# REPORT OF SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING ANALYSIS
# P1267 MESS HALL AND P1317 BEQS
# MCB CAMP LEJEUNE, NORTH CAROLINA

**PREPARED FOR:**

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**VIRGINIA BEACH, VIRGINIA 23452**

**ECS CAROLINAS, LLP PROJECT NO.: 22.15789**

**JUNE 7, 2010**

June 7, 2010

Mr. Walter Moore, P.E.
R. Kenneth Weeks Engineers, LLC
272 Bendix Road
Suite 260
Virginia Beach, Virginia 23452

Re: Report of Subsurface Exploration and Geotechnical Engineering Evaluation
P1267 Mess Hall and P1317 BEQs
MCB Camp Lejeune, North Carolina

ECS Project No.: 22.15789

Dear Mr. Moore:

As authorized by your acceptance of our proposal number 22.13559R, ECS Carolinas, LLP has completed a subsurface exploration for the subject project. This report presents the results of the field exploration and engineering analysis, along with our recommendations for design of geotechnical related items.

We appreciate the opportunity to be of service to you during the design phase of this project and look forward to our continued involvement during the construction phase. If you have any questions concerning the information and recommendations presented in this report, please contact us at (910) 686-9114 for further assistance.

Respectfully submitted,

**ECS CAROLINAS, LLP**

Winslow E. Goins, P.E.
Project Engineer
North Carolina License No. 033751

Walid M. Sobh, P.E.
Principal Engineer
North Carolina License No. 022983

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**JUNE 7, 2010**

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## 1.0 EXECUTIVE SUMMARY

This report contains the results of our subsurface exploration and geotechnical engineering analysis for the P1267 Mess Hall and P1317 BEQs project located off of Sneads Ferry Road in MCB Camp Lejeune, North Carolina. At the time of our field exploration, the site was slightly wooded. The site was relatively level.

ECS understands that the project consists of 9,500 linear feet of roadway widening along Sneads Ferry Road from Louis Road to McHugh Boulevard, an approximately 3 acre, 40 POV parking lot near building SH50, and a Mess Hall building and two BEQ structures adjacent to the P1017/P1047 BEQ project. Project specific information including structural loads information was not available at the time of this report.

**Sneads Ferry Road**: Approximately zero to six inches of organic topsoil was reported by the drillers at the borings locations. Beneath the surface to a depth of approximately 10 feet, the test borings typically encountered intermittent layers of very loose to medium dense silty, clayey, slightly clayey and clean sands (SM, SC, SP-SC, SP) and very soft to stiff sandy clays (CL).

**Mess Hall:** No appreciable organic topsoil was reported by the drillers at the borings locations. Beneath the surface to a depth of approximately 60 feet, the test borings typically encountered intermittent layers of very loose to dense silty, clayey, slightly silty and clean sands (SM, SC, SP-SM, SP).

**Mess Hall Parking**: No appreciable organic topsoil was reported by the drillers at the borings locations. Beneath the surface to a depth of approximately 10 feet, the test borings typically encountered intermittent layers of very loose to medium dense silty, slightly silty, clayey, slightly clayey and clean sands (SM, SC, SP-SC, SP).

**BEQs:** No appreciable organic topsoil was reported by the drillers at the borings locations. Beneath the surface to a depth of approximately 60 feet, the test borings typically encountered intermittent layers of very loose to medium dense silty, slightly silty, clayey, slightly clayey and clean sands (SM, SP-SM, SC, SP-SC, SP).

**SH50 Parking**: No appreciable organic topsoil was reported by the drillers at the borings locations. Beneath the surface to a depth of approximately 10 feet, the test borings typically encountered intermittent layers of very loose to medium dense silty, slightly silty, clayey, slightly clayey and clean sands (SM, SC, SP-SC, SP).

In summary, the mess hall building can be supported on conventional shallow foundations. For foundations designed and constructed in accordance with the recommendations provided in this report, a net allowable soil bearing pressures of 2,000 pounds per square foot (psf) is recommended for use in proportioning shallow foundations. The BEQ structures can be supported on 12-inch square, pre-stressed concrete piles driven to a depth of 45 to 50 feet below current site grades. Once structural loads are determined, we request that they be provided to us to review our recommendations and make any necessary changes.

Specific information regarding the subsurface exploration procedures used, the site and subsurface conditions at the time of our exploration, and our conclusions and recommendations concerning the geotechnical design and construction aspects of the project are discussed in detail in the subsequent sections of this report. Please note this Executive Summary is an important part of this report and should be considered a ***"summary"*** only. The subsequent sections of this report constitute our findings, conclusions, and recommendations in their entirety.

Prepared By:
Winslow E. Goins, P.E.
Project Engineer

Reviewed By:
Walid M. Sobh, P.E.
Principal Engineer

# 2.0 PROJECT OVERVIEW

## 2.1 Project Information

Our understanding of the proposed project is based upon on our discussions with R. Kenneth Weeks, Engineers and the site maps provided by R. Kenneth Weeks, Engineers. The P1267 Mess Hall and P1317 BEQs project is located off of Sneads Ferry Road in MCB Camp Lejeune, North Carolina. At the time of our field exploration, the site was slightly wooded. The site was relatively level.

ECS understands that the project consists of 9,500 linear feet of roadway widening along Sneads Ferry Road from Louis Road to McHugh Boulevard, an approximately 3 acre, 40 POV parking lot near building SH50, and a Mess Hall building and two BEQ structures adjacent to the P1017/P1047 BEQ project. Project specific information including structural loads information was not available at the time of this report.

## 2.2 Scope of Work

The conclusions and recommendations contained in this report are based on the results of:

- thirty eight standard penetration test soil borings (SPT),
- visual examination of the samples obtained during our field exploration,
- the results of select laboratory index and engineering properties testing,
- engineering analyses of the field findings with respect to the provided project information.

## 2.3 Purposes of Exploration

The purpose of this exploration program was to determine the soil and groundwater conditions at the site and to develop engineering recommendations to assist in the design and construction of the proposed project. We accomplished these objectives by:

- performing a site reconnaissance to evaluate the existing site conditions,
- drilling test borings to explore the subsurface soil and groundwater conditions,
- performing laboratory tests on selected representative soil samples from the borings to evaluate pertinent engineering properties; and
- analyzing the field data to develop appropriate geotechnical engineering design and construction recommendations.

# 3.0 EXPLORATION PROCEDURES

## 3.1 Subsurface Exploration Procedures

### 3.1.1 Soil Test Borings

The thirty eight soil test borings drilled on the site were performed using a trailer-mounted CME 450 drill rig utilizing various cutting bits and mud rotary drilling to advance the bore holes. Representative soil samples were obtained by means of the split-barrel sampling procedure in general conformance with ASTM D-1586. In this procedure, a 2-inch O.D., split-barrel sampler is driven into the soil a distance of 18 inches by a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler through a 12-inch interval is termed the Standard Penetration Test (SPT) value and is indicated for each sample on the boring logs in Appendix B.

The SPT value can be used as a qualitative indication of the in-place relative density of cohesionless soils. In a less reliable way, it also indicates the consistency of cohesive soils. This indication is qualitative, since many factors can affect the standard penetration resistance value (i.e., differences between drill crews, drill rigs, drilling procedures, and hammer-rod-sampler assemblies) and prevent a direct correlation between SPT resistance value, or N-Value, and the consistency or relative density of the tested soil. Split-spoon samples were obtained at approximately 2.5-foot intervals within the upper 10 feet and at approximately 5-foot intervals thereafter. The approximate locations of the soil test borings are indicated on the Boring Location Plan in Appendix A of this report.

The drilling crew maintained a field log of the soils encountered in the borings. After recovery, each sample was removed from the sampler and visually classified. Representative portions of each soil sample were then sealed in air-tight containers and brought to our laboratory in Wilmington, North Carolina for visual examination and formal classification by a geotechnical engineer in general accordance with the Unified Soil Classification System guidelines.

## 3.2 Laboratory Testing Program

Representative soil samples obtained during our field exploration were selected and tested in our laboratory to check field classifications and to determine pertinent engineering properties. The laboratory testing program included:

- visual classifications of soil according to ASTM D 2487;
- index property testing included natural moisture content determinations (ASTM D 2216), grain size analyses (ASTM D 1140), Modified Proctor tests (ASTM D 1557-02) and California Bearing Ratio (ASTM D 1883-05).

All data obtained from the laboratory tests are included on the Laboratory Testing Summary and in Appendix C of this report.

The soil samples collected for this investigation will be retained at our laboratory for a period of sixty (60) days, after which they will be discarded unless other instructions are received as to their disposition.

# 4.0 EXPLORATION RESULTS

## 4.1 Site Conditions

The P1267 Mess Hall and P1317 BEQs project is located off of Sneads Ferry Road in MCB Camp Lejeune, North Carolina. At the time of our field exploration, the site was slightly wooded. The site was relatively level.

## 4.2 Regional Geology

The site is located in the Coastal Plain Physiographic Province of North Carolina. The Coastal Plain is composed of seven terraces, each representing a former level of the Atlantic Ocean. Soils in this area generally consist of sedimentary materials transported from other areas by the ocean or rivers. These deposits vary in thickness from a thin veneer along the western edge of the region to more than 10,000 feet near the coast. The sedimentary deposits of the Coastal Plain rest upon consolidated rocks similar to those underlying the Piedmont and Mountain Physiographic Provinces. In general, shallow unconfined groundwater movement within the overlying soils is largely controlled by topographic gradients. Recharge occurs primarily by infiltration along higher elevations and typically discharges into streams or other surface water bodies. The elevation of the shallow water table is transient and can vary greatly with seasonal fluctuations in precipitation.

## 4.3 Soil Conditions

**Sneads Ferry Road**: Approximately zero to six inches of organic topsoil was reported by the drillers at the borings locations. Beneath the surface to a depth of approximately 10 feet, the test borings typically encountered intermittent layers of very loose to medium dense silty, clayey, slightly clayey and clean sands (SM, SC, SP-SC, SP) and very soft to stiff sandy clays (CL). Standard penetration test resistances (N-values) in these soils generally ranged from W.O.H (Weight of Hammer) to 19 blows per foot (bpf).

**Mess Hall:** No appreciable organic topsoil was reported by the drillers at the borings locations. Beneath the surface to a depth of approximately 60 feet, the test borings typically encountered intermittent layers of very loose to dense silty, clayey, slightly silty and clean sands (SM, SC, SP-SM, SP). Standard penetration test resistances (N-values) in these soils generally ranged from 2 to 77 bpf.

**Mess Hall Parking**: No appreciable organic topsoil was reported by the drillers at the borings locations. Beneath the surface to a depth of approximately 10 feet, the test borings typically encountered intermittent layers of very loose to medium dense silty, slightly silty, clayey, slightly clayey and clean sands (SM, SC, SP-SC, SP). Standard penetration test resistances (N-values) in these soils generally ranged from 1 to 18 bpf.

**BEQs:** No appreciable organic topsoil was reported by the drillers at the borings locations. Beneath the surface to a depth of approximately 60 feet, the test borings typically encountered intermittent layers of very loose to medium dense silty, slightly silty, clayey, slightly clayey and clean sands (SM, SP-SM, SC, SP-SC, SP). Standard penetration test resistances (N-values) in these soils generally ranged from 3 to in excess of 100 bpf.

**SH50 Parking**: No appreciable organic topsoil was reported by the drillers at the borings locations. Beneath the surface to a depth of approximately 10 feet, the test borings typically encountered intermittent layers of very loose to medium dense silty, slightly silty, clayey, slightly clayey and clean sands (SM, SC, SP-SC, SP). Standard penetration test resistances (N-values) in these soils generally ranged from 4 to 20 bpf.

The descriptions provided in this section are a general summary of the subsurface conditions encountered within the test borings. The Test Boring Records in Appendix B contain detailed information recorded at each of the boring locations and represent the geotechnical engineer's interpretation of the data based on visual examination of the soil samples obtained during the field exploration. The stratification lines on the Test Boring Records represent approximate boundaries between material types and the actual transition between strata is expected to be gradual. A generalized subsurface profile is also included in Appendix A.

### 4.4 Groundwater Conditions

Groundwater observations were made during the drilling operations at all boring locations. Furthermore, visual observations of the samples retrieved during drilling exploration were also used in evaluating the groundwater conditions. The groundwater depth was observed to range approximately 4.0 to 9.0 feet below the existing grade after completion of the boring. The groundwater depth was observed to range approximately 0.0 to 10.25 feet below the existing grades 24 hours after completion of the borings. The shallow 24 hour observation was influenced by rainfall.

The highest groundwater observations are normally encountered in the late winter and early spring. Variations in the location of the long-term water table may occur as a result of changes in precipitation, evaporation, surface water runoff, and other factors not immediately apparent at the time of this exploration. If long term water levels are crucial to the development of this site, it would be prudent to verify water levels with the use of perforated pipes or piezometers.

The relatively shallow groundwater conditions encountered within the boreholes are expected to utility excavations activities. However, this will depend on final site design grades. Consequently, the diversion of surface water should be expected in order to successfully complete site grading activities.

## 4.5 Laboratory Test Results

Index and engineering properties tests were performed on select samples of the sample soils encountered within the test borings. In summary, the tested samples had in-situ moisture contents ranging from about 5.4 to 30.0 percent.

The grain size analyses of the tested samples indicated that the tested materials had 2.1 to 22.7 percent fines passing the number 200 sieve.

The modified Proctor tests of the bulk samples resulted in maximum dry densities ranging from 101.3 to 118.5 and optimum moisture contents ranging from 9.6 to 13.9.

The CBR tests of the bulk samples resulted in CBR values ranging from 9.3 to 49.9. It is recommended that a maximum CBR value of 10 be used for pavement design.

Specific laboratory test results are provided in the Laboratory Testing Summary and in Appendix C of this report.

## 5.0 ANALYSIS AND RECOMMENDATIONS

The recommendations provided in this report are based upon our understanding of the proposed construction, the information provided to us during this study and our past experience with similar conditions. Should any of the information provided to us be changed prior to final design, ECS should be notified to review these recommendations and make appropriate revisions, if necessary.

### 5.1 Subgrade Preparation

The first step in preparing the site for the proposed construction should be to remove all vegetation, rootmat, topsoil, deleterious materials, existing pavement, foundations and utilities and any other soft or unsuitable materials from the existing ground surface. These operations should extend at least 10 feet, where possible, beyond the planned limits of the proposed building and pavements.

After proper clearing, stripping, grubbing, and prior to fill placement, foundation, slab, or roadway construction, the exposed subgrade soils should be carefully evaluated by an experienced geotechnical engineer to identify any localized unstable or otherwise unsuitable materials. After evaluating the exposed soils, loose and yielding areas should be identified by proofrolling the exposed subgrades, if site and subsurface conditions allow, with an approved piece of equipment, such as a smooth drum vibratory roller, having an axle weight of at least 10 tons. The vibratory proofrolling will also help densify the upper exposed subgrade soils. During this process, it may be necessary to allow groundwater brought to the surface during densification to recede prior to continued densification or subsequent fill placement. Any soft or unsuitable materials identified during proofrolling operations should be either repaired in-place or removed and replaced with an approved backfill placed and compacted in accordance with recommendations of this report.

Site subgrade conditions will be significantly influenced by weather conditions. Subgrades that are evaluated after periods of rainfall will not respond as well to proofrolling as subgrades that are evaluated after periods of more favorable weather. We strongly recommend that rubber tire equipment not be used if subgrade conditions exhibit elevated moisture conditions. The contractor should use tracked equipment to minimize the degradation of marginally stable subgrade.

The preparation of fill subgrades, as well as proposed building subgrades, should be observed on a full-time basis by a representative of ECS. These observations should be performed by an experienced geotechnical engineer, or his representative, to ensure that all unsuitable materials have been removed and that the prepared subgrade is suitable for support of the proposed construction and/or fills.

Haul roads for the site should designed to cross areas that will allow equipment to access the construction areas without crossing proposed building pads or interfere with the operations of the existing buildings. Areas that haul roads cross existing utilities should be designed to prevent damage to the utilities.

## 5.2 Engineered Fill Placement

Following the removal of deleterious surface and subsurface materials, and after achieving a stable subgrade, engineered fills can be placed and compacted to achieve the desired site grades. All fill for support of the proposed construction and for backfill of utility lines within expanded building and pavement limits should consist of an approved material, free of organic matter and debris and cobbles greater than 3 inches, and have a Liquid Limit (LL) and Plasticity Index (PI) less than 40 and 20, respectively. We also recommend that all fills within structural areas have a modified Proctor (ASTM D 1557) maximum dry density of at least 100 pounds per cubic foot (pcf).

Unsuitable fill materials include topsoil, organic materials (OH, OL), and high plasticity clays and silts (CH, MH). All such materials removed during grading operations should be either stockpiled for later use in landscape fills, or placed in approved on or off-site disposal areas.

Existing soils containing significant amounts of organic matter will not be suitable for re-use as engineered fill. As such, the organic content of the near surface cultivated soils should be evaluated to determine if some of these soils will be suitable for re-use as engineered fill. Natural fine-grained soils classified as clays or silts (CL, ML) with LL and PI greater than 40 and 20, respectively, should be evaluated by the geotechnical engineer at the time of construction to determine their suitability for use as engineered fill.

Prior to the commencement of fill operations and/or utilization of any off-site borrow materials, the contractor should provide representative samples of the proposed fill soils to the geotechnical engineer. The geotechnical engineer can determine the material's suitability for use as an engineered fill and develop moisture-density relationships in accordance with the recommendations provided herein. Samples should be provided to the geotechnical engineer at least 3 to 5 days prior to their use in the field to allow for the appropriate laboratory testing to be performed.

Fill materials placed within the building and pavement areas should be placed in lifts not exceeding 8 inches in loose lift thickness and moisture conditioned to within their working range of optimum moisture content. The fills should then be compacted to a minimum of 98 percent of the soil's modified Proctor (ASTM D 1557) maximum dry density to within 12 inches below finished subgrade. The upper 12 inches of fills placed beneath structural development should be compacted to 100 percent of the soil's modified Proctor maximum dry density. The typical working range of optimum moisture for the natural Coastal Plain soils at the site is expected to be within approximately 3 percent of the optimum moisture content. Care should also be taken to provide a smooth, gently sloping ground surface at the end of each day's earthwork activities to help reduce the potential for ponding and absorption of surface water.

Grade controls should also be maintained throughout the filling operations. All filling operations should be observed on a full-time basis by a qualified representative of ECS to determine that the required degrees of compaction are being achieved. We recommend that a minimum of one compaction test per 2,000-square-foot area be performed for each lift of controlled fill. The elevation and location of the tests should be clearly identified at the time of fill placement. Areas which fail to achieve the required degree of compaction should be re-worked until the specified degree of compaction is achieved. Failing test areas may require moisture adjustments or other suitable remedial activities in order to achieve the required compaction.

Fill materials should not be placed on frozen, frost-heaved, and/or soils which have been recently subjected to precipitation. All wet or frozen soils should be removed prior to the continuation of site grading and fill placement. Borrow fill materials, if required, should not contain excessively wet or frozen materials at the time of placement. Additionally, if grading operations occur during the winter months, all frost-heaved soils should be removed prior to placement of engineered fill, granular sub-base materials, foundation or slab concrete, and asphalt pavement materials.

If problems are encountered during the site grading operations, or if the actual site conditions differ from those encountered during our subsurface exploration, the geotechnical engineer should be notified immediately.

### 5.3 Foundations Recommendations

**Mess Hall:** The proposed structures cannot be supported on shallow foundations without a post-tensioned slab. Provided the subgrade preparation and earthwork operations are completed in strict accordance with the recommendations of this report, the proposed construction can be supported on conventional shallow foundations bearing on approved natural materials and/or properly compacted fill. We recommended a net allowable design soil bearing pressure of 2,000 psf for proportioning continuous and isolated column footings. To reduce the possibility of foundation bearing failure and excessive settlement due to local shear or "punching" failures, we recommend that continuous footings have a minimum width of 18 inches and that isolated column footings have a minimum lateral dimension of 30 inches. Furthermore, all footings should bear at a depth to provide adequate frost cover protection. For this region, we recommend the bearing elevation be a minimum depth of 12 inches below the finished exterior grade or in accordance with the local building code requirements. Once structural loads and site grades are determined, we request that they be provided to us to review our recommendations and make any necessary changes.

The net allowable soil bearing pressure refers to that pressure which may be transmitted to the foundation bearing soils in excess of the final minimum surrounding overburden pressure. The final footing elevation should be evaluated by ECS personnel to verify that the bearing soils are capable of supporting the recommended net allowable bearing pressure and suitable for foundation construction. These evaluations should include visual observations, hand rod probing, and dynamic cone penetrometer (ASTM STP 399) testing, or other methods deemed appropriate by the geotechnical engineer at the time of construction, in each column footing excavation and at intervals not greater than 20 feet in continuous footing excavations.

The settlement of a structure is a function of the compressibility of the bearing materials, bearing pressure, actual structural loads, fill depths, and the bearing elevation of footings with respect to the final ground surface elevation. Estimates of settlement for foundations bearing on engineered or non-engineered fills are strongly dependent on the quality of fill placed. Factors which may affect the quality of fill include maximum loose lift thickness of the fills placed and the amount of compactive effort placed on each lift. Provided that the recommendations outlined in this report are strictly adhered to, we expect that total settlements for the proposed construction are expected to be in the range of 1.5 inch or less, while the differential settlement will be approximately ½ of the anticipated total settlement. This evaluation is based on our engineering experience and assumed structural loadings for this type of structure, and is intended to aid the structural engineer with his design.

**BEQs:** the proposed structure can be supported on a deep foundation consisting of driven 12-inch pre-stressed square concrete piles. Each concrete pile should be installed to a depth of 45 to 50 feet. Our evaluation indicates that at this depth the soils are capable of supporting a maximum of 70 tons axially, 20 tons of uplift and 15 tons lateral load. This loading assumes a fixed head pile condition with axial and shear forces applied to the pile head. The design capacity of the soils includes the down-drag forces for the clays in the upper zones. The upper strata are soft and in our opinion would not provide long-term stability for piles supported by skin friction with less capacity at higher depths.

We recommend that the pile driving hammer used to install each pile have a minimum rated energy blow of 22,000 foot/pounds. Driving criteria and bearing elevations should be established during test pile installation and PDA testing.

It is suggested that several over length piles be driven prior to the start of production pile driving, to establish the driving criteria, pile lengths to be ordered and to determine if auger "pilot" holes are justified. Production piles should not be ordered until the pile lengths can be verified. Three test piles are recommended for the building. A pile should be driven at both ends and in the center of the building.

The over length piles could be driven in production pile locations. All pile installation operations and PDA testing should be monitored by a senior soil technician working under the supervision of a Licensed Engineer. ECS has the PDA equipment and would be pleased to provide PDA testing once the method of installation and the contractor has been selected. Construction of pile caps or grade beams could begin only after all piles have been installed.

### 5.4 Floor Slab Design

Provided a suitable subgrade will be prepared as recommended herein, ground level slabs can be designed as slabs-on-grade with out surcharging the building pad. Our findings indicate that a modulus of subgrade reaction ($k_s$) of 150 pci is appropriate for design provided that upper 12 inches of the slab subgrade soils have been uniformly compacted to at least 98 percent of their modified Proctor maximum dry density.

We also recommend that all slabs-on-grade be underlain by a minimum of 6 inches of open graded aggregate to help prevent the capillary rise of subsurface moisture from adversely affecting the slab. If floor covering such as tile or carpet will be utilized for interior finishes, a polyethylene vapor barrier may be used beneath the floor slab for moisture control considerations.

### 5.5 Seismic Site Class Determination and Liquefaction Potential

North Carolina has adopted (with State amendments) the 2006 Edition of the International Building Code (IBC 2006), and the IBC 2006 requires that a seismic Site Class be assigned for new structures. The method for determining the Site Class is presented in Section 1615.5.5 of the IBC 2006. The seismic Site Class is typically determined by a calculating a weighted average of N-values from standard penetration testing in conventional soil test borings, undrained shear strengths, or the shear wave velocities of the materials in the upper 100 feet of the site. According to the IBC 2006, a seismic Site Class "D" may be used for this site based upon the a weighted average N-value of 16.3.

Based on the USGS Seismic Hazard Curves and the IBC 2006, for a seismic site class "D" at latitude 34.663 degrees and longitude -77.322 degrees, the $S_{DS}$ value is 0.210 and the $S_{D1}$ value is 0.119. The seismic design category depends on the occupancy group of the building and should be determined by the structural engineer.

The soils encountered in the borings were evaluated for liquefaction potential using simplified procedures developed by Seed and Idriss. For the analysis, the peak ground acceleration was assumed in accordance with IBC 2006 Section 1803.5.12 to be $S_{DS}/2.5$ in the absence of a site specific seismic study. The liquefaction potential for this site is low.

### 5.6 Pavement Design Considerations

For the design and construction of exterior pavements, the subgrades should be prepared in strict accordance with the recommendations in the "Subgrade Preparation" and "Engineered Fill Placement" sections of this report. An important consideration with the design and construction of pavements is surface and subsurface drainage. Where standing water develops, either on the pavement surface or within the base course layer, softening of the subgrade and other problems related to the deterioration of the pavement can be expected. Furthermore, good drainage should minimize the possibility of the subgrade materials becoming saturated during the normal service period of the pavement.

**Sneads Ferry Road:** ECS estimated that 5,000 vehicles a day are anticipated and 5 percent of the vehicles are anticipated to be trucks. Of the truck traffic, 2.5 percent is anticipated to be three axles and the 2.5 percent to be five axles. Based on our calculations, we recommend a flexible pavement section consisting of 2 inches of S9.5A surface course overlying 3 inches of I 19.0B intermediate course overlaying 8 inches of ABC stone base course should be used. For a rigid pavement section, we recommend a rigid pavement section consisting of 8 inches of 4,000 psi compressive strength concrete overlying 8 inches of ABC stone should be used. The design values were determined using the 1993 AASHTO Guide for Pavement Structures and the American Concrete Pavement Association.

**Mess Hall Parking and SH50 Parking:** ECS recommends a flexible pavement section of 2 inches of surface SF9.5 mix overlying 6 inches of compacted crushed stone in the light pedestrian type vehicle areas and 3.0 inches of surface SF9.5 mix overlying 8 inches of compacted crushed stone in the main heavily traveled drive areas, in truck delivery and dumpster areas.

Regardless of the section and type of construction utilized, saturation of the subgrade materials and asphalt pavement areas results in a softening of the subgrade material and shortened life span for the pavement. Therefore, we recommend that both the surface and subsurface materials for the pavement be properly graded to enhance surface and subgrade drainage. By quickly removing surface and subsurface water, softening of the subgrade can be reduced and the performance of the parking area can be improved. Site preparation for the parking areas should be similar to that for the building area including stripping, proofrolling, and the placement of compacted structural fill.

Please note that large, front-loading trash dumpsters frequently impose concentrated front-wheel loads on pavements during loading. This type of loading typically results in rutting of bituminous pavements and ultimately pavement failures and costly repairs. Consequently, we recommend the use of an eight inch thick, mesh reinforced concrete slab that extends the entire length of the truck. Concrete pavements should be properly jointed and reinforced as needed to help reduce the potential for cracking and to permit proper load transfer.

### 5.7 Site Drainage

Positive drainage should be provided around the perimeter of the structure to minimize the potential for moisture infiltration into the foundation and slab subgrade soils. We recommend that landscaped areas adjacent to these structures be sloped away from the construction and maintain a fall of at least 6 inches for the first 10 feet outward from the structures. The parking lots, sidewalks, and any other paved areas should also be sloped to divert surface water away from the proposed building.

The proper diversion of surface water during site grading and construction will help reduce the potential for delays associated with periods of inclement weather. The proper diversion of surface water is especially critical since portions of the site soils are expected to be moisture sensitive. Based upon our past experience, the use of "crowning" large areas of exposed soils should be useful to help divert surface water from the prepared subgrades.

Please note that the need for construction dewatering should be determined at the time of construction. If grading operations are performed during the wet seasons (i.e. fall and winter) the use of gravity flow ditches may be necessary to divert precipitation and surface water away from the construction areas.

### 5.8 Construction Considerations

Exposure to the environment may weaken the soils at the foundation bearing elevation if the foundation excavations remain exposed during periods of inclement weather. Therefore, foundation concrete should be placed the same day that proper excavation is achieved and the design bearing pressure verified. If the bearing soils are softened by surface water absorption or exposure to the environment, the softened soils must be removed from the foundation excavation bottom immediately prior to placement of concrete. If the excavation must remain open overnight, or if inclement weather becomes imminent while the bearing soils are exposed, we recommend that a 1 to 3 inch thick "mud-mat" of "lean" concrete be placed over the exposed bearing soils before the placement of reinforcing steel.

It is imperative to maintain good site drainage during earthwork operations to help maintain the integrity of the surface soils. The surface of the site should be kept properly graded to enhance drainage of surface water away from the proposed construction areas during the earthwork phase of this project. We recommend that surface drainage be diverted away from the proposed building and pavements areas without significantly interrupting its flow. Other practices would involve sealing the exposed soils daily with a smooth-drum roller at the end of the day's work to reduce the potential for infiltration of surface water into the exposed soils.

The key to minimizing disturbance problems with the soils is to have proper control of the earthwork operations. Specifically, it should be the earthwork contractor's responsibility to maintain the site soils within a workable moisture content range to obtain the required in-place density and maintain a stable subgrade. Scarifying and drying operations should be included in the contractor's price and not be considered an extra to the contract. In addition, construction equipment cannot be permitted to randomly run across the site, especially once the desired final grades have been established. Construction equipment should be limited to designated lanes and areas, especially during wet periods to minimize disturbance of the site subgrades. It will likely be necessary to utilize tracked equipment during grading operations particularly if the subgrade soils exhibit elevated moisture conditions.

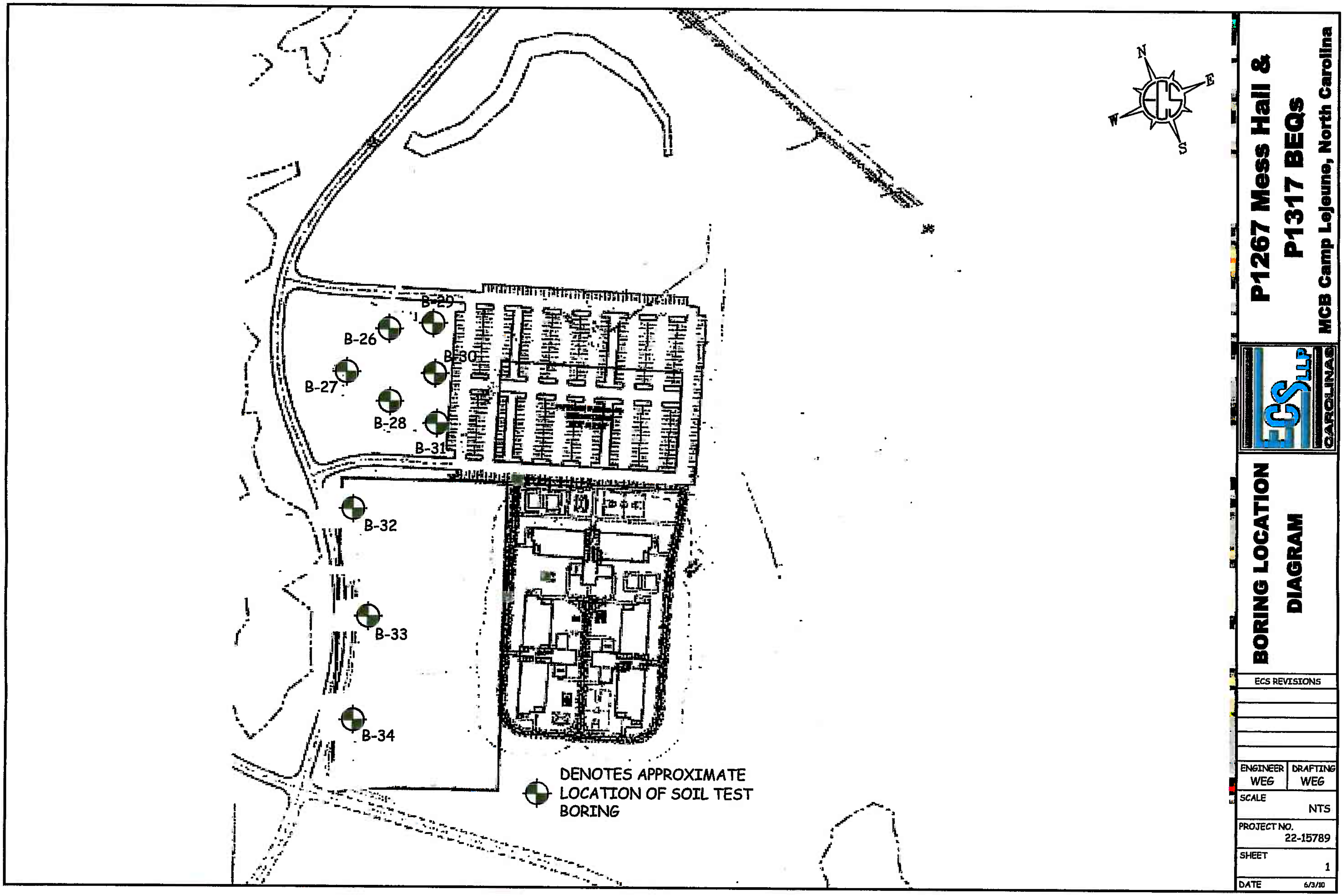
## 6.0 CLOSING

Our geotechnical evaluation of the site has been based on our understanding of the site, the project information provided to us, and the data obtained during our exploration. The general subsurface conditions utilized in our evaluations have been based on interpolation of subsurface data between the borings. If the project information provided to us is changed, please contact us so that our recommendations can be reviewed and appropriate revisions provided, if necessary. The discovery of any site or subsurface conditions during construction which deviate from the data outlined in this exploration should be reported to us for our review, evaluation and revision of our recommendations, if necessary. The assessment of site environmental conditions for the presence of pollutants in the soil and groundwater of the site is beyond the scope of this geotechnical exploration.

# APPENDICES

# APPENDIX A

# FIGURES


N
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DENOTES APPROXIMATE
LOCATION OF SOIL TEST
BORING
P1267 Mess Hall &
P1317 BEQs
MCB Camp Lejeune, North Carolina
ECS LLP
CAROLINAS
BORING LOCATION
DIAGRAM
ECS REVISIONS
ENGINEER
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DRAFTING
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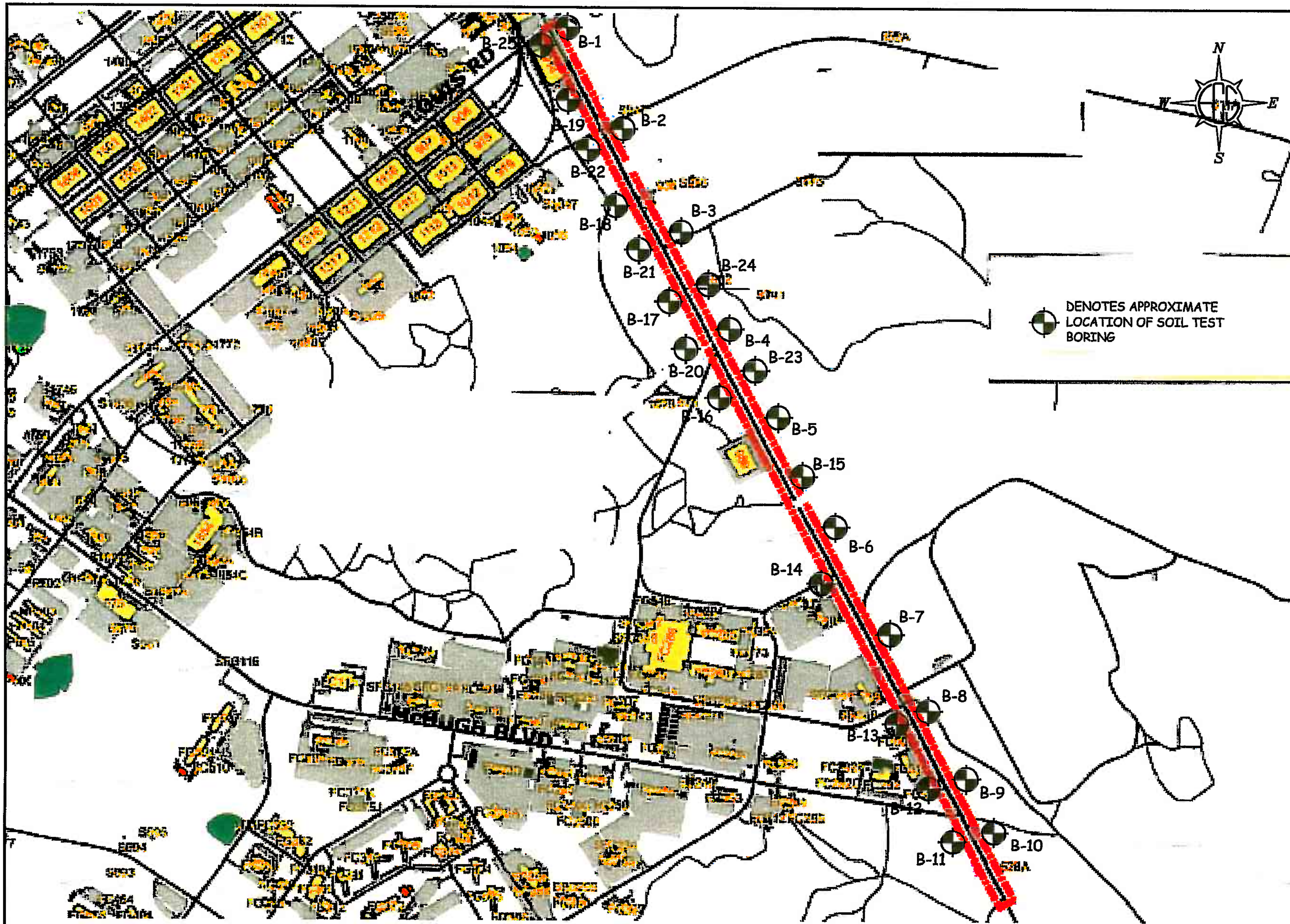
SCALE
NTS
PROJECT NO.
22-15789
SHEET
1
DATE
6/3/10

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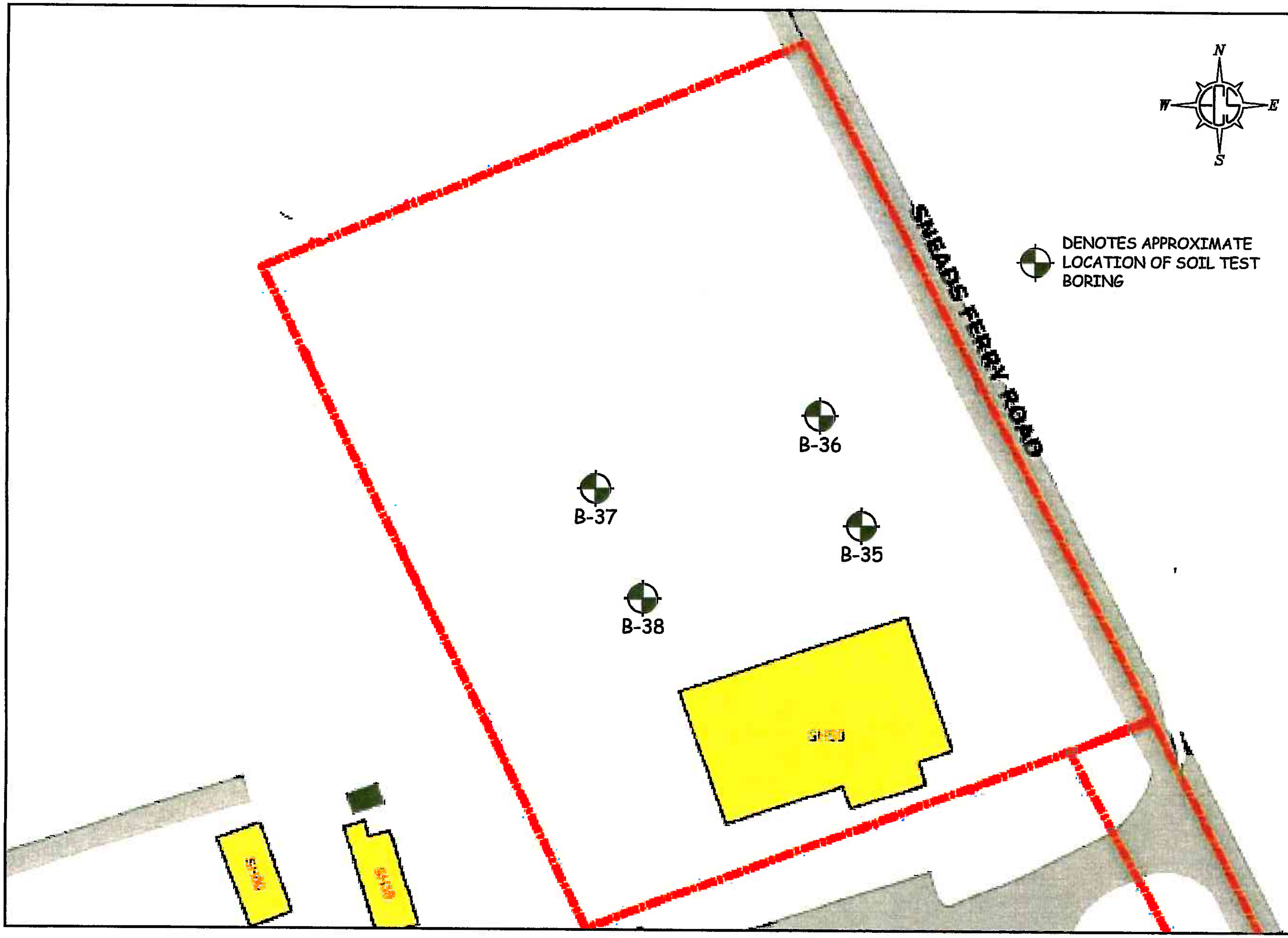
**MCB Camp Lejeune, North Carolina**

ECS LLP CAROLINAS

**BORING LOCATION DIAGRAM**

ECS REVISIONS

| | |
|---|---|
| ENGINEER WEG | DRAFTING WEG |
| SCALE | NTS |
| PROJECT NO. | 22-15789 |
| SHEET | 2 |
| DATE | 6/3/10 |

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**MCB Camp Lejeune, North Carolina**

ECS LLP CAROLINAS

**BORING LOCATION DIAGRAM**

ECS REVISIONS

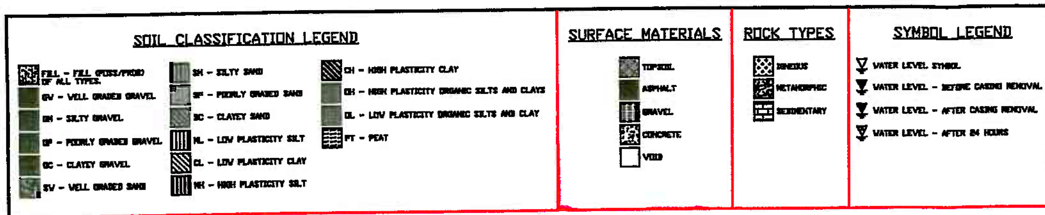
| ENGINEER | DRAFTING |
|---|---|
| WEG | WEG |

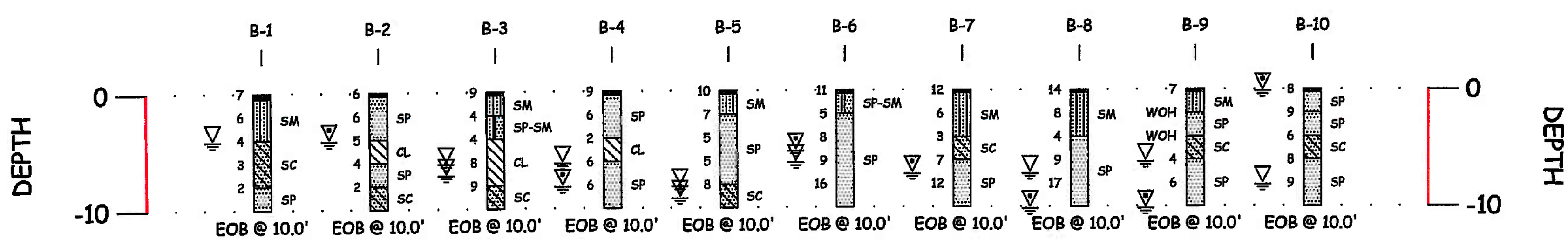
SCALE NTS

PROJECT NO. 22-15789

SHEET 3

DATE 6/3/10

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## CROSS SECTION DIAGRAM

| | |
|---|---|
| ECS REVISIONS | |
| ENGINEER WEG | DRAFTING WEG |
| SCALE Horiz. & Vert. NTS | |
| PROJECT NO. 22-15789 | |
| SHEET 4 | |
| DATE 5/26/10 | |

**SOIL CLASSIFICATION LEGEND**

- FILL – FILL (POSS/PROB) OF ALL TYPES
- GW – WELL GRADED GRAVEL
- GM – SILTY GRAVEL
- GP – POORLY GRADED GRAVEL
- GC – CLAYEY GRAVEL
- SW – WELL GRADED SAND
- SM – SILTY SAND
- SP – POORLY GRADED SAND
- SC – CLAYEY SAND
- ML – LOW PLASTICITY SILT
- CL – LOW PLASTICITY CLAY
- MH – HIGH PLASTICITY SILT
- CH – HIGH PLASTICITY CLAY
- OH – HIGH PLASTICITY ORGANIC SILTS AND CLAYS
- OL – LOW PLASTICITY ORGANIC SILTS AND CLAY
- PT – PEAT

**SURFACE MATERIALS**

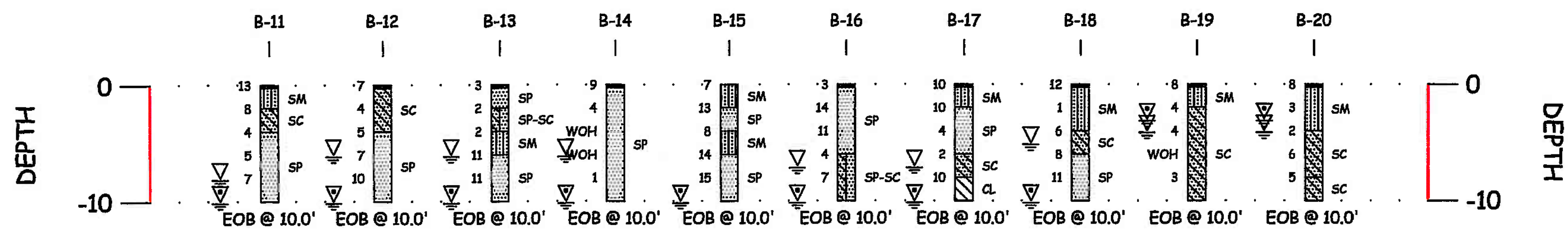
- TOPSOIL
- ASPHALT
- GRAVEL
- CONCRETE
- VOID

**ROCK TYPES**

- IGNEOUS
- METAMORPHIC
- SEDIMENTARY

**SYMBOL LEGEND**

- WATER LEVEL SYMBOL
- WATER LEVEL – BEFORE CASING REMOVAL
- WATER LEVEL – AFTER CASING REMOVAL
- WATER LEVEL – AFTER 24 HOURS




# P-1267 Mess Hall

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**CROSS SECTION DIAGRAM**

| ECS REVISIONS | |
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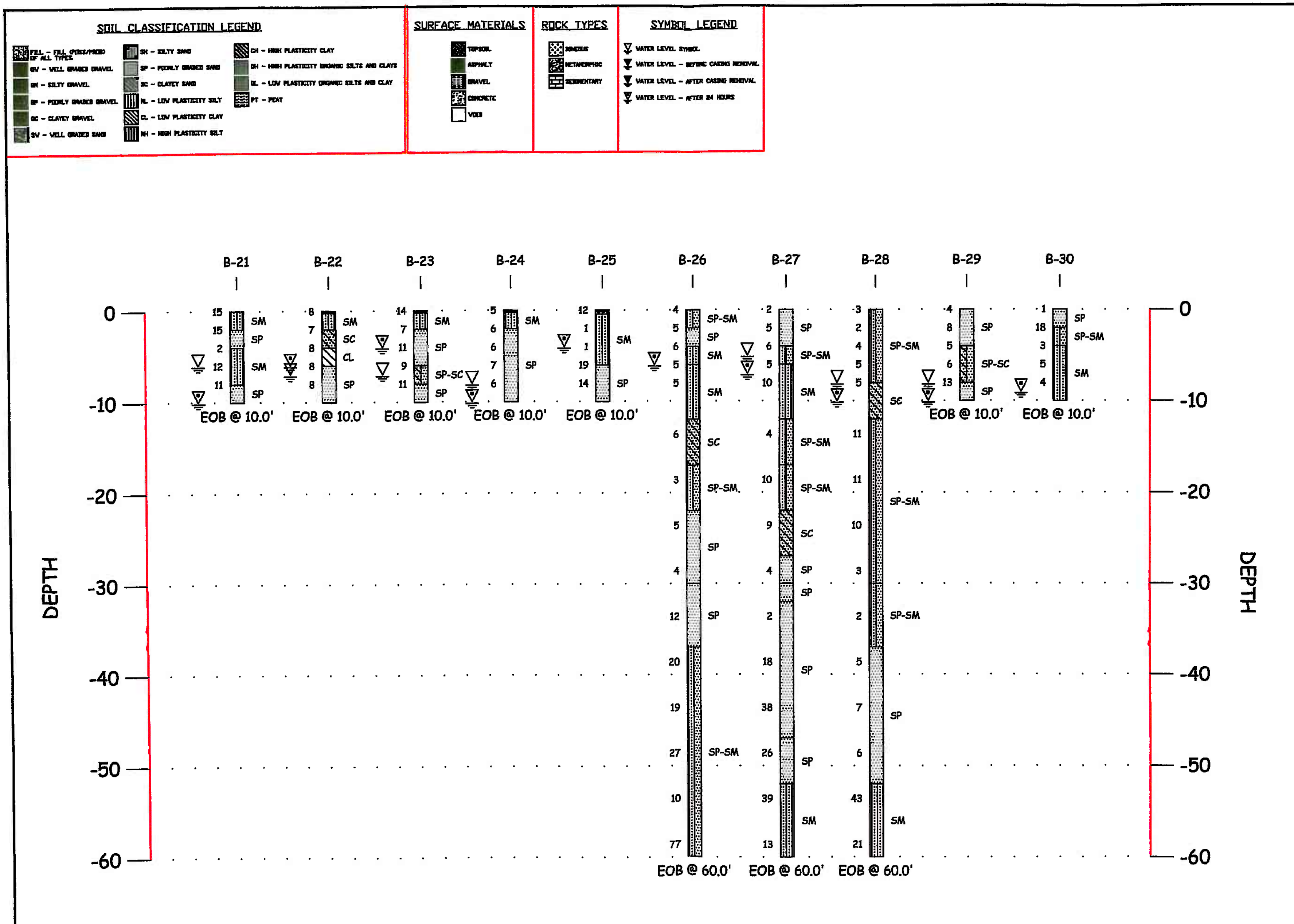
| ENGINEER WEG | DRAFTING WEG |
| SCALE Horiz. & Vert. NTS | |
| PROJECT NO. 22-15789 | |
| SHEET 5 | |
| DATE 5/26/10 | |

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## MCB Camp Lejeune

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## CROSS SECTION DIAGRAM

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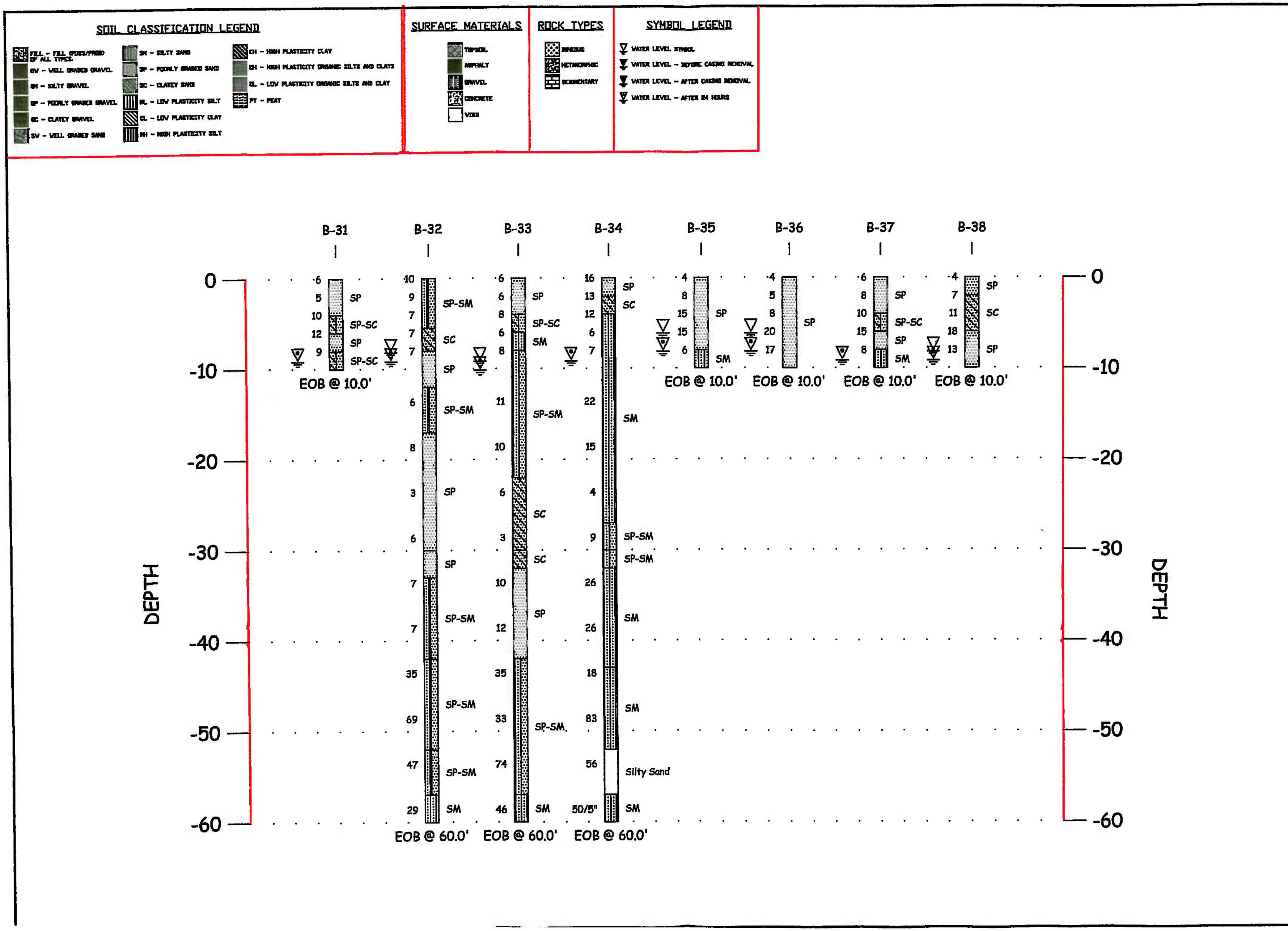
| ECS REVISIONS | |
| ENGINEER WEG | DRAFTING WEG |
| SCALE Horiz. & Vert. NTS | |
| PROJECT NO. 22-15789 | |
| SHEET 6 | |
| DATE 5/26/10 | |




# P-1267 Mess Hall

MCB Camp Lejeune

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# CROSS SECTION DIAGRAM

ECS REVISIONS

| ENGINEER | DRAFTING |
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| WEG | WEG |

SCALE Horiz. & Vert. NTS

PROJECT NO. 22-15789

SHEET 7

DATE 5/26/10

## APPENDIX B

## SPT BORING LOGS

# Unified Soil Classification System
## (ASTM Designation D-2487)

| Major Division | | Group Symbol | Typical Names | Classification Criteria |
|---|---|---|---|---|
| Coarse-grained soils More than 50% retained on No. 200 sieve | Gravels More than 50% of coarse fraction retained on No. 4 sieve | GW | Well-graded gravels and gravel-sand mixtures, little or no fines | $C_u = D_{60}/D_{10}$ Greater than 4<br>$C_z = (D_{30})^2/(D_{10} x D_{60})$ Between 1 and 3 |
| | | GP | Poorly graded gravels and gravel-sand mixtures, little or no fines | Not meeting both criteria for GW |
| | | GM | Silty gravels, gravel-sand-silt mixtures | Atterberg limits plot below "A" line or plasticity index less than 4 |
| | | GC | Clayey gravels, gravel-sand-clay mixtures | Atterberg limits plot above "A" line and plasticity index greater than 7 |
| | Sands More than 50% of coarse fraction passes No. 4 sieve | SW | Well-graded sands and gravelly sands, little or no fines | $C_u = D_{60}/D_{10}$ Greater than 6<br>$C_z = (D_{30})^2/(D_{10} x D_{60})$ Between 1 and 3 |
| | | SP | Poorly graded sands and gravelly sands, little or no fines | Not meeting both criteria for SW |
| | | SM | Silty sands, sand-silt mixtures | Atterberg limits plot below "A" line or plasticity index less than 4 |
| | | SC | Clayey sands, sand-clay mixtures | Atterberg limits plot above "A" line and plasticity index greater than 7 |
| Fine-grained soils 50% or more passing No. 200 sieve | Silts and Clays Liquid limit 50% or less | ML | Inorganic silts, very fine sands, rock flour, silty or clayey fine sands | |
| | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays | |
| | | OL | Organic silts and organic silty clays of low plasticity | |
| | Silts and Clays Liquid limit greater than 50% | MH | Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts | |
| | | CH | Inorganic clays of high plasticitiy, fat clays | |
| | | OH | Organic clays of medium to high plasticity | |
| Highly organic soils | | Pt | Peat, muck and other highly organic soils | Fibrous organic matter; will char, burn, or glow |

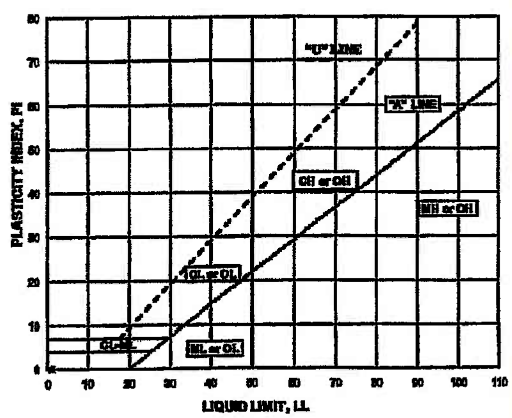
Classification on basis of percentage of fines

Less than 5% Pass No. 200 sieve — GW, GP, SW, SP

More than 12% Pass No. 200 sieve — GM, GC, SM, SC

5% to 12% Pass No. 200 sieve — Borderline classification requiring use of dual symbol

Note: U-line represents approximate upper limit of LL and PI combinations for natural soils (empirically determined). ASTM-D2487.




Plasticity chart for the classification of fine-grained soils. Tests made on fraction finer than No. 40 sieve

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# UNIFIED SOIL CLASSIFICATION SYSTEM

## Reference Notes for Boring Logs

### I. Drilling and Sampling Symbols:

SS - Split Spoon Sampler
ST - Shelby Tube Sampler
RC - Rock Core: NX, BX, AX
PM - Pressuremeter
DC - Dutch Cone Penetrometer
RB - Rock Bit Drilling
BS - Bulk Sample of Cuttings
PA - Power Auger (no sample)
HSA - Hollow Stem Auger
WS - Wash Sample

Standard Penetration (Blows/Ft) refers to the blows per foot of a 140 lb. hammer falling 30 inches on a 2 inch O.D. split spoon sampler, as specified in ASTM D-1586. The blow count is commonly referred to as the N-value.

### II. Correlation of Penetration Resistances to Soil Properties:

Relative Density-Sands, Silts

| SPT-N | Relative Density |
|---|---|
| 0 - 4 | Very Loose |
| 5 - 10 | Loose |
| 11 - 30 | Medium Dense |
| 31 - 50 | Dense |
| 51 or more | Very Dense |

Consistency of Cohesive Soils

| N-Values | Consistency |
|---|---|
| 0-2 | Very Soft |
| 3-4 | Soft |
| 5-8 | Firm |
| 9-15 | Stiff |
| 16-30 | Very Stiff |
| 31-50 | Hard |
| 51 or more | Very Hard |

### III. Unified Soil Classification Symbols:

| | | |
|---|---|---|
| GP | - | Poorly Graded Gravel |
| GW | - | Well Graded Gravel |
| GM | - | Silty Gravel |
| GC | - | Clayey Gravels |
| SP | - | Poorly Graded Sands |
| SW | - | Well Graded Sands |
| SM | - | Silty Sands |
| SC | - | Clayey Sands |
| ML | - | Low Plasticity Silts |
| MH | - | High Plasticity Silts |
| CL | - | Low Plasticity Clays |
| CH | - | High Plasticity Clays |
| OL | - | Low Plasticity Organics |
| OH | - | High Plasticity Organics |
| CL-ML | - | Dual Classification (Typical) |

### IV. Water Level Measurement Symbols:

| | | |
|---|---|---|
| WL | - | Water Level |
| WS | - | While Sampling |
| WD | - | While Drilling |
| BCR | - | Before Casing Removal |
| ACR | - | After Casing Removal |
| WCI | - | Wet Cave In |
| DCI | - | Dry Cave In |

The water levels are those water levels actually measured in the borehole at the times indicated by the symbol. The measurements are relatively reliable when augering, without adding fluids, in a granular soil. In clays and plastic silts, the accurate determination of water levels may require several days for the water level to stabilize. In such cases, additional methods of measurement are generally applied.

The elevations indicated on the boring logs should be considered approximate and were not determined using accepted surveying techniques.