*SET NO.* _____

# PRODUCT LITERATURE

*CONSTRUCTION DOCUMENTS FOR:*

# PORT OF BROWNSVILLE
# ANCHOR PARK

BROWNSVILLE, TEXAS

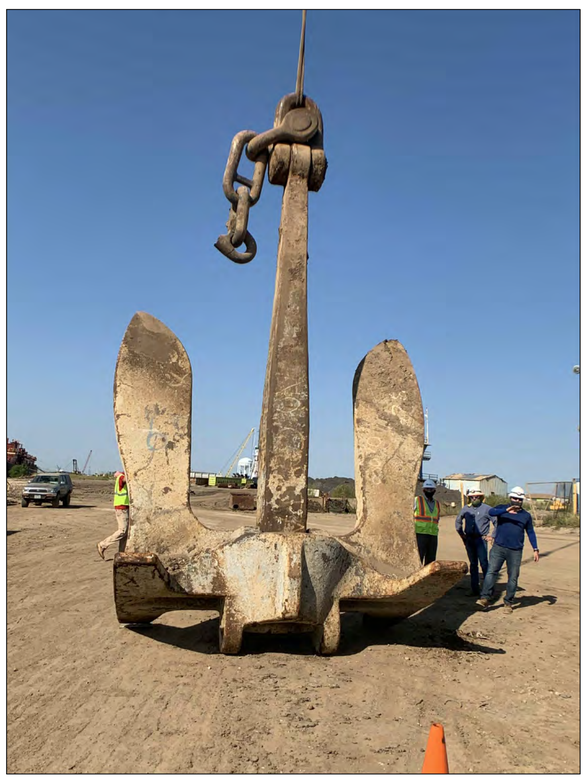
*OWNER:*

*BROWNSVILLE NAVIGATION DISTRICT*
*1000 FOUST ROAD*
*BROWNSVILLE, TEXAS 78521-1000*

*DATE:*

*JANUARY 8, 2021*

ROBERTO J RUIZ
ARCHITECT, INC.
615 W. TANDY ROAD
BROWNSVILLE, TEXAS 78520
(956) 350-9195 OFFICE
(956) 350-9196 FAX
ARCH1RUIZ@AOL.COM



USS SARATOGA AIRCRAFT CARRIER ANCHOR

letter option - contact:
Melonie Zavodnik 412 306 5131 mzavodnik@matw.com

MELONIE ZAVODNIK
TERRITORY ACCOUNT MANAGER
O: 412.306.5131 | 2015665
mzavodnik@matw.com | matthewsid.com
DL Clark Building 503 Martindale St. | Pittsburgh, PA 15212

We thank you for your interest in our products and hope you will keep us in mind for the future.

Kindly,
Arlene Kamm



J & G Diversified, Inc.
235 Jersey Avenue
New Brunswick NJ 08901
732.543.2537
arlene@cut-metal-letters.com
www.cut-metal-letters.com

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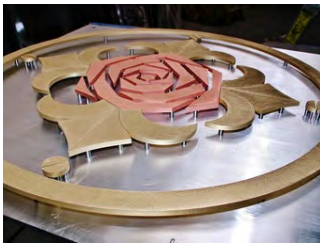


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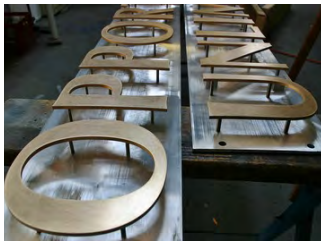





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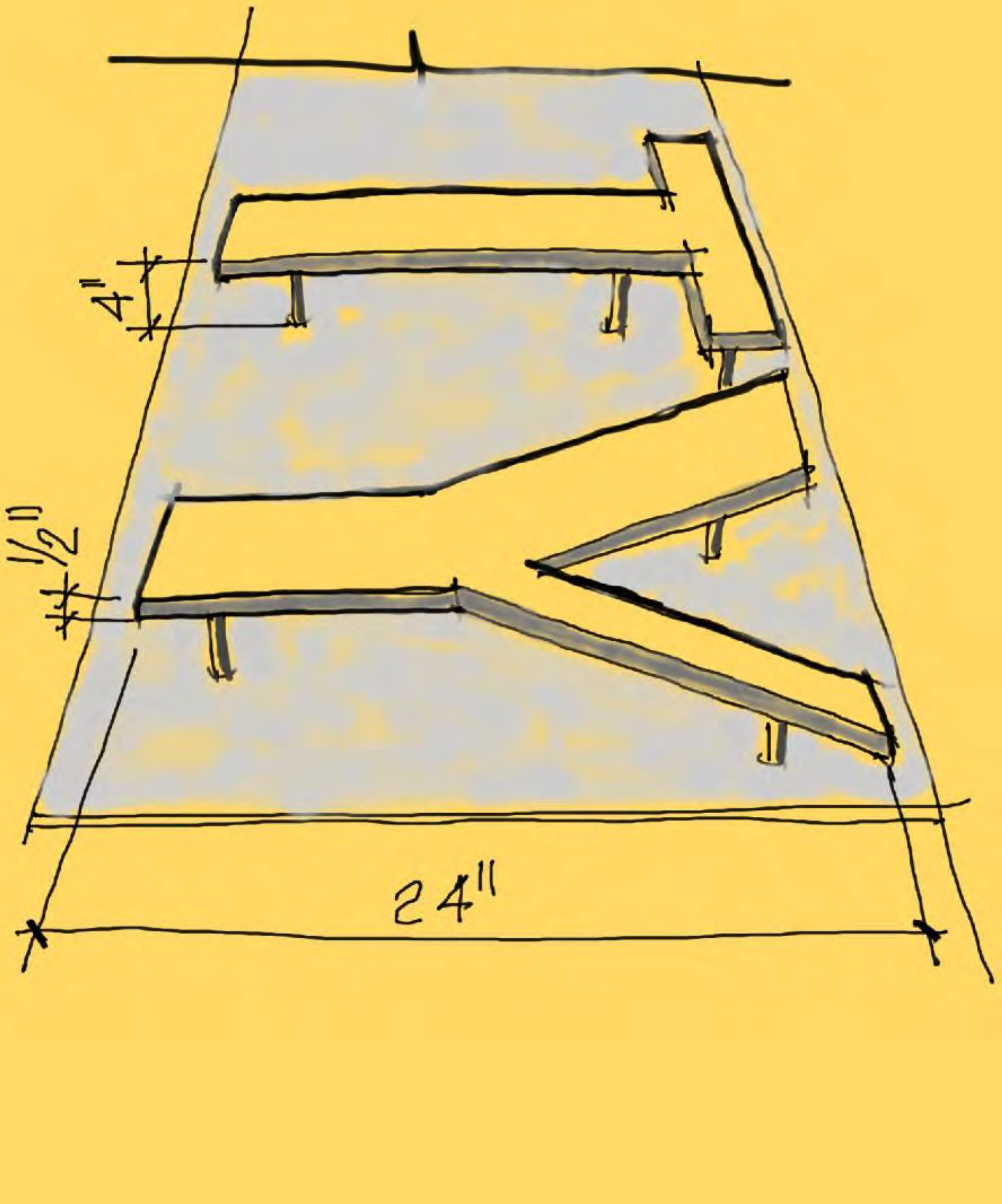
4"
1/2 11
24"

PORT OF BROWNSVILLE

the port that *works*

**From:** achavez@portofbrownsville.com,
**To:** arch1ruiz@aol.com,
**Cc:** arch2ruiz@aol.com, deymard@portofbrownsville.com, pesquivel@portofbrownsville.com,
**Subject:** Re: Port Anchor
**Date:** Fri, Dec 4, 2020 9:44 am

---

Roberto,

The font name is **Compacta Black**. You can download it for free and it is a TrueType font which will be HiRez regardless of size.

What image do you need in HiRez?

Ariel Chávez II
Sent from my iPhone

> On Dec 2, 2020, at 2:06 PM, ROBERTO J RUIZ <arch1ruiz@aol.com> wrote:
>
> Ariel,
> Can you please provide me with the name of the Port's font style and a high resolution image.
>
> Thanks.
>
> Roberto J. Ruiz, AIA
> Roberto J.Ruiz Architect Inc.
> 615 W. Tandy Road
> Brownsville Texas 78520
> (956) 350-9195 Office
> (956) 371-5787 Mobile
>
> Sent from my iPhone

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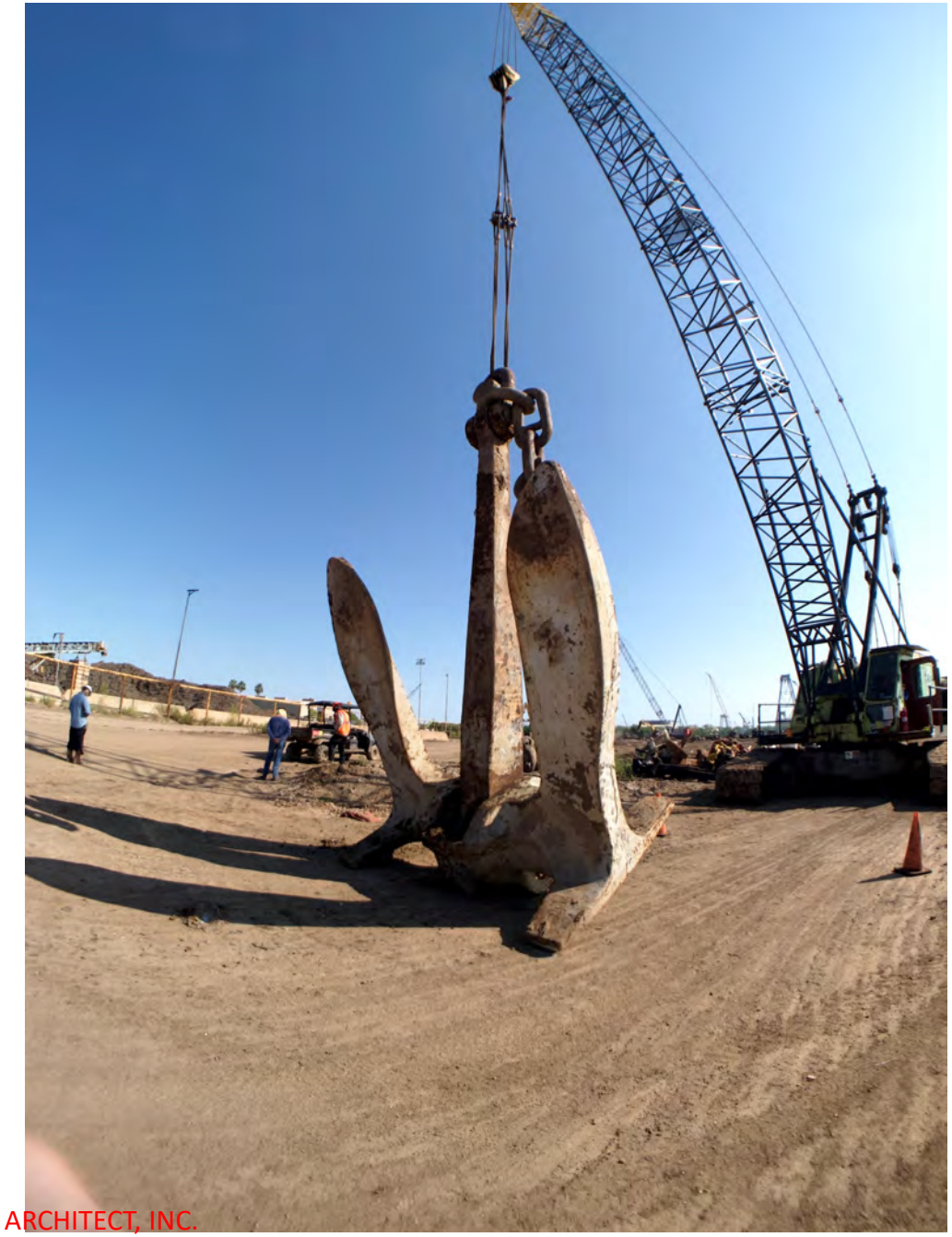
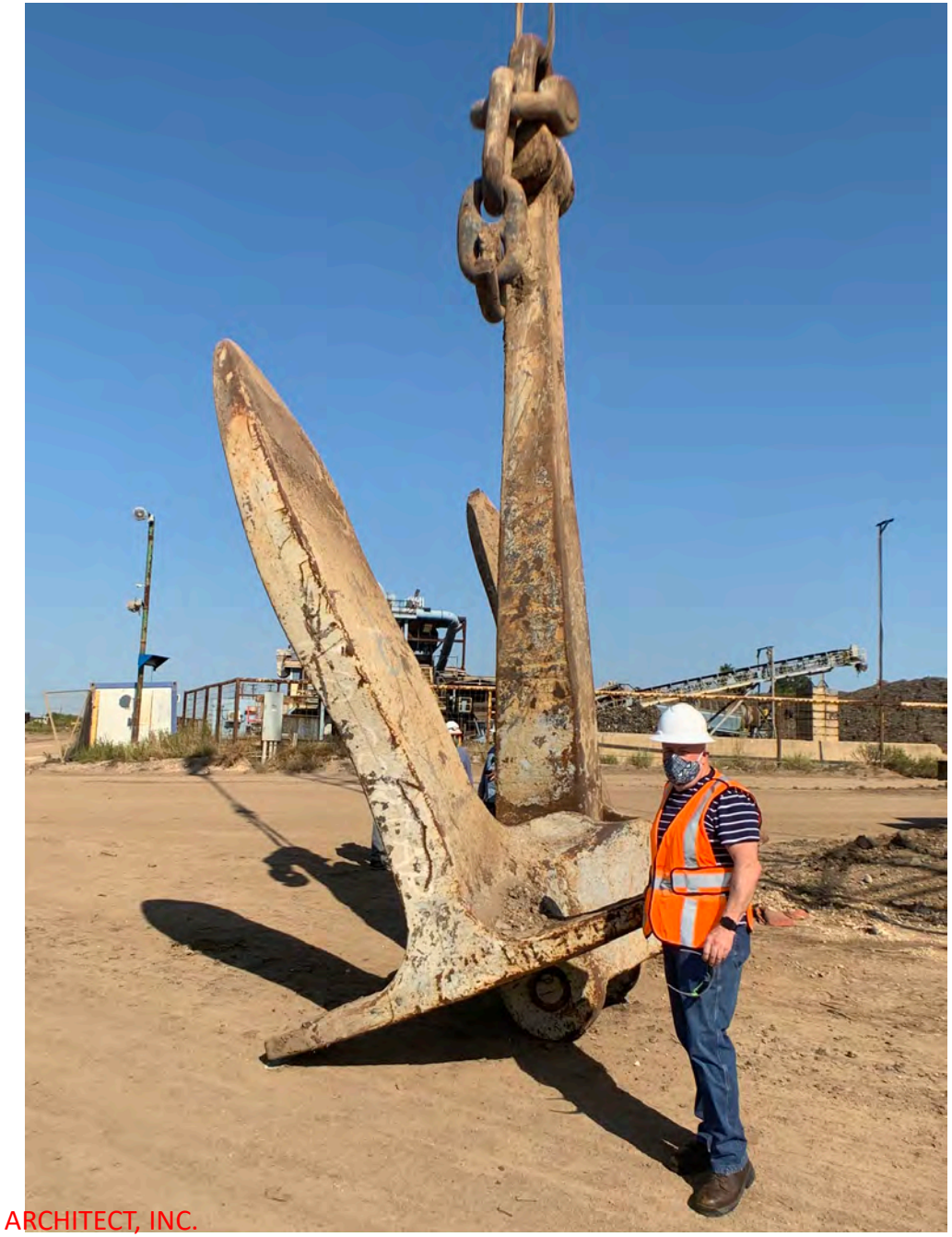
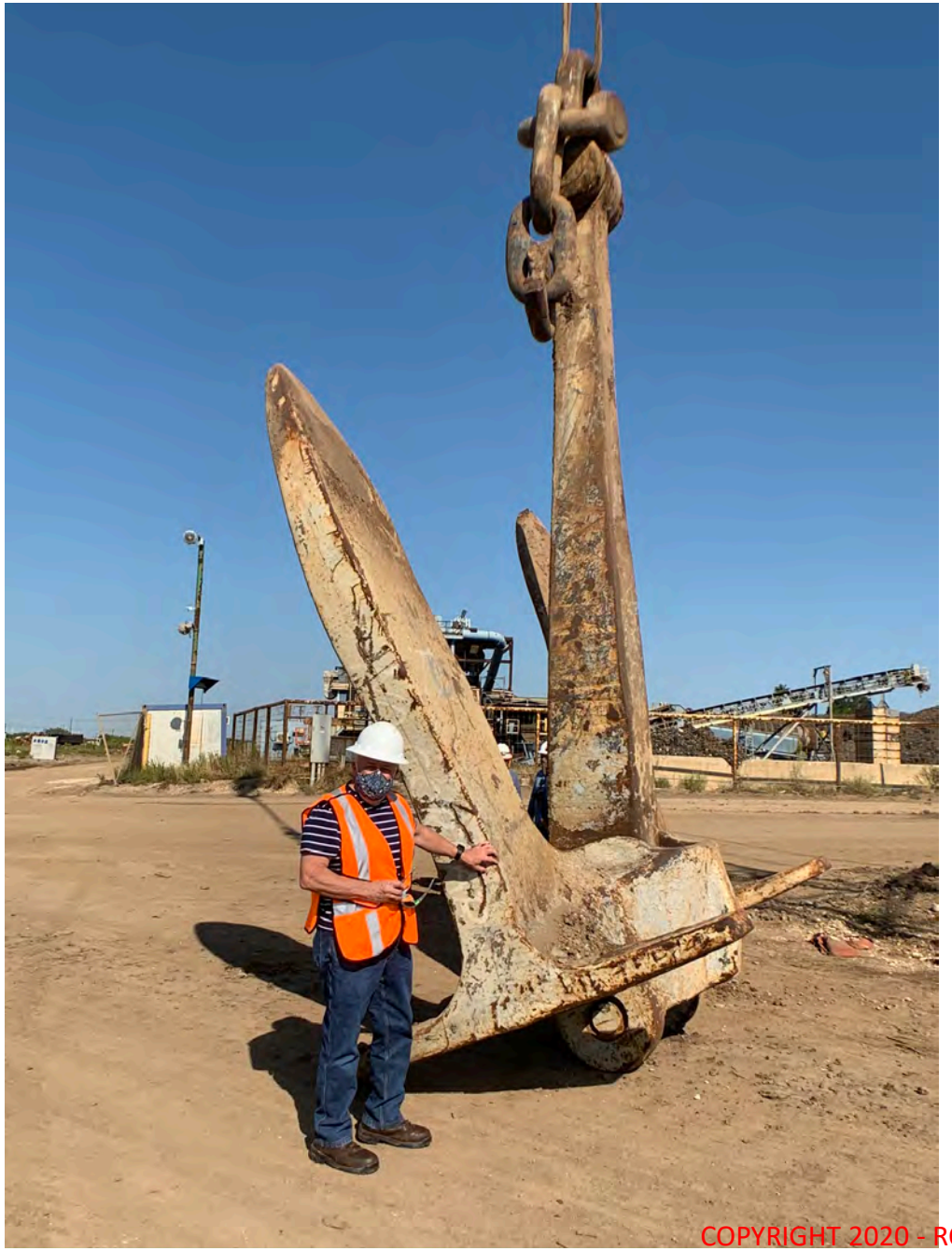
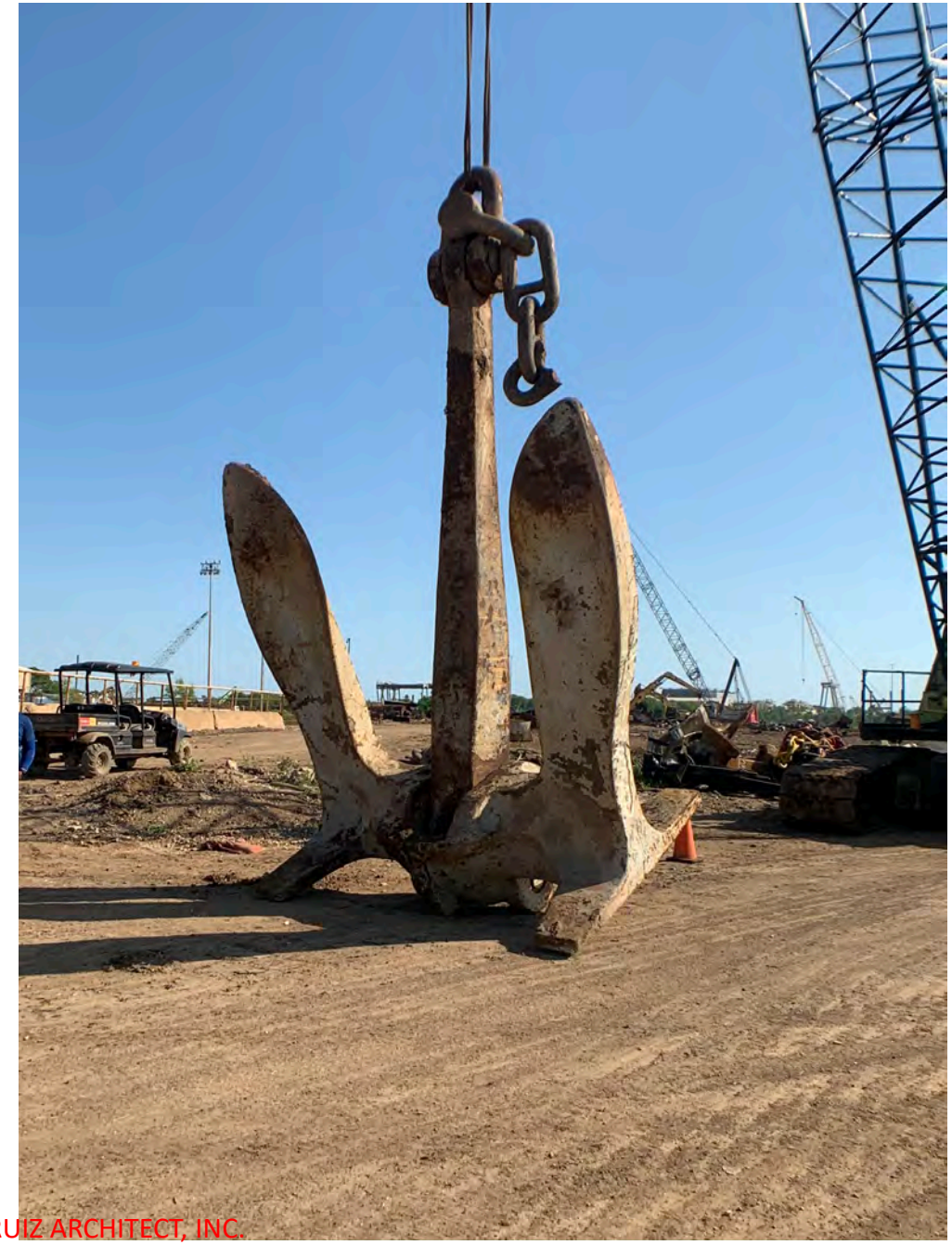
# PORT ANCHOR PARK

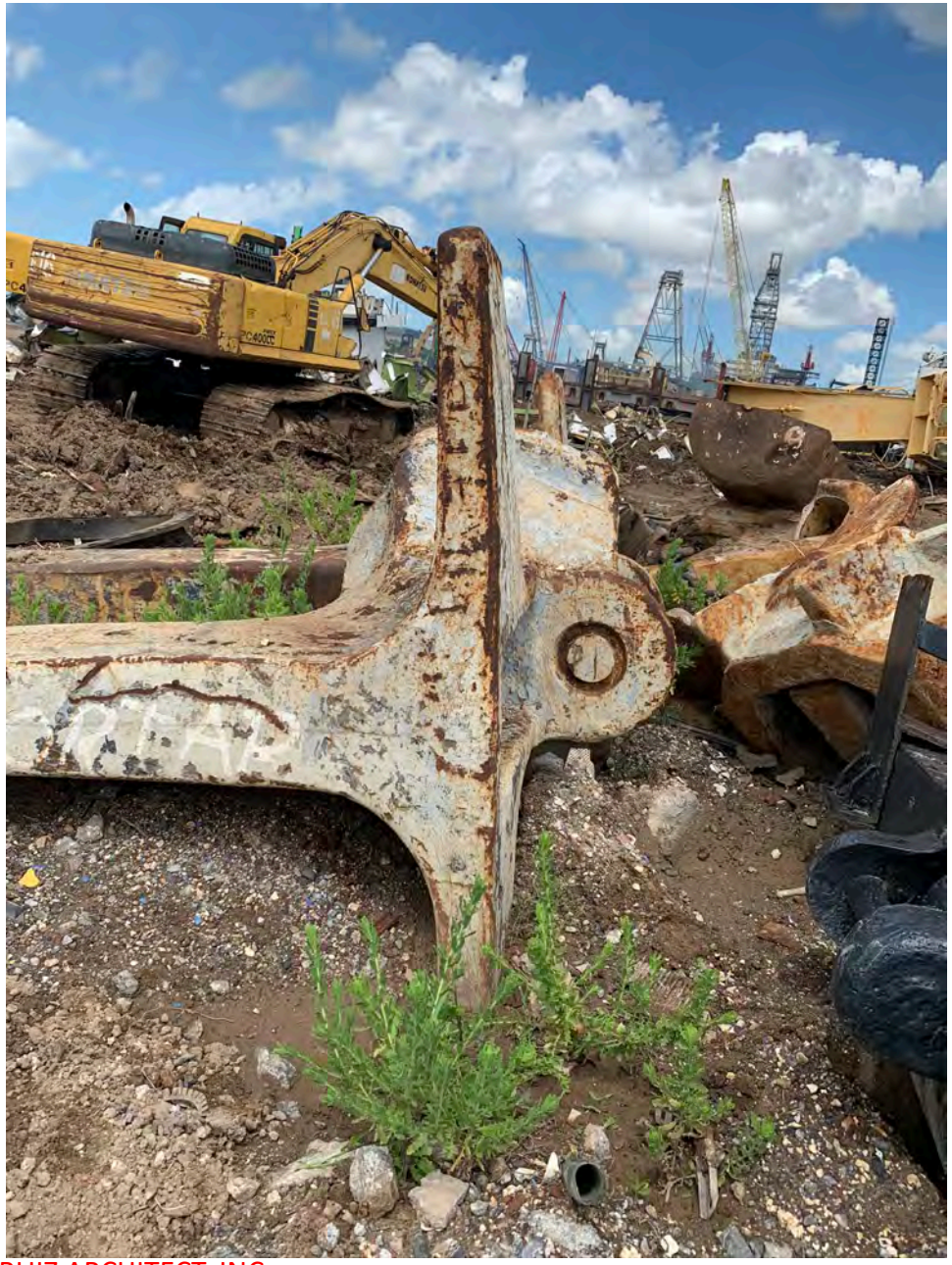
USS SARATOGA ANCHOR











# GEOTECHNICAL ENGINEERING REPORT

## Port of Brownsville Anchor Park
## Capt. Donald L Foust Road
## Brownsville, Texas

## PSI Project No. 03122187

**PREPARED FOR:**

**Brownsville Navigation District**
**1000 Capt. Donald L Foust Rd**
**Brownsville, TX 78526**

**December 4, 2020**

**BY:**

**PROFESSIONAL SERVICE INDUSTRIES, INC.**
**2020 N. Loop 499, Ste 302**
**Harlingen, Texas 78550**
**Phone: (956) 423–6826**
**Fax: (956) 423–5735**

Professional Service Industries, Inc.
2020 N. Loop 499, Ste 302
Harlingen, TX 78550
Office - 956.423.6826

December 4, 2020

**Brownsville Navigation District**
1000 Capt. Donald L Foust Rd
Brownsville, TX 78526

Attn: Mr. Ariel Chavez, P.E., R.P.L.S.

**RE: GEOTECHNICAL ENGINEERING REPORT**
**PORT OF BROWNSVILLE ANCHOR PARK**
**CAPT. DONALD L FOUST ROAD**
**BROWNSVILLE, TEXAS**
**PSI Project No. 03122187**

Dear Mr. Chavez:

Professional Service Industries, Inc. (PSI), an Intertek company, is pleased to submit this Geotechnical Engineering Report for the referenced project. This report includes the results of field and laboratory testing along with recommendations for use in preparation of the appropriate design and construction documents for this project.

PSI appreciates the opportunity to provide this Geotechnical Engineering Report and looks forward to continuing participation during the design and construction phases of this project. If there are any questions pertaining to this report, or if PSI may be of further service, please contact our office.

PSI also has great interest in providing materials testing and inspection services during the construction of this project. If you will advise us of the appropriate time to discuss these engineering services, we will be pleased to meet with you at your convenience.

Respectfully submitted,

***PROFESSIONAL SERVICE INDUSTRIES, INC.***
*Texas Board of Professional Engineers Certificate of Registration # F003307*

Rockford Miller, E.I.T.
Project Manager

Richard E. Webb, P.E.
Principal Consultant


December 4, 2020

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# 1.0 PROJECT INFORMATION

## 1.1 PROJECT AUTHORIZATION

Professional Service Industries, Inc., (PSI), an Intertek company, has completed a field exploration and geotechnical evaluation for the proposed Port of Brownsville Anchor Park project to be constructed on Capitan Donald L Foust Road in Brownsville, Texas. Mr. Ariel Chavez, P.E., R.P.L.S., representing Brownsville Navigation District, authorized PSI's services on November 3, 2020 by issuing Purchase Order No. PO74121 and with respect to PSI Proposal No. 325271-R1 dated November 2, 2020. PSI's proposal contained a proposed scope of work, fee, and PSI's General Conditions.

## 1.2 PROJECT DESCRIPTION

Based on information provided by the Mr. Roberto J. Ruiz, AIA, PSI's review of a site plan entitled Port of Brownsville Anchor Park dated September 30, 2016 and prepared by Roberto J. Ruiz Architect, Inc. A summary of the proposed project is presented in the following table.

**TABLE 1.1: GENERAL PROJECT DESCRIPTION**

| | |
|---|---|
| Project Items | 1 Anchor Monument, 4 Anchor Monument Walls at 7 Feet in Height, Asphalt Paving and Side Walk Areas |
| Requested or Anticipated Foundation Types | Anchor Monument: Mat Foundations<br>Anchor Monument Walls: Mat Foundation or Spread Footings |
| Finished Floor Elevation (FFE) of Anchor Monument | 15.50 feet |
| Anchor Monument Weight | 65,000 pounds |
| Anticipated Maximum Design Anchor Monument Wall Loads | 2.5 kips per Lineal Foot |
| Pavements | Flexible Asphalt (HMAC) and/or Rigid Concrete Pavement |

The geotechnical recommendations presented in this report are based on the available project information, structure locations, and the subsurface materials described in this report. If any of the noted information is incorrect, please inform PSI so that the recommendations presented in this report can be amended as necessary. PSI will not be responsible for the implementation of provided recommendations if not notified of changes in the project.

## 1.3 PURPOSE AND SCOPE OF SERVICES

The purpose of this study is to evaluate the subsurface conditions at the site and develop geotechnical engineering recommendations and guidelines for use in preparing the design and other related construction documents for the proposed project. The scope of services included drilling borings, performing laboratory testing, and preparing this geotechnical engineering report.

This report briefly outlines the available project information, describes the site and subsurface conditions, and presents the recommendations regarding the following:

- A review of surface topographical features, geologic features, and site conditions.

- Boring location plan and boring logs with laboratory test results of subsurface materials encountered including groundwater levels.
- Geotechnical discussion pertaining to subsurface conditions, expansive soils, variation of soil stratums and soil strengths, groundwater and other geotechnical related issues.
- Recommendations for site preparation and excavation, fill compaction, and the use of on-site and imported fill material under structures.
- Foundation recommendations for the proposed Anchor Monument and Wall structures.
- Seismic design site classification per the 2018 International Building Code.
- Recommendations for the design of flexible asphaltic and rigid concrete pavement systems for the proposed parking and drive areas.

The scope of services for this geotechnical exploration did not include an environmental, mold nor detailed seismic/fault assessment for determining the presence or absence of wetlands, or hazardous or toxic materials in the soil, bedrock, surface water, groundwater, or air on or below, or around this site. Any statements in this report or on the boring logs regarding odors, colors, and unusual or suspicious items or conditions are strictly for informational purposes.

# 2.0 SITE AND SUBSURFACE CONDITIONS

## 2.1 SITE DESCRIPTION

The following table provides a generalized description of the existing site conditions based on visual observations during the field activities and other available information.

**TABLE 2.1: SITE DESCRIPTION**

| | |
|---|---|
| Site Location | Capt. Donald L Foust Rd, Port of Brownsville<br>Brownsville, Texas<br>Approximate GPS Coordinates<br>WGS84 (Latitude: 25.9516°, Longitude: -97.4114°) |
| Site History | Previously used as a construction lay down yard, before that, the site was an open field |
| Existing Site Ground Cover | Grass with spare gravels at surface |
| Existing Grade/Elevation Changes | Relatively level |
| Site Boundaries/Neighboring Development | North: Open Field<br>East: Open Field<br>South: Brownsville Navigation District<br>West: Brownsville Fire Department Station 8 |

## 2.2 FIELD EXPLORATION

Field exploration for the project consisted of drilling a total of six (6) borings. The boring design element, boring labels, and approximate depths are provided in the following table.

**TABLE 2.2: FIELD EXPLORATION SUMMARY**

| Design Element | Boring Label | Approx. Depth of Boring |
|---|---|---|
| Anchor Monument | B-1 | 20 feet |
| Anchor Walls Monument | B-2 | 6 feet |
| Portable Event Tent | B-4 | 6 feet |
| Side Walks and Pavements | B-4 | 6 feet |

The boring locations were selected by the client and were located in the field by the client. The State Plane Coordinates and elevations of the boring locations were provided by the client and are noted on the boring logs. The approximate boring locations are shown on the Boring Location Plan provided in the Appendix.

**TABLE 2.3: FIELD EXPLORATION DESCRIPTION**

| | |
|---|---|
| Drilling Equipment | Truck-Mounted Drilling Equipment |
| Drilling Method | Continuous-Flight Auger |
| Drilling Procedure | Applicable ASTM and PSI Safety Manual |
| Field Testing Procedures | Standard Penetration Test (ASTM D1586) |
| Sampling Procedure | Split-Barrel Sampling of Soils (ASTM D1586) |

| | |
|---|---|
| Frequency of Groundwater Level Measurements | Initial Reading and After Drilling Reading |
| Boring Backfill Procedures | Soil Cuttings |
| Sample Preservation and Transportation Procedure | General accordance with ASTM D4220 |

During the field activities, the encountered subsurface conditions were observed, logged, and visually classified (in general accordance with ASTM D2488). Field notes were maintained to summarize soil types and descriptions, water levels, changes in subsurface conditions, and drilling conditions.

During our field drilling activities ponding water was observed near B-2 adjacent to Captain Donald Foust Road. The cause of the ponding water is unknown and should be further investigated by others.

## 2.3 LABORATORY TESTING PROGRAM

PSI supplemented the field exploration with a laboratory testing program to determine additional engineering characteristics of the subsurface soils encountered. The laboratory testing program included:

- Moisture Content Tests (ASTM D2216)
- Atterberg Limits (ASTM D4318)
- Material Finer than No. 200 (ASTM D1140)

The laboratory testing program was conducted in general accordance with applicable ASTM test methods. The results of the laboratory tests are provided in the Appendix on the Logs of Boring. Portions of samples not altered or consumed by laboratory testing will be retained for 60 days from the date shown this report and will then be discarded.

## 2.4 SITE GEOLOGY

As shown on the Geologic Atlas of Texas, McAllen-Brownsville Sheet, reprinted in 1979, the site is located in an area where the **Alluvium Deposits (Qam)** formation is mapped at or near the ground surface. The Alluvium Deposits are floodplain deposits of the lower course of Rio Grande and are divided into areas dominantly silt and sand with elements of clay, gravel, and organic matter.

## 2.5 SUBSURFACE CONDITIONS

The results of the field and laboratory testing have been used to develop a generalized surface profile of the project site. The following subsurface descriptions highlight the major subsurface stratification features and material characteristics. This soil profile descriptions have been summarized in the following table.

**TABLE 2.4: GENERALIZED SOIL PROFILE**

| Layer | Depth of Layer (ft) Top | Bot. | Soil Type | Avg. ω (%) | Avg. LL (%) | Avg. PI | Range % Pass. #200 | Avg. SPT N-Value |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 14 | Fat Clay & Fat Clay w/ Sand | 25 | 60 | 41 | 76 - 96 | 6 |
| 2 | 14 | 20 | Clayey Sand | 27 | - | - | 25 - 37 | 6 |

Note: ω: Moisture Content
LL: Liquid Limit
PI: Plasticity Index
% Pass. #200: Percent Passing the No. 200 Sieve by Wash
SPT N-Value: Standard Penetration Test N-Value (blows per foot)

Approximately 1½ feet of clayey sand with gravel was encountered at the ground surface at boring location B-1. These soils are believed to be remnants of the construction lay down yard used for the construction of Brownsville Navigation District Permit and Records Building.

The boring logs included in the Appendix should be reviewed for information at the boring locations. The boring logs include soil descriptions, stratifications, locations of the samples, and field and laboratory test data. The stratifications shown on the boring logs only represent the conditions the specific boring location and represent the approximate boundaries between subsurface materials. The actual transitions between strata may be more gradual or more distinct. Variations will occur and should be expected across the site.

### *2.5.1 GROUNDWATER INFORMATION*

Water level measurements were performed during drilling and after completion of drilling. Specific information concerning groundwater is noted on each boring log presented in the Appendix of this report. The groundwater measurements are summarized in the following table.

**TABLE 2.5: GROUNDWATER LEVELS (DEPTHS)**

| Boring Designation | Boring Depth (feet) | During Drilling (feet) | After Drilling (feet) |
|---|---|---|---|
| B-1 | 20 | 8 | 6 |
| B-2 | 6 | Not encountered | None |
| B-3 | 6 | Not encountered | None |
| B-4 | 6 | Not encountered | None |

Groundwater levels fluctuate seasonally as a function of rainfall, proximity to creeks, rivers and lakes, the infiltration rate of the soil, seasonal and climatic variations and land usage. If more detailed water level information is required, observation wells or piezometers could be installed at the site, and water levels could be monitored.

The groundwater levels presented in this report are the levels that were measured at the time of our field activities. The contractor should be prepared to control groundwater, if encountered, during construction.

# 3.0 GEOTECHNICAL EVALUATION AND RECOMMENDATIONS

## 3.1 GEOTECHNICAL DISCUSSION

Based upon the information gathered from the soil borings and laboratory testing, the clay soils encountered at this site within the seasonally active zone (estimated to be 6 feet below existing grade) have a high potential for expansion. In addition, these soils are also firm to soft in stiffness and possess low shear strength and moderate to high potential for settlement. The potential for vertical movement (either expansion or settlement) of these soils should be addressed in the design and construction of this project to reduce the potential for foundation movements.

PSI recommends an improved foundation pad under Anchor Monument foundation to reduce the potential for foundation movement. PSI recommends a portion of the Layer 1 fat clay soils be removed and replaced with a geogrid reinforced, crushed limestone select fill material. Upon completion of the improved foundation pad, PSI recommends the Anchor Monument be supported using a mat foundation.

PSI recommends the Anchor Walls be supported using shallow footings with an improved foundation.

PSI understand that approximately 2 feet of fill will be place over the entire site to raise grade and match the finished floor elevation of the existing Brownsville Navigation District Records and Permit Building. The increase in finished grade has been considered in our analyses and recommendations.

The following design recommendations have been developed based on the previously described project characteristics and subsurface conditions encountered. If there are changes in the project criteria, PSI should be retained to review the changes to determine if modifications of the recommendations presented in this report will be required. The findings of such a review will be presented in a supplemental report. Once final design plans and specifications are available, a general review by PSI is recommended to verify that the earthwork and foundation recommendations were properly interpreted and implemented within the construction documents.

## 3.2 POTENTIAL VERTICAL MOVEMENT OF EXPANSIVE SOILS

The soils encountered at the soil boring locations exhibit a high potential for volumetric changes, due to fluctuations in soil moisture content. PSI has conducted laboratory testing on the soils to estimate the expansive soil potential with soil moisture variations. These soil moisture variations are based on historical climate change data. Determining the soil potential for shrinking and swelling, combined with historical climate variation, aids the engineer in quantifying the soil movement potential of the soils supporting the shallow foundations. Various shrink/swell movement procedures were used to estimate the Potential Vertical Movement (PVM) for this location.

### *3.2.1 SHRINK/SWELL MOVEMENT (PVM) ESTIMATE*

Based on laboratory testing results and our analyses, the potential vertical movement within the proposed project area was estimated to be approximately **2 inches.**

The unknown factors previously mentioned cannot be determined at the time of the geotechnical study. Therefore, estimated shrink/swell movements are calculated only in consideration of historical climate data related to soil moisture variations. Movements exceeding those estimated should be anticipated and routine maintenance should be provided to address these issues throughout the life of the structure.

## 3.3 FOUNDATION DISCUSSION

Based on information obtained during the field operations, results of the laboratory testing and engineering analyses, the existing near surface subgrade soils exhibit low shear strengths with a moderate to high settlement potential and possess a high potential for expansive soil-related movements (PVM) within the seasonally active moisture zone. To support the proposed Anchor Monument and Wall foundations, PSI recommends that improved foundation pads be constructed to increase the bearing capacity of the soils, reduce the potential for settlement and reduce the potential for PVM.

The improved foundation pads should be reinforced with geogrid and constructed with crushed limestone select fill soils placed in controlled and moisture conditioned compacted lifts. More specific recommendations for construction of the foundation pads are presented in the following sections.

### *3.3.1 EARTHWORK RECOMMENDATIONS FOR FOUNDATION PADS*

Foundation pad improvement should consist of removing the upper soils to the recommended minimum over-excavation depth, compacting the exposed subgrade, and placement and compaction of the select fill to finish tank floor grade. The following table provides recommendations for the construction of the foundation pad.

**TABLE 3.1: EARTHWORK RECOMMENDATIONS**

| | |
|---|---|
| Site Stripping Removal | Upper 6 inches of organics and deleterious material including debris to expose clean subgrade |
| Foundation Improvement Method | Remove and replace existing soils with select fill |
| Minimum Over-Excavation | Anchor Monument: 5 feet below existing grade elevation<br>Anchor Walls: 2 feet below bottom of foundations |
| Horizontal Undercut Extent | Below the foundation area and at least 2 feet beyond the foundation perimeter |
| Anchor Monument Geogrid Recommendations | Place 1 layer of Tensar TriAx TX5 geogrid on exposed subgrade prior to placing select fill.<br>Place 2 additional layers of Tensar TriAx TX5 equally spaced within the select fill |
| Anchor Walls Geogrid Recommendations | Place 1 layer of Tensar TriAx TX5 on exposed subgrade prior to placing select fill |
| Exposed Subgrade Treatment | Scarify, moisture condition, and compact 9 inches of exposed subgrade |
| Select Fill Thickness | Anchor Monument: Minimum 5 feet<br>Anchor Walls: Minimum 2 feet |
| Select Fill Material | TxDOT Item 247 (Crushed Limestone Material)<br>Type A or B<br>Grade 1-2 or 3 |
| Maximum Loose Lift Thickness | 8 inches |
| Time Between Subgrade Prep. and Select Fill Placement | Less than 48 hours |

## 3.4 COMPACTION AND TESTING RECOMMENDATIONS FOR FOUNDATION PAD AREAS

The following table outlines foundation pad compaction and testing recommendations.

**TABLE 3.2: COMPACTION RECOMMENDATIONS FOR UNDERCUT AND REPLACE METHOD**

| Location | Material | Test Method for Density Determination | Percent Compaction | Optimum Moisture Content | Testing Frequency |
|---|---|---|---|---|---|
| **Foundation Pad Areas** | Subgrade Soil (Base of excavation) | ASTM D698 | ≥ 98% | 0 to +4% | 1 per 5,000 SF |
| | Select Fill (Pit Run) | ASTM D698 | ≥ 98% | -1 to +3% | 1 per 5,000 SF; min. 3 per lift |

## 3.5 FOUNDATION DESIGN RECOMMENDATIONS

### *3.5.1 ANCHOR MONUMENT MAT FOUNDATION RECOMMENDATIONS*

PSI recommends that the Anchor Monument be supported on a shallow mat foundation. The following table provides parameters for use in the design of a shallow mat or footing foundation.

**TABLE 3.3: SHALLOW MAT FOUNDATION DESIGN PARAMETERS**

| | |
|---|---|
| Foundation Depth Range | 2 feet below final adjacent grade |
| Allowable Bearing Pressure | 2,000 psf |
| Approximate PVM | 1 inch or less |
| Approximate Settlement | 1 inch |
| Minimum Diameter of Mat Foundation | 10 feet |
| Modulus of Subgrade Reaction ($k_1$) | 100 pci |
| Sliding Resistance (ultimate) | Utilize a coefficient of friction of 0.35 between the base of the foundation element and underlying material |
| Passive Resistance (ultimate) | An equivalent fluid weighing 360 pcf may be used to resist lateral forces |
| Uplift Resistance (ultimate) | Utilize the weight of the foundation concrete and the soil above it. The ultimate uplift resistance can be based on effective unit weights of 110 and 150 pcf for soil and concrete, respectively |
| Exposed Subgrade Treatment | Free of soft/loose soil, wet materials, and debris. The Geotechnical Engineer's representative should observe the bearing surface prior to forming footings. |
| Adjacent Foundations | Closely spaced isolated footings may have overlapping stress distribution zones. PSI should review foundation schedules and drawings for isolated footing designs. |

### *3.5.2 ANCHOR WALL SHALLOW FOOTING FOUNDATION RECOMMENDATIONS*

**TABLE 3.4: SPREAD FOOTING DESIGN PARAMETERS**

| | |
|---|---|
| Footing Foundation Depth Range | 2 feet below final adjacent grade |
| Allowable Bearing Pressure | 1,500 psf |
| Factor of Safety | 3.0 |
| Approximate PVM | 1 inch or less |
| Approximate Settlement | Approximately 1 inch |
| Minimum Width of Spread Footing | 24 inches |
| Sliding Resistance (ultimate) | Utilize a coefficient of friction of 0.35 between the base of the foundation element and underlying material |
| Passive Resistance (ultimate) | An equivalent fluid weighing 360 pcf may be used to resist lateral forces |
| Uplift Resistance (ultimate) | Utilize the weight of the foundation concrete and the soil above it. The ultimate uplift resistance can be based on effective unit weights of 110 and 150 pcf for soil and concrete, respectively |
| Footing Exposed Subgrade Treatment | Free of soft/loose soil, wet materials, and debris. Geotechnical Engineer's representative should observe bearing surface prior to forming footings. |
| Adjacent Foundations Minimum Spacing | Min. Spacing = 4·W + L<br><br>Where; W = Width of Largest Footings<br>L = Difference in Bottom of Footing Elevation |

## 3.6 SITE SEISMIC DESIGN RECOMMENDATIONS

For the purposes of seismic design, based on the encountered site conditions and local geology, PSI interpreted the subsurface conditions to satisfy the **Site Class E** criteria for use at this site as defined by the International Building Code (IBC). The site class is based on the subsurface conditions encountered at the soil borings, the results of field and laboratory testing, experience with similar projects in this area, and considering the site prepared as recommended herein. The table below provides recommended seismic parameters for the project based on the 2018 edition of the IBC.

**TABLE 3.5: RECOMMENDED DESIGN SEISMIC PARAMETERS**

| Seismic Parameter | IBC 2018 |
|---|---|
| 0.2 sec ($S_S$) | 0.037g |
| 1.0 sec ($S_1$) | 0.012g |
| Site Coefficient 0.2sec, $F_a$ | 2.4 |
| Site Coefficient 1.0 sec, $F_v$ | 4.2 |
| 0.2 sec ($S_{DS}$) | 0.059g |
| 1.0 sec ($S_{D1}$) | 0.035g |

# 4.0 PAVEMENT DESIGN RECOMMENDATIONS

## 4.1 PAVEMENT DESIGN PARAMETERS

PSI understands that flexible and rigid pavements will be considered for this project. Therefore, pavement design recommendations for several levels of traffic loading were developed based on assumptions of potential traffic, drive paths or patterns and anticipated soil support characteristics of pavement subgrades. PSI utilized the "AASHTO Guide for Design of Pavement Structures" published by the American Association of State Highway and Transportation Officials to evaluate the pavement thickness recommendations in this report. This method of design considers pavement performance, traffic, roadbed soil, pavement materials, environment, drainage and reliability. Each of these items is incorporated into the design methodology. PSI is available to provide laboratory testing and engineering evaluation to refine the site specific design parameters and sections, upon request.

Specific design traffic types and volumes for this project were not available to PSI at the issuance of this report. This traffic information is typically used to determine the number of 18-kip Equivalent Single Axle Loads (ESAL) that is applied to the pavement over its design life. Furthermore, the scope of services for this project did not include California Bearing Ratio (CBR) testing. In lieu of project specific design parameters, general traffic and subgrade parameter assumptions were used for this design. Based on this information, PSI has provided recommended pavement sections for "light-duty" and "heavy-duty" pavements constructed on stable and properly prepared/compacted subgrades. Flexible pavement options with and without geogrid options are also provided for consideration. Details regarding the basis for this design are presented in the table below.

**TABLE 4.1: PAVEMENT DESIGN PARAMETERS AND ASSUMPTIONS (RIGID AND FLEXIBLE)**

| | |
|---|---|
| **Reliability, percent** | 75 |
| **Initial Serviceability Index, Flexible Pavement** | 4.2 |
| **Initial Serviceability Index, Rigid Pavement** | 4.5 |
| **Terminal Serviceability Index** | 2.0 |
| **Traffic Load for Light-Duty Pavement** | 15,000 equivalent single axle loads (ESALs) |
| **Traffic Load for Heavy-Duty Pavement** | 150,000 equivalent single axle loads (ESALs) |
| **Standard Deviation, Flexible Pavement** | 0.45 |
| **Standard Deviation, Rigid Pavement** | 0.35 |
| **Concrete Compressive Strength** | 4,000 psi |
| **Subgrade California Bearing Ratio (CBR)** | 2.0 for high plasticity clay subgrade |
| **Subgrade Modulus of Subgrade Reaction, k in pci** | 75 for high plasticity clay subgrade |

Pavements supported on expansive soils will be subject to PVM previously presented. These soil movements typically occur to some degree over the life of the pavement. Consequently, pavements can be expected to crack and require periodic maintenance.

Light-duty areas include parking and drive lanes that are subjected to passenger vehicle traffic only and exclude entrance aprons and general and single access roadway drives to the parking lot area.

Heavy-duty areas include entrance aprons, general and single access roadway drives to the parking lot area, areas subjected to fire trucks, 18-wheel tractor trailers, including loading and unloading areas, and areas where truck turning, and maneuvering may occur.

During the paving life, maintenance to seal surface cracks within concrete or asphalt paving and to reseal joints within concrete pavement should be undertaken to achieve the desired paving life. Perimeter drainage should be controlled to prevent or retard influx of surface water from areas surrounding the paving. Water penetration leads to paving degradation. Water penetration into base or subgrade materials, sometimes due to irrigation or surface water infiltration leads to pre-mature paving degradation. Curbs should be used in conjunction with asphalt paving to reduce potential for infiltration of moisture into the base course. Curbs should extend the full depth of the base course and should extend at least 3 inches into the underlying clayey subgrade.

Material specifications, construction considerations, and thickness section recommendations are presented in following sections.

The presented recommended pavement sections are based on the field and laboratory test results for the project, local pavement design practice, design assumptions presented herein and previous experience with similar projects. The project Civil Engineer should verify that the ESAL and other design values are appropriate for the expected traffic and design life of the project. PSI should be notified in writing if the assumptions or design parameters are incorrect or require modification.

## 4.2 PAVEMENT SECTION RECOMMENDATIONS

PSI is providing parking and drive area sections based on experience with similar facilities constructed on similar soil conditions for the design traffic loading anticipated.

### *4.2.1 FLEXIBLE PAVEMENT*

Recommendations for flexible asphaltic concrete pavement are provided below.

**TABLE 4.2: FLEXIBLE PAVEMENT ROADWAY AND PARKING AREA SECTION OPTIONS**

| Material | Option 1 | | Option 2 | |
|---|---|---|---|---|
| Traffic Type | Light | Heavy | Light | Heavy |
| Hot Mix Asphaltic Concrete | 2” | 3” | 2” | 3” |
| Flexible Base | 7” | 10” | 7” | 10” |
| Lime Stabilized Subgrade | 8” | | No | |
| Geogrid | No | | Yes | |
| Compacted Subgrade | — | | 8” | |

### *4.2.2 RIGID PAVEMENT*

Recommendations for rigid concrete pavement are provided below.

**TABLE 4.3: RIGID PAVEMENT ROADWAY AND PARKING AREA SECTION OPTIONS**

| Material | Option 1 | | Option 2 | |
|---|---|---|---|---|
| Traffic Type | Light | Heavy | Light | Heavy |
| Portland Cement Concrete | 5” | 7” | 5” | 7” |
| Flexible Base | — | — | 6” | 6” |
| Lime Stabilized Subgrade | 8” | | No | |
| Compacted Subgrade | — | | 8” | |

### *4.2.3 GENERAL PAVEMENT DESIGN AND CONSTRUCTION RECOMMENDATIONS*

**TABLE 4.4: PAVEMENT DESIGN AND CONSTRUCTION RECOMMENDATIONS**

| | |
|---|---|
| Minimum Undercut Depth | 6 inches or as needed to remove roots |
| Reuse Excavated Soils | Free of roots and debris and meet material requirements of intended use |
| Undercut Extent | 2 feet beyond the paving limits |
| Exposed Subgrade Treatment | Proof-roll with rubber-tired vehicle weighing at least 20 tons. A representative of the Geotechnical Engineer should be present during proof-roll. |
| Proof-Rolled Pumping and Rutting Areas | Excavate to firmer materials and replace with compacted general or select fill under direction of a representative of the Geotechnical Engineer |
| General Fill | Materials free of roots, debris, and other deleterious materials with a maximum rock size of 4 inches with a CBR greater than 3 |
| Minimum General Fill Thickness | As required to achieve grade |
| Maximum General Fill Loose Lift Thickness | 9 Inches |
| Lime Stabilization | Performed in general accordance with TxDOT Item 260. Soils stabilized with lime should achieve a pH of 12.4 or greater. Sulfate testing should be conducted before placement of lime. For budgeting purposes, 6% hydrated lime by dry weight. Actual lime content should be determined by lime series testing after the pavement subgrade is established. |
| Geogrid | Geogrid must meet TxDOT Item DMS - 6240. Subgrade should be leveled and smoothed prior to geogrid placement on compacted subgrade. |
| Flexible Base | TxDOT Item 247, Type A, Grade 1-2 |
| Maximum Flexible Base Loose Lift Thickness | 9 Inches |
| Hot Mix Asphaltic Concrete | TxDOT Item 340, Type D |
| Concrete Minimum Recommended Strength | 4,000 psi (avg. 28-day comp. strength) |
| Concrete Minimum Reinforcement | No. 3 bars, 18 inches on-center each way<br>Located in top half of concrete section<br>Minimum 2 inches cover |

| | |
|---|---|
| Concrete Construction Joint Minimum Reinforcement | ¾-inch diameter dowels<br>14 inches long<br>Spaced 12 inches on-center along the joint |
| Contraction Joint Spacing<br>**(In General Accordance with ACI 330)** | Maximum joint spacing should be less than 30 times the thickness of the concrete pavement or 15 feet, whichever is smaller. |

**TABLE 4.5: COMPACTION AND TESTING RECOMMENDATIONS FOR PAVEMENT AREAS**

| Location | Material | Test Method for Density Determination | Percent Compaction | Optimum Moisture Content | Testing Frequency |
|---|---|---|---|---|---|
| **Pavement Areas** | Scarified On-site Soil (Subgrade) | ASTM D 698 | ≥ 95% | 0 to +4% | 1 per 7,500 SF; min. 3 tests |
| | General Fill (Onsite Material) | ASTM D 698 | ≥ 95% | 0 to +4% | 1 per 10,000 SF; min. 3 per lift |
| | Flexible Base Material | ASTM D 1557 | ≥ 95% | ±3% | 1 per 5,000 SF; min. 3 per lift |

# 5.0 CONSTRUCTION CONSIDERATIONS

PSI should be retained to provide observation and testing of construction activities involved in the foundations, earthwork, pavements and related activities of this project. PSI cannot accept any responsibility for any conditions which deviate from those described in this report, nor for the performance of the foundations or pavements if not engaged to also provide construction observation and materials testing for this project. The PSI geotechnical engineer-of-record should be retained to provide continuing geotechnical consulting services and construction document review, even if periodic on-call testing is contracted with PSI Construction Services.

## 5.1 INITIAL SITE PREPARATION CONSIDERATIONS

### *5.1.1 SUBGRADE PREPARATION FOR SITE WORK OUTSIDE FOUNDATION PAD AND PAVEMENT AREAS*

Grade adjustments outside of the foundation pads and pavement areas can be made using select or general fill materials. The clean excavated onsite soils may also be reused in areas not sensitive to movement.

**TABLE 5.1: SUBGRADE PREPARATION FOR NON-STRUCTURAL - GENERAL FILL**

| | |
|---|---|
| Minimum Undercut Depth | 6 inches or as needed to remove roots, organic and/or deleterious materials |
| Exposed Subgrade Treatment | Proof-roll with rubber tired vehicle weighing at least 20 tons. A representative of the Geotechnical Engineer should be present during proof-roll. |
| Proof-Rolled Pumping and Rutting Areas | Excavate to firmer materials and replace with compacted general or select fill under direction of a representative of the Geotechnical Engineer |
| General Fill Type | Clean material free of roots, debris and other deleterious material with a maximum particle size of 4 inches |
| Maximum General Fill Loose Lift Thickness | 8 inches |

**TABLE 5.2: FILL COMPACTION RECOMMENDATIONS OUTSIDE OF FOUNDATION AND PAVEMENT AREAS**

| Location | Material | Test Method for Density Determination | Percent Compaction | Optimum Moisture Content | Testing Frequency |
|---|---|---|---|---|---|
| Outside of Structure or Pavement Areas | General Fill | ASTM D698 | ≥ 95% | 0 to +4% | 1 per 10,000 SF; min. 3 per lift |

### *5.1.2 EXISTING SITE CONDITIONS*

The following table outlines construction considerations in consideration of demolition of existing structures, demolition of existing paving, procedures for abandoning old utility lines and removing trees.

**TABLE 5.3: CONSIDERATIONS FOR DEMOLITION**

| Existing Structures | |
|---|---|
| Foundations of former structures located below new structures | Impact of foundation of former structures should be evaluated on a case by case basis |
| Foundations for former structures located below new paving | Cut off at least 3 feet below finished paving grade |

| | |
|---|---|
| **Existing Pavement** | |
| Former paving located within below new structures | Remove concrete and/or HMAC surface course and base entirely or review impact on case by case basis |
| Former paving located within footprint of proposed new paving | Remove concrete and/or HMAC surface course and evaluate if base can be reused |
| **Abandoned Utilities** | |
| Utilities of former structures located within new foundation pad/footprint of proposed structures | Remove pipe, bedding and backfill and then replace with select fill placed using controlled compaction |
| Utilities of former structures located outside new foundation pad/footprint of proposed structures | Abandon in place using a grout plug |
| **Tree Removal** | |
| Trees located within proposed structure footprints; roadways, parking, and sidewalk areas; and 5 feet of structure areas | Remove root system for full vertical and lateral extent and extend removal for at least 3 feet beyond presence of any root fragment and replace void with compacted general fill or flowable fill |

## 5.2 MOISTURE SENSITIVE SOILS/WEATHER RELATED CONCERNS

The soils encountered are sensitive to disturbances caused by construction traffic and changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. In addition, soils which become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. It will, therefore, be advantageous to perform earthwork, foundation, and construction activities during dry weather.

## 5.3 BUILDING FOUNDATION EXCAVATION OBSERVATIONS

The foundation excavations should be observed by a representative of PSI prior to reinforcing steel or concrete placement to assess that the foundation materials are consistent with the materials discussed in this report. This is especially important to identify the condition and acceptability of the exposed subgrades under the foundation. Soft or loose soil zones encountered at the bottom of the beam excavations should be removed to the level of competent soils as directed by the Geotechnical Engineer. Cavities formed as a result of excavation of soft or loose soil zones should be backfilled with compacted select fill or lean concrete.

After opening, excavations should be observed, and concrete placed as quickly as possible to avoid exposure to wetting and drying. Surface run-off water should be drained away from the excavations and not be allowed to pond. If excavations must be left open for more than 48 hours, they should be protected to reduce evaporation or entry of moisture.

## 5.4 DRAINAGE CONSIDERATIONS

Water should not be allowed to collect in or adjacent to foundation excavations, on foundation surfaces, or on prepared subgrades within the construction area either during or after construction. Proper drainage around grade supported sidewalks and flatwork is also important to reduce potential movements. Excavated areas should be sloped toward one corner to facilitate removal of collected rainwater, groundwater, or surface runoff. Providing rapid, positive drainage away from the building will reduce moisture variations within the underlying soils and will therefore provide a valuable benefit in reducing the magnitude of potential movements.

## 5.5 EXCAVATIONS AND TRENCHES

Excavation equipment capabilities and field conditions may vary. Geologic processes are erratic and large variations can occur in small vertical and/or lateral distances. Details regarding “means and methods” to accomplish the work (such as excavation equipment and technique selection) are the sole responsibility of the project contractor. The comments contained in this report are based on small diameter borehole observations. The performance of large excavations may differ.

The Occupational Safety and Health Administration (OSHA) Safety and Health Standards (29 CFR Part 1926, Revised October 1989), require that excavations be constructed in accordance with the current OSHA guidelines. Furthermore, the State of Texas requires that detailed plans and specifications meeting OSHA standards be prepared for trench and excavation retention systems used during construction. PSI understands that these regulations are being strictly enforced, and if they are not closely followed, the owner and the contractor could be liable for substantial penalties.

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. The contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and Federal safety regulations.

PSI is providing this information solely as a service to the client. PSI does not assume responsibility for construction site safety or the contractor's or other parties’ compliance with local, state, and Federal safety or other regulations. A trench safety plan was outside the scope of this project.

## 6.0 REPORT LIMITATIONS

The recommendations submitted in this report are based on the available subsurface information obtained by PSI and design details furnished by the client for the proposed project. If there are any revisions to the plans for this project, or if deviations from the subsurface conditions noted in this report are encountered during construction, PSI should be notified immediately to determine if changes in the foundation recommendations are required. If PSI is not notified of such changes, PSI will not be responsible for the impact of those changes on the project.

The Geotechnical Engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional Geotechnical Engineering practices in the local area. No other warranties are implied or expressed. This report may not be copied without the expressed written permission of PSI.

After the plans and specifications are more complete, the Geotechnical Engineer should be retained and provided the opportunity to review the final design plans and specifications to check that the engineering recommendations have been properly incorporated in the design documents. At this time, it may be necessary to submit supplementary recommendations. If PSI is not retained to perform these functions, PSI will not be responsible for the impact of those conditions on the project.

This report has been prepared for the exclusive use of Brownsville Navigation District for specific application to the proposed Port of Brownsville Anchor Park project to be constructed at the Captain Donald L Foust Road in Brownsville, Texas.

# APPENDIX


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Harlingen, Texas 78550
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## Site Vicinity Map

Port of Brownsville Anchor Park
Capt. Donald L Foust Rd.
Brownsville, TX
PSI Project No.: 03122187

**NOT TO SCALE**
**Google Earth 2020**
PLATE 1

N


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2020 N. Loop 499, Suite 302
Harlingen, Texas 78550
Office - 956.423.6826

## Boring Location Map

Port of Brownsville Anchor Park
Capt. Donald L Foust Rd.
Brownsville, TX
PSI Project No.: 03122187

**NOT TO SCALE**
**Google Earth 2020**
PLATE 2

N

# LOG OF BORING NO. B-1

Port of Brownsville Anchor Park
Capt. Donald L Foust Rd, Brownsville, TX
PSI Project No.:03122187

TYPE BORING: Continuous Flight Auger

LOCATION: N:16509305.94, E:1341998.60

| DEPTH, FT. | SYMBOL | SAMPLES | SOIL DESCRIPTION | % PASSING #200 SIEVE | BLOWS PER FOOT | LIQUID LIMIT | PLASTIC INDEX | MOISTURE CONTENT | SHEAR STRENGTH KSF ○HAND PEN ●UNC 1.0 2.0 3.0 PL WC LL 20 40 60 | UNIT DRY WT. LB./CU FT. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SURF. ELEV.: 13.71 ft | | | | | | | |
| | | | Clayey Sand with Gravel (SC), medium brown, medium dense, with gravel at surface | 45 | 19 | | | 8 | | |
| | | | Fat Clay (CH), medium brown, firm, moist | 94 | 6 | 64 | 50 | 18 | | |
| 5 | | | | | 7 | | | 29 | | |
| | | | | 94 | 5 | | | 29 | | |
| 10 | | | | 96 | 3 | 50 | 32 | 32 | | |
| | | | Clayey Sand (SC), medium brown, medium dense to very loose, wet | 37 | 10 | | | 28 | | |
| 15 | | | | | | | | | | |
| | | | | 25 | 2 | | | 26 | | |
| 20 | | | | | | | | | | |
| 25 | | | | | | | | | | |

COMPLETION DEPTH: 20.0 FEET
DATE: 11/12/20

DEPTH TO WATER: During Drilling: 8 ft
DELAYED WATER READING: After Drilling: 6 ft

BL_TEXAS ANCHOR PARK BL.GPJ PSI_CORP.GDT 12/2/20

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PLATE 3

# LOG OF BORING NO. B-2

Port of Brownsville Anchor Park
Capt. Donald L Foust Rd, Brownsville, TX
PSI Project No.:03122187

TYPE BORING: Continuous Flight Auger

LOCATION: N:16509251.17 E:1342006.12

| DEPTH, FT. | SYMBOL | SAMPLES | SOIL DESCRIPTION | % PASSING #200 SIEVE | BLOWS PER FOOT | LIQUID LIMIT | PLASTIC INDEX | MOISTURE CONTENT | SHEAR STRENGTH KSF ○HAND PEN ●UNC 1.0 2.0 3.0 PL WC LL 20 40 60 | UNIT DRY WT. LB./CU FT. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SURF. ELEV.: 13.28 ft | | | | | | | |
| | | | Fat Clay (CH), medium brown, firm, moist | 94 | 8 | 63 | 44 | 26 | | |
| | | | | | 8 | | | 25 | | |
| 5 | | | | 91 | 4 | | | 28 | | |
| 10 | | | | | | | | | | |
| 15 | | | | | | | | | | |
| 20 | | | | | | | | | | |
| 25 | | | | | | | | | | |

COMPLETION DEPTH: 6.0 FEET
DATE: 11/12/20

DEPTH TO WATER: During Drilling: Not encountered
DELAYED WATER READING: After Drilling: None

BL_TEXAS ANCHOR PARK BL.GPJ PSI_CORP.GDT 12/2/20

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PLATE 4

# LOG OF BORING NO. B-3

Port of Brownsville Anchor Park
Capt. Donald L Foust Rd, Brownsville, TX
PSI Project No.:03122187

TYPE BORING: Continuous Flight Auger

LOCATION: N:16509384.41 E:1341992.80

| DEPTH, FT. | SYMBOL | SAMPLES | SOIL DESCRIPTION | % PASSING #200 SIEVE | BLOWS PER FOOT | LIQUID LIMIT | PLASTIC INDEX | MOISTURE CONTENT | SHEAR STRENGTH KSF ○HAND PEN ●UNC 1.0 2.0 3.0 PL WC LL 20 40 60 | UNIT DRY WT. LB./CU FT. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SURF. ELEV.: 13.59 ft | | | | | | | |
| | | | Fat Clay with Sand (CH), medium brown, firm, dry to moist | | 7 | | | 8 | | |
| | | | | 84 | 7 | 64 | 46 | 12 | | |
| 5 | | | | | 6 | | | 26 | | |
| 10 | | | | | | | | | | |
| 15 | | | | | | | | | | |
| 20 | | | | | | | | | | |
| 25 | | | | | | | | | | |

COMPLETION DEPTH: 6.0 FEET
DATE: 11/12/20

DEPTH TO WATER: During Drilling: Not encountered
DELAYED WATER READING: After Drilling: None

BL_TEXAS ANCHOR PARK BL.GPJ PSI_CORP.GDT 12/2/20

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PLATE 5

# LOG OF BORING NO. B-4

Port of Brownsville Anchor Park
Capt. Donald L Foust Rd, Brownsville, TX
PSI Project No.:03122187

TYPE BORING: Continuous Flight Auger

LOCATION: N:16509255.95 E:1342064.73

| DEPTH, FT. | SYMBOL | SAMPLES | SOIL DESCRIPTION | % PASSING #200 SIEVE | BLOWS PER FOOT | LIQUID LIMIT | PLASTIC INDEX | MOISTURE CONTENT | SHEAR STRENGTH KSF ○HAND PEN ●UNC 1.0 2.0 3.0 / PL WC LL 20 40 60 | UNIT DRY WT. LB./CU FT. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SURF. ELEV.: 13.90 ft | | | | | | | |
| | | | Fat Clay with Sand (CH), medium brown, stiff to firm, moist | 76 | 10 | 51 | 32 | 19 | | |
| | | | | | 7 | | | 26 | | |
| 5 | | | | | 6 | | | 30 | | |
| 10 | | | | | | | | | | |
| 15 | | | | | | | | | | |
| 20 | | | | | | | | | | |
| 25 | | | | | | | | | | |

COMPLETION DEPTH: 6.0 FEET
DATE: 11/12/20

DEPTH TO WATER: During Drilling: Not encountered
DELAYED WATER READING: After Drilling: None

BL_TEXAS ANCHOR PARK BL.GPJ PSI_CORP.GDT 12/2/20

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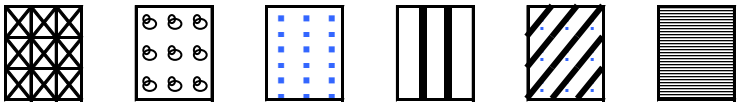
PLATE 6

# KEY TO TERMS AND SYMBOLS USED ON LOGS

## SOIL TYPE

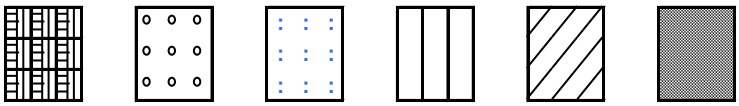


ROCK | GRAVEL | SAND | SILT | CLAY | SHALE

## SAMPLER TYPE

NO SAMPLE | AUGER SAMPLE | SHELBY TUBE | SPLIT SPOON

## MODIFIERS



STONE | GRAVELY | SANDY | SILTY | CLAYEY | FILL

NO RECOVERY | ROCK CORE | 2" SHELBY TUBE | TXDOT CONE

## UNIFIED SOIL CLASSIFICATION SYSTEM - ASTM D 2487

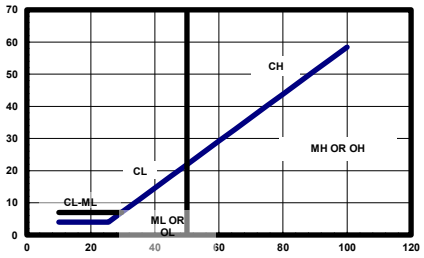
| MAJOR DIVISIONS | | | LETTER SYMBOL | TYPICAL DESCRIPTIONS |
|---|---|---|---|---|
| COARSE GRAINED SOILS LESS THAN 50% PASSING NO. 4 SIEVE | GRAVEL & GRAVELY SOILS LESS THAN 50% PASSING NO. 4 SIEVE | CLEAN GRAVEL (LITTLE OR NO FINES | GW | WELL GRADED GRAVEL, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES |
| | | | GP | POORLY GRADED GRAVEL, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES |
| | | W/ APPRECIABLE FINES | GM | SILTY GRAVEL, GRAVEL-SAND-SILT MIXTURES |
| | | | GC | CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES |
| | SANDS MORE THAN 50% PASSING NO. 4 SIEVE | CLEAN SANDS LITTLE FINES | SW | WELL GRADED SAND, GRAVELY SAND (LITTLE FINES) |
| | | | SP | POORLY GRADED SANDS, GRAVELY SAND (L.FINES) |
| | | SANDS WITH APPREA. FINES | SM | SILTY SANDS, SAND-SILT MIXTURES |
| | | | SC | CLAYEY SANDS,SAND-CLAY MIXTURES |
| FINE GRAINED SOILS MORE THAN 50% PASSING NO. 200 SIEVE | SILTS AND CLAYS LIQUID LIMIT LESS THAN 50 | | ML | INORGANIC SILTS & VERY FINE SANDS,ROCK FLOUR SILTY OR CLAYEY FINE SANDS OR CLAYEY SILT W/ LOW PI |
| | | | CL | INORGANIC CLAY OF LOW TO MEDIUM PI LEAN CLAY GRAVELY CLAYS, SANDY CLAYS, SILTY CLAYS |
| | | | OL | ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PI |
| | SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50 | | MH | INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS |
| | | | CH | INORGANIC CLAYS OF HIGH PLASTICITY FAT CLAYS |
| | | | OH | ORGANIC CLAYS OF MED TO HIGH PI, ORGANIC SILT |
| HIGHLY ORGANIC SOIL | | | PT | PEAT AND OTHER HIGHLY ORGANIC SOILS |
| UNCLASSIFIED FILL MATERIALS | | | ARTIFICIALLY DEPOSITED AND OTHER UNCLASSIFIED SOILS AND MAN-MADE SOIL MIXTURES | |

## CONSISTENCY OF COHESIVE SOILS

| CONSISTENCY | SHEAR STRENGTH IN TONS/FT$^2$ |
|---|---|
| VERY SOFT | 0. TO 0.125 |
| SOFT | 0.125 TO 0.25 |
| FIRM | 0.25 TO 0.5 |
| STIFF | 0.5 TO 1.0 |
| VERY STIFF | 1.0 TO 2.0 |
| HARD | > 2.0 OR 2.0+ |

## RELATIVE DENSITY - GRANULAR SOILS

| CONSISTENCY | N-VALUE (BLOWS/FOOT) |
|---|---|
| VERY LOOSE | 0-4 |
| LOOSE | 4-9 |
| MEDIUM DENSE | 10-29 |
| DENSE | 30-49 |
| VERY DENSE | > 50 OR 50+ |




## ABBREVIATIONS

HP - HAND PENETROMETER
TV - TORVANE
MV - MINIATURE VANE
UC - UNCONFINED COMPRESSION TEST
UU - UNCONSOLIDATED UNDRAINED TRAIXIAL
CU - CONSOLIDATED UNDRAINED

NOTE: PLOT INDICATES SHEAR STRENGTH AS OBTAINED BY ABOVE TESTS

HYDRO-STATIC WATER LEVEL

WATER LEVEL UNDER HYDRO - STATIC PRESSURE HEAD

## CLASSIFICATION OF GRANULAR SOILS

U.S. STANDARD SIEVE SIZE(S)

| 6" | 3" | 3/4" | 4 | 10 | 40 | 200 |
|---|---|---|---|---|---|---|

| BOULDERS | COBBLES | GRAVEL | | SAND | | | SILT OR CLAY | CLAY |
|---|---|---|---|---|---|---|---|---|
| | | COARSE | FINE | COARSE | MEDIUM | FINE | | |

| 152 | 76.2 | 19.1 | 4.76 | 2.0 | 0.42 | 0.074 | 0.002 |
|---|---|---|---|---|---|---|---|

GRAIN SIZE IN MM

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PLATE 7