bearing capacity of 2,500 psf. The recommended allowable bearing capacity includes a factor of safety of three (3) against bearing failure. A short-term subgrade modulus (k) value of 125 pci may be used.

### **Site Preparation**

Site preparation is expected to include, but not be limited to, the stripping and removal of any topsoil, vegetations, organics, and any other deleterious material from the tank area and extending a minimum of five (5) feet beyond the outside perimeter of the ringwall foundation. After stripping to a minimum depth of about eight (8) inches, the exposed subgrade in the tank area should be proofrolled with a smooth steel drum roller weighing at least 20 tons. Soils, which are observed to rut or deflect excessively under the moving load should be undercut and replaced with properly compacted fill. The amount of undercutting will primarily depend on the site conditions at the time of construction. The proofrolling and undercutting activities should be witnessed by a representative of the geotechnical engineer and should be performed during a period of dry weather.

If fill is needed, it should be placed in relatively uniform horizontal lifts and should be compacted to at least 95 percent of the Standard Proctor maximum dry density as determined by ASTM Designation D698. The structural fill could consist of locally available clayey or silty sand with a maximum liquid limit of 40 percent and a maximum plasticity index of 18. The fill should be placed in maximum lifts of eight (8) inches of loose material and should be compacted within the range of  $\pm 3$  percent of the optimum moisture content. If water must be added, it should be uniformly applied and thoroughly mixed into the soil by disking or scarifying. Each lift of compacted structural fill should be tested by a representative of the geotechnical engineer prior to the placement of subsequent lifts.

### **Dynamic Soil Properties**

We understand that a generator supported on an elevated platform will be constructed at the project site. The dynamic shear modulus (G's), Poisson's ratio ( $\nu$ ), and mass density ( $\gamma$ ) are soil properties that are of interest for dynamic analysis of foundations.

The actual value of dynamic shear modulus depends upon the amplitude of dynamic strain, effective stress, void ratio, frequency of vibrations, degree of saturation of soil, and grain size characteristics and structure of the soil. Based on the soil information along with standard published correlations, the recommended dynamic soil parameters are presented herein. Actual values of shear modulus (G's) can be determined by performing crosshole field test or resonant

column test in the lab. The recommended soil dynamic soil parameters are as follows:

APPROX. DEPTH (FT)	SHEAR MODULUS (ksf)	MATERIAL DAMPING (%)	MASS DENSITY (slugs)	POISSON'S RATIO
0 to 8	720	3.0	3.7	0.3 - 0.4
8 to 12	720	3.0	3.2	0.3 - 0.4
12 to 27	1500	3.0	3.7	0.3 - 0.4
27 to 47	1500	3.0	3.4	0.35 - 0.45
47 to 120	1500	3.0	3.7	0.3 - 0.4


Reference: Design of Structures and Foundations for Vibratory Machines: Mr. Suresh Arya, Dr. Michael O'Neill, and Mr. George Pincus

### Dewatering

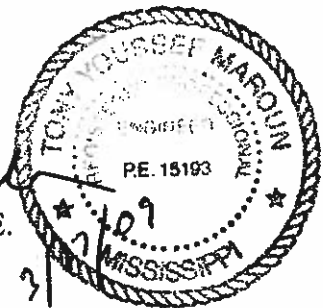
Delayed groundwater was measured at depths of 2.5 to six (6) feet below the existing ground surface after 24 hours of completion of the drilling. The groundwater level presented in this report is the level that was encountered at the time of our field activities and may not have become fully static at the time of measurement. However, groundwater level at this site may vary due to recent rainfall or weather conditions. The methods, means and sequence of dewatering, if required, should be the responsibility of the general contractor who must be experienced in this type of construction. The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom.

If you should have any questions regarding these supplemental recommendations, please do not hesitate to call.

Respectfully submitted,  
PROFESSIONAL SERVICE INDUSTRIES, INC.

  
Rupesh R. Kadam, P.E.  
Project Manager  
Geotechnical Services

  
Tony Y. Maroun, P.E.  
Vice President



Reviewed by: Mark J. Carlson, P.E.  
Chief Engineer