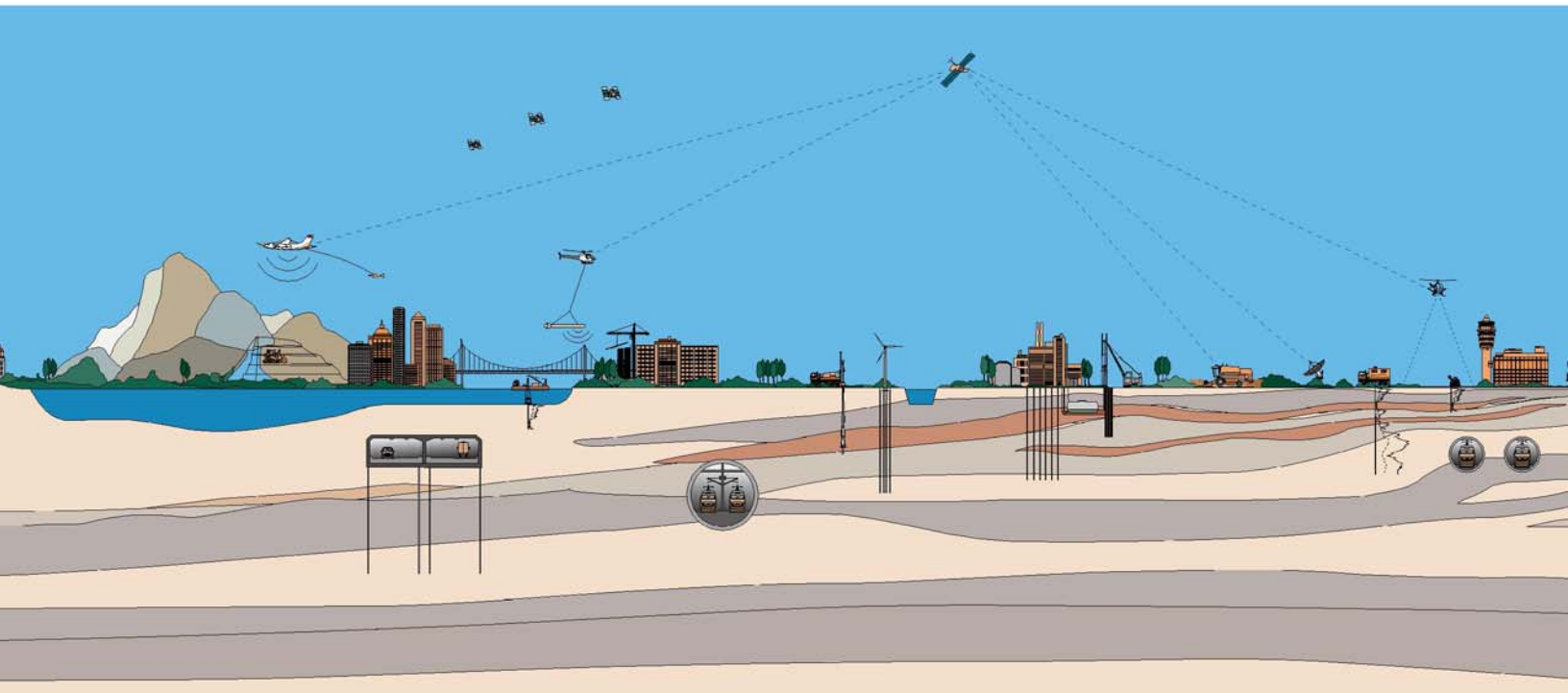
FUGRO CONSULTANTS, INC.

PHASE 1 GEOTECHNICAL INVESTIGATION
CEDAR RIDGE RESERVOIR
THROCKMORTON COUNTY, TEXAS

ENPROTEC / HIBBS & TODD, INC.
ABILENE, TEXAS



FUGRO CONSULTANTS, INC.

8613 Cross Park Drive
Austin, Texas 78754
Tel: 512-977-1800
Fax: 512-973-9966

Enprotec / Hibbs & Todd, Inc.
402 Cedar Street
Abilene, Texas 79601

Report No. 04.10013715
February 16, 2009

Attention: Mr. Scott Hibbs, P.E.

Phase 1 Geotechnical Investigation
Cedar Ridge Reservoir
Throckmorton County, Texas

Submitted herewith is the report of the Phase 1 Geotechnical Investigation for the above referenced project. In brief, the report includes a plan of borings, boring logs, field and laboratory test results and descriptions of subsurface conditions and site observations. Based on the findings, preliminary geotechnical engineering analyses and initial site assessment are provided for the proposed dam and impoundment area.

Fugro Consultants, Inc. appreciates the opportunity to provide these preliminary geotechnical engineering services to you and look forward to future phases of the project.

Sincerely,

FUGRO CONSULTANTS, INC.
TBE Firm Registration No. 299

Lewis B. Yates, P.E.
Special Projects Manager

Robert P. Ringholz, P.E.
Chief Engineer

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Report to:

ENPROTEC / HIBBS & TODD, INC.
Abilene, Texas

Submitted By:

FUGRO CONSULTANTS, INC.
FEBRUARY 2009

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INTRODUCTION

On April 10, 2008, Fugro Consultants, Inc. (Fugro) initiated a Phase 1 Geotechnical Investigation for the proposed Cedar Ridge Reservoir located about 40 miles northeast of Abilene, Texas (see Plate 1). Specifically, the reservoir is situated on the Clear Fork of the Brazos River about five miles upstream of the confluence with Paint Creek. The proposed dam location is in Throckmorton County but the impoundment area includes portions of Haskel and Shackelford Counties. The primary purpose of the reservoir is water supply for the City of Abilene. The major components of the overall project include an earth embankment dam, service spillway, emergency spillway, intake/pump station and pipeline. This Phase 1 investigation is limited to a preliminary geotechnical assessment of the proposed dam and emergency spillway area, and the impoundment area near the proposed dam.

Enprotec/Hibbs & Todd, Inc. (EHT) and HDR Engineering, Inc. (HDR) are providing project management and civil engineering services for the owner of the project, the City of Abilene. Fugro was retained by EHT to provide specific and limited geotechnical engineering services for this phase of the project.

AUTHORIZATION

Mr. Scott Hibbs, P.E., president of EHT, authorized the investigation on April 1, 2008 with execution of a Subconsultant Agreement. The agreement includes Fugro Proposal No. 1001-3715 dated July 26, 2007. The proposal contains specific and limited scope of services agreed upon for this Phase 1 geotechnical investigation.

PURPOSE AND SCOPE

The purpose of this Phase 1 investigation was to provide an initial geotechnical and geological assessment of the suitability of the proposed dam site for water impoundment, dam support, and potential borrow materials.

The scope of the investigation included 1) a limited field investigation to assess subsurface conditions at specific, widely-spaced boring locations and obtaining representative samples for classification and testing, 2) a laboratory testing program to aid in the classification of the substrata and to provide parameters for preliminary seepage and embankment slope stability assessments, 3) a geological reconnaissance walkthrough of the immediate area upstream and downstream of the proposed dam site, and 4) engineering analyses and evaluations of the results of the field and laboratory data to aid in assessing the geology and geotechnical engineering characteristics of the proposed dam site and nearby impoundment area.

Field sampling, laboratory testing, soil classifications and strata descriptions are in general accordance with methods, procedures, and practices set forth by the American Society for Testing and Materials, 2007 Annual Book of ASTM Standards, where applicable.

FIELD INVESTIGATION

Subsurface conditions were explored by four core borings advanced to depths ranging from 50 to 350 feet below existing grade. The two deepest borings (B-1, B-3) were drilled at truck accessible locations near each dam abutment at the proposed dam site. Boring B-2 was drilled in the river channel near the proposed centerline of the dam. This boring was terminated short of the planned depth for safety reasons due to encountering pressurized gas at 62.5 feet. Boring S-1 was drilled in the area of the proposed emergency spillway excavation. The approximate boring locations are shown on Plate 2. The borings were located in the field by representatives of Fugro and HDR using available aerial and topographic maps. Sheppard Surveying Company, Inc. of Abilene, Texas, provided surveyed boring locations and elevation data. The logs of borings and Keys to Terms and Symbols used on the logs are contained in Appendix 1 of this report.

The borings were drilled with a truck-mounted drill rig equipped with 1) continuous flight and/or hollow stem augers for advancing the holes dry and recovering disturbed samples of soil (ASTM D 1452), 2) seamless steel push-tubes for obtaining samples of cohesive soil strata (similar to ASTM D 1587, but thicker wall), 3) split-barrel samplers and drive-weight assembly for obtaining representative samples and measuring penetration resistance (N-values) of non-cohesive soil strata (ASTM D 1586), and 4) double-tube wireline core barrels equipped with diamond and/or carbide bits for obtaining 2-inch diameter rock and rock-like cores (ASTM D 2113).

Detailed descriptions of subsurface materials encountered are presented on the boring logs. Pocket penetrometer values in tons per square foot, standard penetration test N-values in blows per foot, and core recovery and Rock Quality Designation (ASTM D 6032) values in percent, are also shown on the logs of borings. The borings were logged in the field by a staff geotechnical engineer (EIT) and in the laboratory by a staff geologist.

Unlined borehole single and double packer tests were conducted below the proposed reservoir elevation of 1430-feet (msl) in the bedrock strata in borings B-1, B-2 and B-3. The procedure consists of seating an inflatable rubber packer at the top and bottom of the test zone for the double packer test, and pumping water into the test zone through a metering system. For the single packer test, only one packer is used at the top of the test zone and the bottom of the boring is used in place of the bottom packer. A constant pressure was applied to the water entering the test zone and maintained for a specified time period. Water loss into the test zone

was recorded. The test duration ranged from 5 minutes to 10 minutes and the gauge pressure at the top of the boring varied from 5 to 20 psi. The total applied pressure in the test zone is the gauge pressure plus the head of water in the pipe. A schematic for the double packer setup is shown on Plate 3. Data and results are presented on Plate 4. The test procedure and calculations for hydraulic conductivity (k) are in general accordance with U.S. Bureau of Reclamation procedures[1].

LABORATORY TESTING

The laboratory testing program of the materials recovered from the borings included the following conventional geotechnical tests: water contents, Atterberg limits, sieve analyses, unconfined compression tests, and unit dry weights. Durability tests (specific gravity, absorption, abrasion and soundness) were conducted on individual and composite samples of the rock in the area of the proposed emergency spillway excavation for preliminary evaluation of these materials as dam embankment rockfill and riprap. Brief descriptions of the physical laboratory tests are presented in the following subsections. The lab tests were conducted in general accordance with the basic requirements of the ASTM or other specification listed in parenthesis.

Natural Water Content (ASTM D 2216)

Natural water content tests were performed on samples in which classification and/or strength tests were performed. Each sample was visually classified in the laboratory. Natural water contents are tabulated at sample depth on the boring logs.

Atterberg Limits (ASTM D 4318)

Atterberg limit tests are classification tests that determine the liquid limit and plastic limit of the soil fraction finer than the No. 40 sieve. The Atterberg limits are approximate water contents at which the soil tested behaves in a specified manner. The liquid limit is determined by measuring, in a standard device, the water content and number of blows required to close a specific width groove cut in a remolded soil sample a specified length. The plastic limit is determined by measuring the water content when threads of soil 1/8-inch in diameter begin to crumble. The plasticity index, defined as the difference between the liquid and plastic limits, indicates the degree of plasticity or the magnitude of the water content over which the soil remains plastic. Liquid limit and plasticity index values are tabulated at sample depth on the boring logs.

1 "Design on Small Dams, U.S. Bureau of Reclamation, 2nd Edition, 1973, Page 196.

Sieve Analysis (ASTM D 422)

Grain-size characteristics of the natural soils were investigated by the determination of the percent of soil passing the No. 4, 40 and 200 sieves. These tests were performed by washing or sieving material through the respective sieves. The results are tabulated at sample depth on the boring logs for the percent passing the Nos. 4 and 200 sieves.

Unconfined Compression Test of Soil (ASTM D 2166)

In the unconfined compression test, a cohesive soil specimen is subjected to a compressive load without any lateral restraint. The specimen is sheared in compression without drainage at a constant rate of axial deformation of about ½ to 2 percent strain per minute to produce failure in a test time not to exceed about 15 minutes. The soil samples tested had diameters of about 2.8 inches and heights of about 5.6 inches. The measured applied load was recorded for selected increments of deformation. The sample is tested to failure or 15 percent strain, whichever occurs first. Results of these tests, including compressive strength, water content and unit dry weights, are tabulated on boring logs at specimen recovery depth.

Compressive Strength of Intact Rock Core Specimens (ASTM D 7012)

In the unconfined compression test of intact rock core specimens, a laterally unsupported cylindrical rock specimen is loaded axially in compression to failure. The axial load is applied at a constant rate of deformation to produce failure in a test time between 2 and 15 minutes. The cores tested were approximately 2 inches in diameter by 4 inches in length. The measured applied load at failure is recorded. Natural water contents and unit dry weights were determined as routine parts of the test procedures in the compression tests. Results of these tests, including unconfined compressive strength, water content, and unit dry weights, are tabulated on the boring logs at core recovery depth.

Specific Gravity, Absorption, Abrasion and Soundness (ASTM D 6473, C 88, C 131)

Specific gravity and absorption tests on individual core samples, and abrasion and soundness tests on composite core samples were conducted to evaluate the durability of the limestone proposed for use as embankment rockfill and riprap. It should be noted that size limitations of core samples prevented strict adherence to size and gradation requirements of the ASTM procedures. Results of these tests are summarized on Plate 5.

Immersion Tests of Gypsum Rock Core Specimens

This simple, non-specification test was used to determine the weight loss of gypsum core samples immersed in river water over a period of time. A sample of river water was obtained from the site on June 18, 2008. Core samples of the gypsum from borings B-1, B-2 and B-3 were initially weighed, then immersed in separate beakers filled with river water. At periodic intervals,

the samples were removed from the beakers, patted dry of free moisture, weighed and returned to the immersion beakers. The immersion water was not changed during the testing process. Results of these tests are summarized on Plate 6. It should be recognized that this test was not intended to provide specific solubility characteristics of the gypsum samples and should not be used for that purpose.

Strata Descriptions

Descriptions of strata made in the field at the time the borings were drilled were modified in accordance with results of laboratory tests and visual examination. All recovered soil samples were classified in general accordance with ASTM D 2487 and described as recommended in ASTM D 2488. Rock strata were classified in general accordance with "Rock Classification and Description", Chapter 1, Section 5, NAVFAC DM-7[2]. Classification of soils and finalized descriptions of both rock and soil strata are shown on the boring logs.

SITE AND SUBSURFACE CONDITIONS

Physiography

The proposed site of the dam and reservoir is located on the Clear Fork of the Brazos River near the end of a rather sinuous section of river channel about five miles upstream of the confluence with Paint Creek. The width of the river channel at the proposed dam location is relatively narrow at 350 feet, and the riverbed is about elevation 1290 feet. At the proposed dam location, the channel is flanked on either side by steep hillsides with crest elevations of about 1500 feet at the left abutment (facing downstream), and 1450 feet at the right abutment. In general, the site is moderately wooded and rugged with limited access. Numerous producing oil and/or gas wells are present within the area. Although the proposed impoundment area is generally uninhabited, it is part of working ranches and recreational hunting leases.

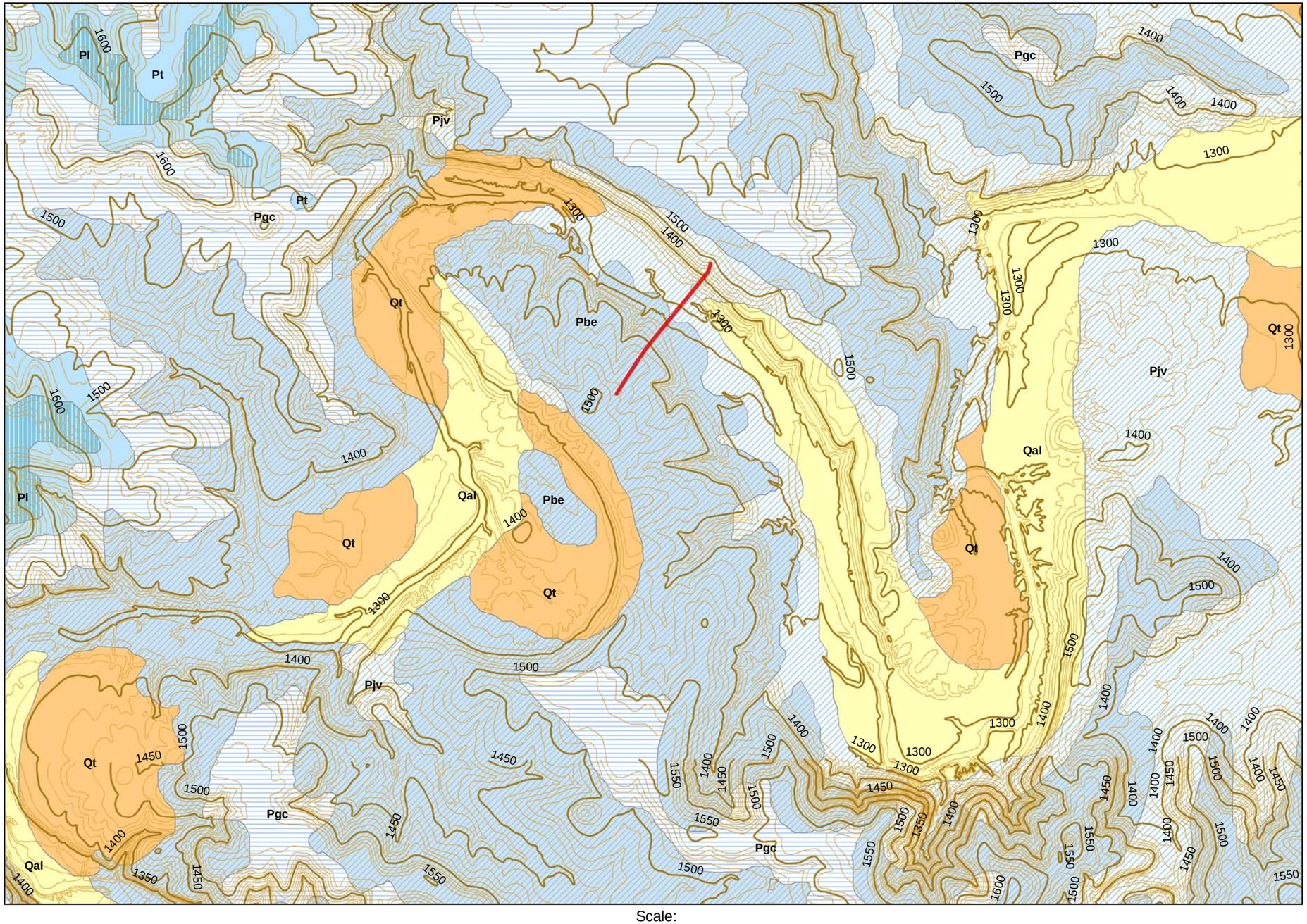
Geological Synopsis

The geologic interpretations contained herein are based on available geologic maps and literature, inspection of the material retrieved from the core borings, and site reconnaissance observations. Particular reliance is placed on the information contained in the Geologic Atlas of Texas, Abilene Sheet[3] and Wichita Falls-Lawton Sheet[4], portions of which are combined and reproduced as Figure 1 on the following page.

2 U.S. Navy (1971), Design Manual - Soil Mechanics, Foundations, and Earth Structures, NAVFAC DM-7.

3 Geologic Atlas of Texas, Abilene Sheet, The University of Texas at Austin Bureau of Economic Geology, 1972

4 Geologic Atlas of Texas, Wichita Falls-Lawton Sheet, The University of Texas at Austin Bureau of Economic Geology, 1987



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Legend

- Proposed Dam Location
- Index Contour
- Intermediate Contour
- Depression Contour
- Supplemental Contour

Geologic Formation

- Qal - Alluvium
- Qt - Fluviatile terrace deposits
- Pl - Lueders Formation
- Pt - Talpa Formation
- Pgc - Grape Creek Formation
- Pbe - Bead Mountain Formation
- Pjv - Jagger Bend and Valera Formation undivided

Source: Texas Natural Resource Information System - Geologic Atlas of Texas, Abilene, Whichita Falls and Lawton Sheets
Fugro Consultants, Inc.
Projection: Stateplane
Application Program: ArcGIS 9.1
Date of Composition: May 13, 2008
Composed by: Paul M. Jones

Scale:
1 inch = 2,000 feet
2,000 1,000 0 2,000 Feet

GEOLOGIC MAP
Cedar Ridge Dam Structure
Cedar Ridge Reservoir
Throckmorton County, Texas

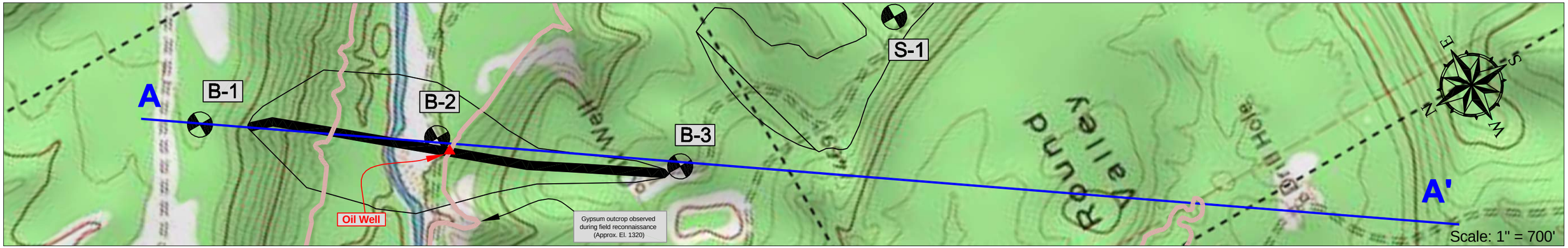
FIGURE 1

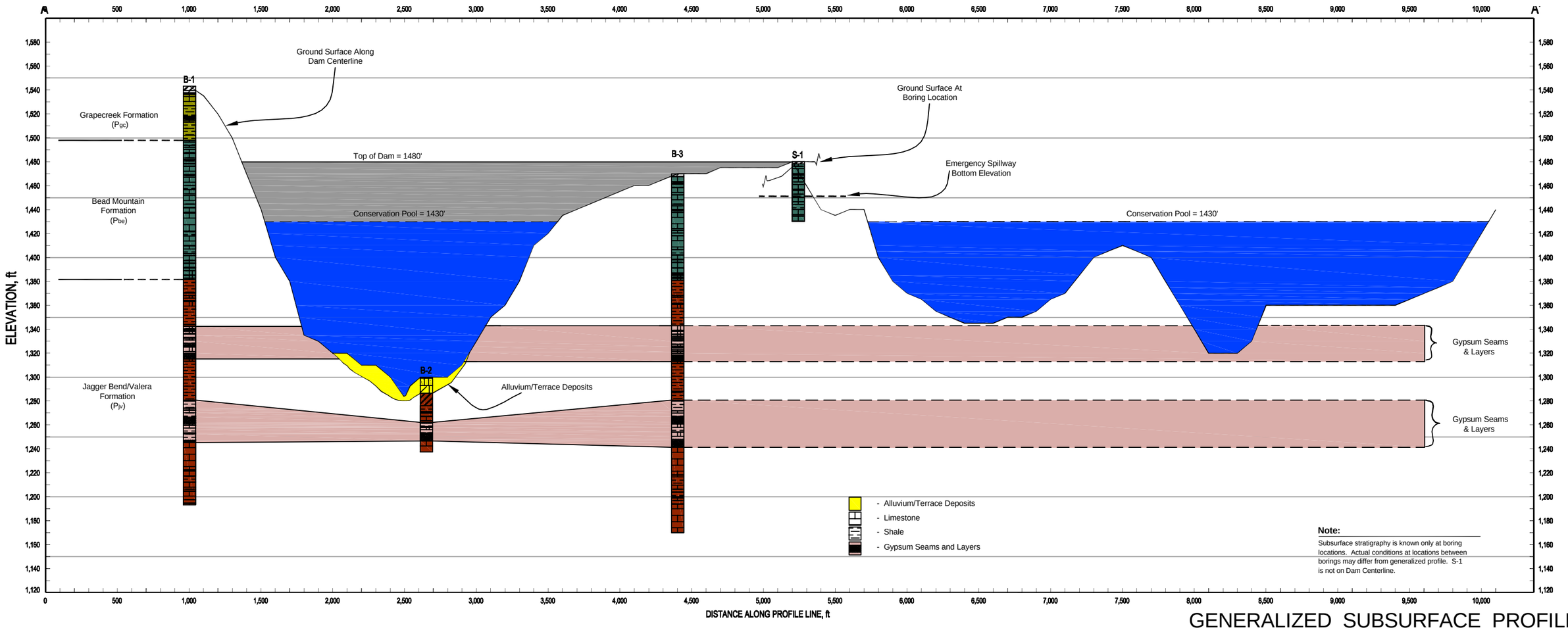
A detailed discussion of the site and regional geology is contained in the "Geological Reconnaissance Report" prepared for this project and included in Appendix 2 as an integral part of this report.

In short, the "bedrock" units that outcrop within the proposed dam and impoundment area consist of Permian age formations of the Wichita-Albany Group. The specific formations of interest are, from youngest to oldest, the Grape Creek Formation (P_{gc}), the Bead Mountain Formation (P_{be}) and the Jagger Bend and Valera Formations undivided (Pjv). These formations are described in the referenced geologic literature as consisting predominantly of alternating layers of limestone and shale. The bedrock formations in the river channel have been eroded and overlain, in most places, by more recent Quaternary age Alluvium (Q_{al}) and Fluviatile terrace deposits (Q_t). These flood plain deposits are described as consisting primarily of gravel, sand and silt.

The materials observed at the surface, at erosion outcrops near the location of the proposed dam, and in the core borings drilled for this study are consistent with the published literature with **one major exception**. Significant layers, seams and nodules of gypsum were observed in the three core borings along the proposed dam alignment generally between elevations 1225 and 1343 feet. Additionally, gypsum beds were observed in an outcrop about ¼ mile upstream of the proposed dam location. Stratigraphically, this would place the gypsum within the Jagger Bend/Valera Formations, about 35 to 40 feet below the contact with the overlying Bead Mountain Formation. The gypsum appears to be horizontally continuous along the proposed dam alignment and of consistent thickness (refer to Plate 3 in Appendix 2). Individual gypsum layers up to 6 feet in thickness were measured in the borings. This unanticipated subsurface condition is important since gypsum is a highly soluble mineral and can adversely affect the performance of dams and reservoirs.

Figure 2 contains a generalized subsurface profile along the proposed dam alignment and extension through the Round Valley impoundment area. Our interpretation of the location of the various geologic formations discussed above is shown on this figure. We have also delineated two major zones within the limestone and shale strata that contain gypsum layers at least one foot thick. These zones have been interpolated from the three borings between the proposed dam abutments, and extrapolated through the impoundment *assuming constant elevation*. From this extrapolation and direct observation during the geological reconnaissance (see Appendix 2), it appears that reservoir water at this location will have direct access to the upper gypsum zone.





GENERALIZED SUBSURFACE PROFILE

Cedar Ridge Reservoir

Throckmorton County, Texas

FIGURE 2

Site Stratigraphy and Engineering Properties

Subsurface conditions can best be understood by a thorough review of the boring logs contained in Appendix 1. Descriptions of the major strata encountered and pertinent engineering properties are described in the following paragraphs. The term “depth(s)” used in this report is the vertical distance below existing ground surface at the boring locations at the time of drilling.

The general stratigraphy observed in the borings drilled at the abutments (B-1, B-3) and emergency spillway (S-1) consists of:

- brown to tan clayey residual overburden soils to depths of 2 to 6 ft, followed by;
- tan, light gray and bluish gray *moderately weathered* limestone and shale to depths of 30 to 45 ft, followed by;
- gray, bluish-gray and grayish-brown *slightly weathered* limestone and shale with distinct intervals containing gypsum nodules, seams and layers. Boring S-1 was terminated above the elevation that gypsum was observed in the deeper abutment borings.

The boring drilled in the river valley (B-2) contained the following general stratigraphy:

- reddish-brown lean clay, silty sand, and sandy silty clay alluvial soils to a depth of 13.5 feet, followed by;
- greenish-gray fat clay (highly to completely weathered shale) to a depth of 24 feet, followed by;
- bluish-gray to gray shale and limestone with gypsum nodules, seams and layers.

Boring B-2 was terminated at 62.5 feet for safety reasons after encountering pressurized gas. The gas initially blew out the entire column of drilling fluid and smaller, intermittent gas releases continued for over an hour. A producing well is located on a terrace ridge about 100 feet southwest of B-2. The pressurized gas observed in B-2 may be due to a leaking casing in the nearby well (refer to the Geological Reconnaissance Report in Appendix 2).

The overburden soils observed in B-1, B-3 and S-1 consist mostly of fat clay and sandy lean clay with measured liquid limits (LL) of 54 to 73, plasticity indexes (PI) of 32 to 45, and percent passing a #200 sieve (-200) of 84 to 92. These soil like materials were formed in-place by extreme weathering of the parent bedrock formation, i.e., residual. The alluvial soils observed in boring B-2 in the creek channel consist of lean clay, sandy silty clay, and silty sand. The clays have measured liquid limits of 24 to 29, plasticity indexes of 5 to 16, and percent passing a #200 sieve of 65 to 71. The silty sand is non-plastic with a percent passing a #200 sieve of 44. These soils were eroded from upstream bedrock formations and transported to the present location by water. The fat clay stratum below the alluvial soils was weathered in place from the bedrock

shale stratum and has a liquid limit of 51, plasticity index of 30, and percent passing a #200 sieve of 88.

For discussion purposes, the limestone and shale strata are collectively referred to as bedrock units in this report. The shale generally has a soft to medium rock hardness with measured unconfined compressive strengths ranging from 2 to 95 tons per square foot and unit dry weights ranging from 104 to 140 pounds per cubic foot. The limestone is comparatively very dense and hard with unconfined compressive strengths ranging from 139 to 326 tons per square foot and unit dry weights ranging from 138 to 163 pounds per cubic foot.

Occasional to numerous discontinuities are present in all the bedrock units. In general, the bedrock units in the abutment borings (B-1, B-3) below elevation 1430 ft (proposed normal pool) have very low permeability based on observations of drilling fluid circulation during the rock coring process and zero water losses recorded in the packer test zones. Packer tests conducted in the bedrock in B-2 in the river channel had recorded water losses ranging from zero to 1.8 gallons per minute. The mass permeability of the shale and limestone in the river channel varied from $5x10^{-5}$ to $1x10^{-6}$ cm/sec, excluding the one impermeable interval at 29.5 to 39.5 feet. There were no signs of dissolution of the gypsum observed in the borings, but the pressurized gas blowout at the bottom of B-2 may be an indication of more permeable zones below the termination depth of the boring.

Groundwater

As noted on the boring logs, groundwater was not observed in any of the borings prior to using drilling fluid to core the bedrock units. It is our opinion that groundwater will be present on top of the bedrock units in the river channel closer to the normal elevation of the river and at higher elevations during and sometime after flood events. Temporary seepage water may also be present during wet periods in joints and fractures in the bedrocks, particularly in the upper moderately weathered zones. The water observations conducted for this investigation should be considered short-term and should not be interpreted as a “Groundwater Study”.

PRELIMINARY GEOTECHNICAL ASSESSMENT AND RECOMMENDATIONS

General Considerations

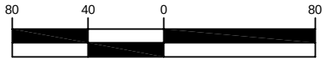
From a geotechnical engineering perspective, the assessment of this proposed dam site includes consideration of embankment dam and foundation stability, seepage through and under the dam, lateral leakage through the river channel sidewalls, and borrow materials for use in constructing the dam. The proposed dam cross section (see Figure 3) consists of a zoned earth and rockfill embankment with exterior upstream and downstream slope angles of 2.5 horizontal to 1.0 vertical (2.5H:1V). The dam will consist of a central clay core section flanked on both sides by rockfill zones. The core and rockfill zones are separated by an upstream filter and downstream chimney drain. Underseepage will be controlled with a clay core trench and grout curtain (if required).

Dam Stability

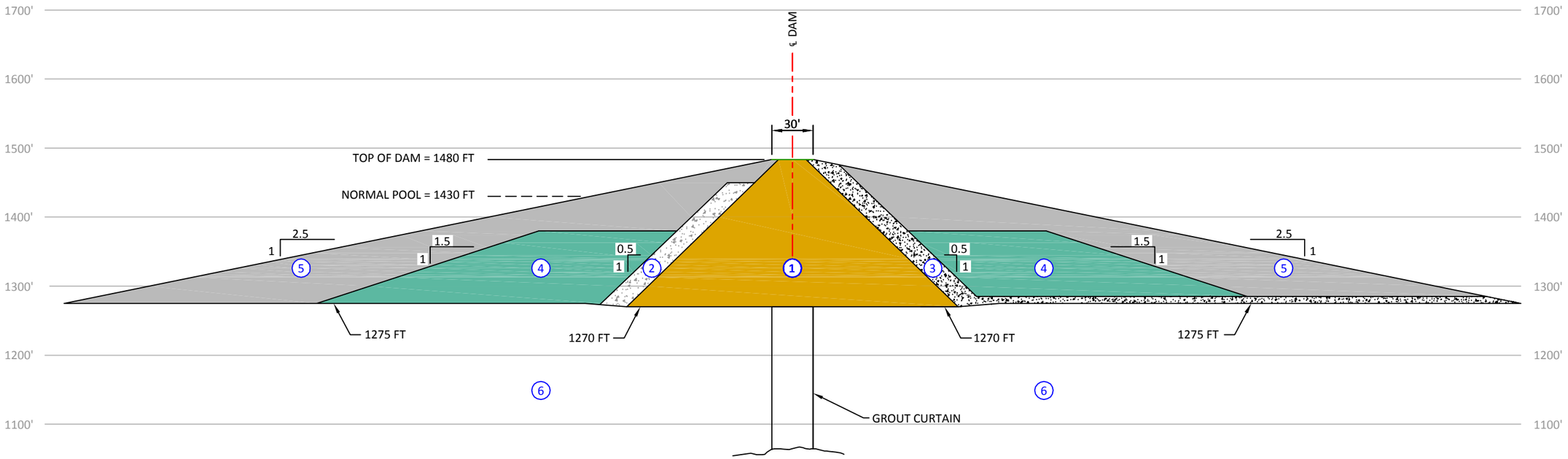
Based on the proposed cross section and subsurface conditions observed at B-2, a top of ground elevation of 1275 ft and core trench elevation of 1270 ft were used to model the maximum embankment section. Embankment material properties were assumed based on engineering judgment and experience. The loading and seepage conditions analyzed for this preliminary study were limited to the End of Construction (EOC) condition and Steady State Seepage (SSS) at normal pool elevation of 1430 feet. The Earthquake condition was not analyzed for this preliminary assessment but should be included in final design slope analyses using current seismic hazard mapping. The Rapid Drawdown condition should be analyzed for final design if pumping rates are high enough to cause a rapid drawdown condition to occur. The results of our preliminary slope stability analyses for the proposed embankment cross-section are summarized in the following table and graphically presented on Figures 4, 5 and 6.

Loading Condition	Factor of Safety	
	Computed	USACE Minimum
EOC – Downstream Slope	1.1	1.3
SSS - Downstream Slope	1.6	1.5
SSS – Upstream Slope	1.6	1.5

ZONE	MATERIAL DESCRIPTION
1	CLAY CORE
2	UPSTREAM FILTER
3	DOWNSTREAM FILTER/DRAIN
4	RANDOM ROCKFILL ZONE (PRIMARILY SHALE)
5	ROCKFILL ZONE (PRIMARILY LIMESTONE)
6	FOUNDATION (LIMESTONE & SHALE)



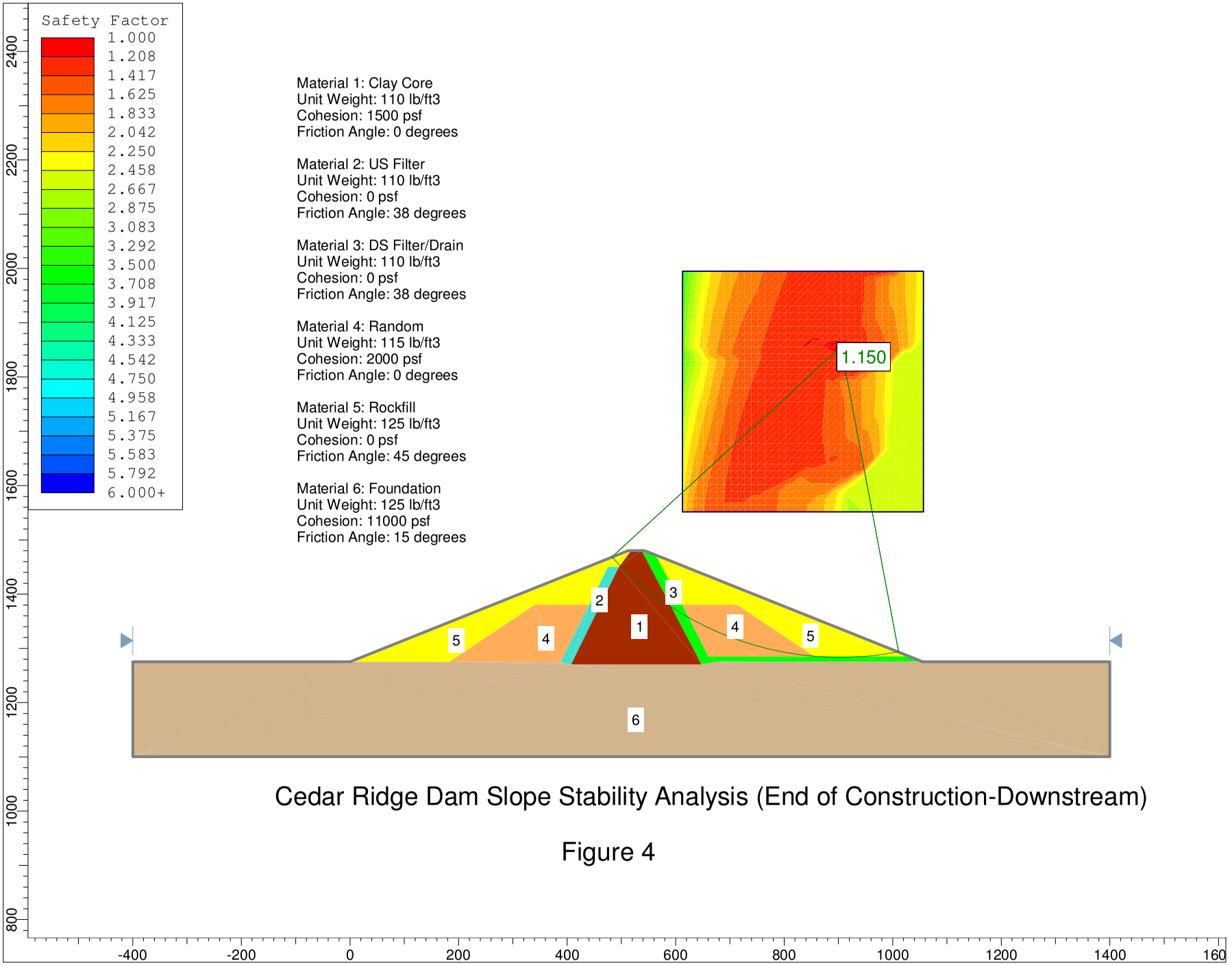
Scale: 1" = 80'



PROPOSED DAM CROSS SECTION
(At Boring B-2 Location)

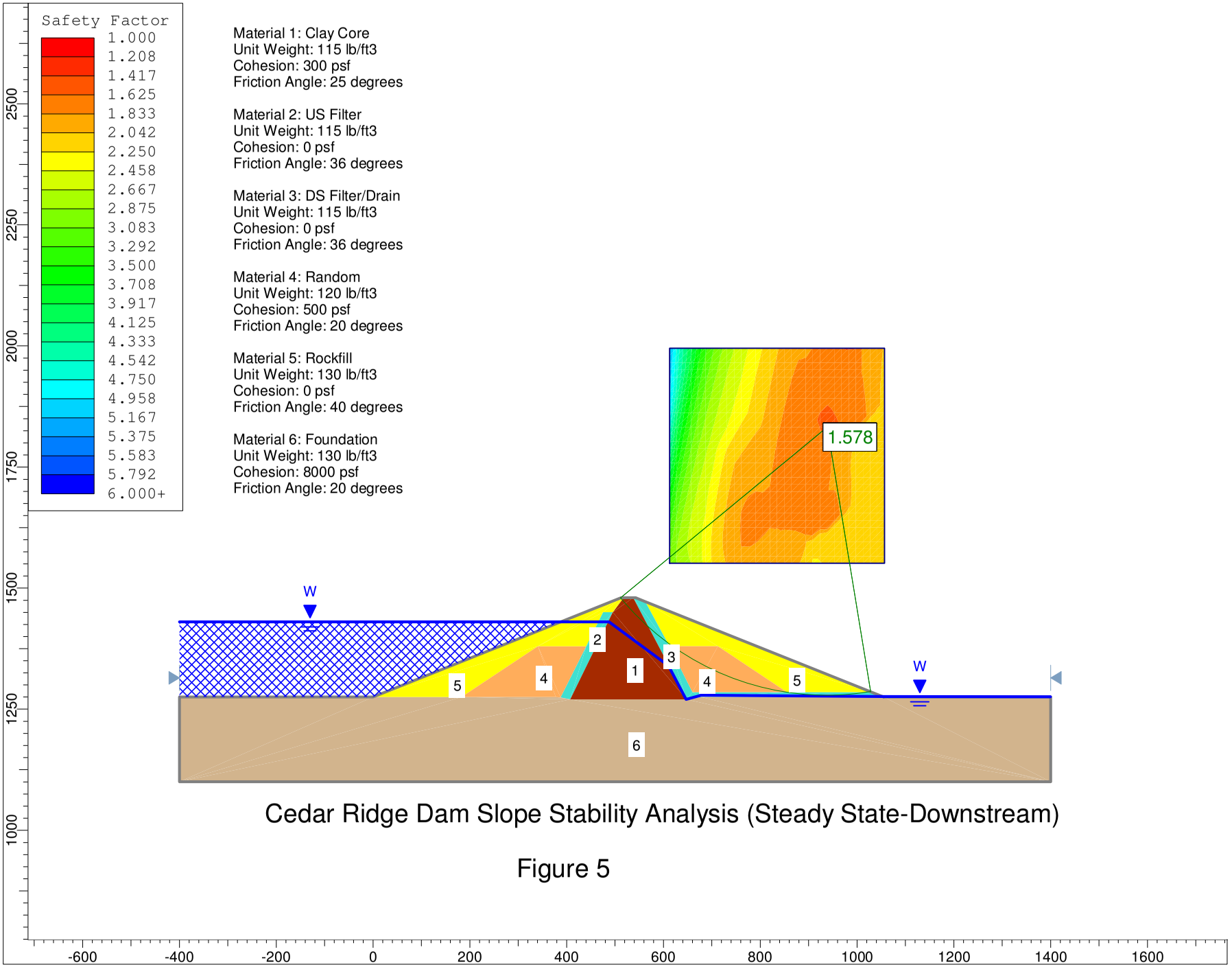
DAM CROSS SECTION
Cedar Ridge Reservoir
Throckmorton County, Texas

FIGURE 3



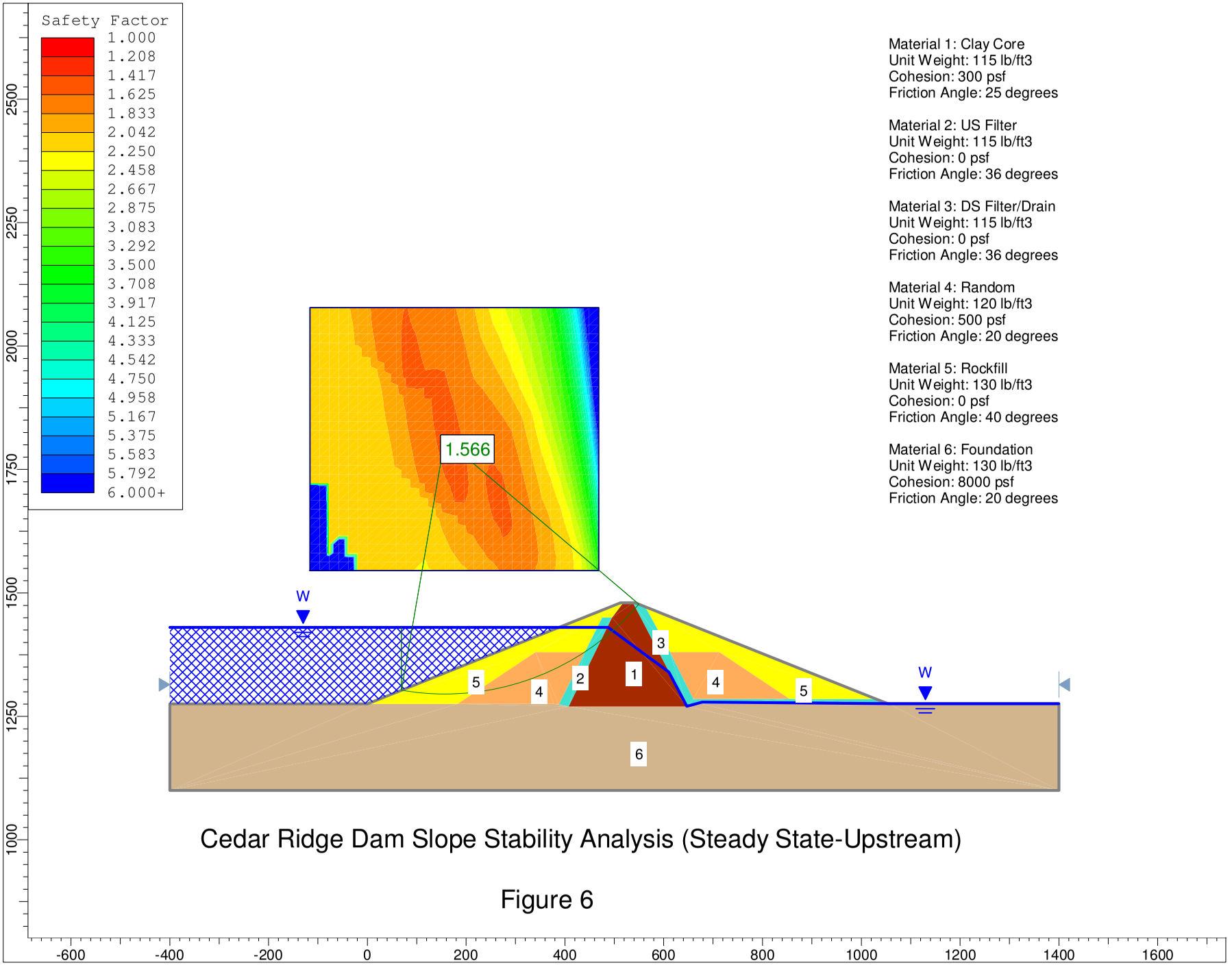
Cedar Ridge Dam Slope Stability Analysis (End of Construction-Downstream)

Figure 4



Cedar Ridge Dam Slope Stability Analysis (Steady State-Downstream)

Figure 5



Material 1: Clay Core
Unit Weight: 115 lb/ft3
Cohesion: 300 psf
Friction Angle: 25 degrees

Material 2: US Filter
Unit Weight: 115 lb/ft3
Cohesion: 0 psf
Friction Angle: 36 degrees

Material 3: DS Filter/Drain
Unit Weight: 115 lb/ft3
Cohesion: 0 psf
Friction Angle: 36 degrees

Material 4: Random
Unit Weight: 120 lb/ft3
Cohesion: 500 psf
Friction Angle: 20 degrees

Material 5: Rockfill
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 40 degrees

Material 6: Foundation
Unit Weight: 130 lb/ft3
Cohesion: 8000 psf
Friction Angle: 20 degrees

Cedar Ridge Dam Slope Stability Analysis (Steady State-Upstream)

Figure 6

The minimum factor of safety recommended by the U.S Army Corps of Engineers (USACE) for earth and rockfill dams shown in the preceding table may be higher for embankments on clay-shale foundations. For our preliminary analyses, we have assumed that the base of the dam and core trench will extend through the alluvium terrace and residual fat clay strata, and be founded on competent shale. **Also implicit in our analyses is that a weak failure plane through dissolution of gypsum in the foundation will not occur.**

The computed factor of safety for the EOC condition is less than the USACE recommended minimum. The computed factors of safety for the SSS conditions are slightly above the minimum. All of these analyses assume the random Zone 4 is comprised predominantly of shale and the rockfill Zone 5 is durable rock. Flattening the slope, adding a stabilizing berm at the toe of the slope, and/or specifying a stronger material in the random Zone 4 can increase embankment stability. Embankment slope configurations that meet USACE minimum standards will be highly dependent on material properties, particularly shear strength. Final design slope stability analyses should be conducted only after borrow materials are thoroughly evaluated and tested.

Embankment and Foundation Seepage and Lateral Impoundment Leakage

A central clay core and chimney drain, as proposed, will control seepage through the embankment section. This type of conventional seepage control is common and has a long history of successful performance. Seepage estimates through the dam for sizing drains should be provided during final design after embankment cross sections are finalized and borrow materials are tested. A conventional excavated core trench and grout curtain as shown in Figure 3 can control seepage under the dam. Most of the underlying shale and limestone can be classified as having low to very low relative permeability based on the results of the packer tests and the current condition of the gypsum beds; i.e., no observed dissolution. Dissolution of gypsum, however, will adversely affect foundation seepage. Additional borings along the centerline of the dam during final design will help define the termination depths of both the core trench and grout curtain.

Lateral leakage of reservoir water through the shale and limestone in the impoundment area should be minimal. As previously discussed, though, dissolution of gypsum could create avenues for significant reservoir water loss. Of particular concern is the relatively narrow section of bedrock between Round Valley and the river channel downstream of the proposed dam location. This also coincides with the proposed location of the emergency spillway.

Borrow Materials

The alluvial/terrace lean and fat clays with a Unified Soil Classification of CL or CH are suitable for use in the clay core embankment zone. The sandy silty clay (CL-ML) alluvium/terrace is marginal for use in the embankment core zone, but might be suitable if mixed with the more plastic clayey soils. The granular sand and gravel will need to be placed in the downstream random zone, processed for filter or drainage material, or wasted. We recommend that any borrow area in the river channel be at least 200 ft upstream from the upstream embankment toe, and 400 ft downstream of the downstream embankment toe. Residual clay soils outside of the impoundment area that are derived from the bedrock formations will likely be suitable for use in the clay core. Based on the very limited durability tests conducted on small-scale samples of the limestone in the area of the proposed emergency spillway, it appears that most of the limestone will be suitable for rockfill, but marginal for riprap. Some of the limestone layers observed in boring S-1 are harder and more durable than other layers. The harder rock can be identified during excavation and selected for use in the riprap layer. Additionally, the riprap layer can be thickened to accommodate weathering over time.

Conclusions and Recommendations

Based on the results of this preliminary assessment, the presence of gypsum in the bedrock will have a significant impact on the project at the current location. Gypsum is a highly soluble mineral. Dissolution can create seepage paths below the dam and abutments as well as lateral leakage paths in the reservoir impoundment area. If measures to control seepage are not adequate, this seepage can compromise the dam foundation over time. The numerous oil and gas wells, particularly in the reservoir impoundment area, could exacerbate the problem with the potential for direct communication of reservoir water into the gypsum zones. Mitigation procedures such as a deep cut-off wall will likely be required.

If the project is to proceed at the current location, a comprehensive geotechnical and geological investigation should be conducted for final design. This should include the following:

1. A detailed analysis of the gypsum and mitigation measures;
2. An investigation of the depth of weathering into the abutments;
3. Detailed stability analyses based on tests results on the embankment construction materials;
4. Delineation of stratigraphy along centerline and deeper core borings in the river channel;
5. Geotechnical investigation at pump station and along water line;
6. A detailed borrow source investigation.

CONDITIONS

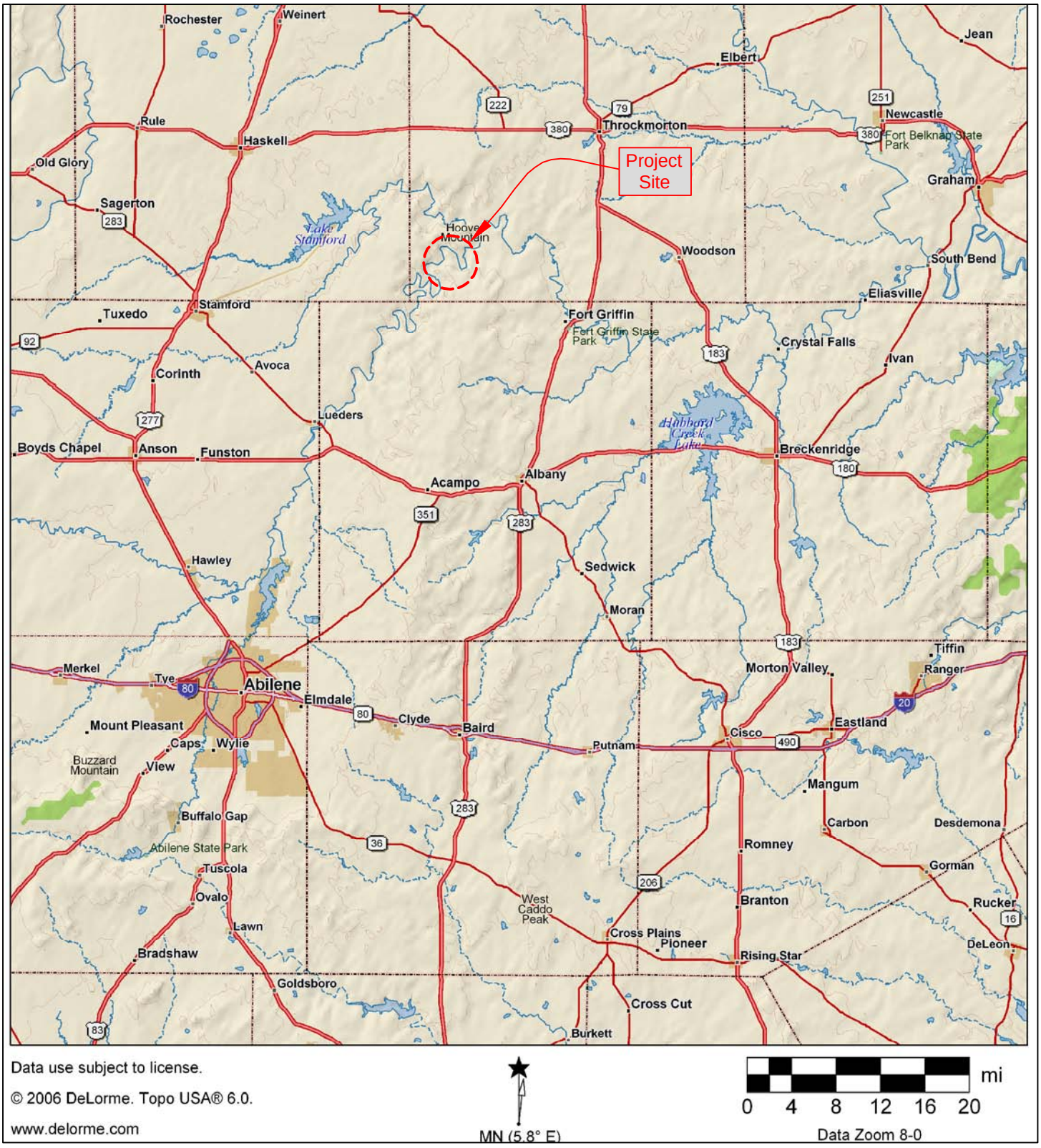
Since some variation was found in subsurface conditions at boring locations, all parties involved should take notice that even more variation may be encountered between boring locations. Statements in the report as to subsurface variation over given areas are intended only as estimations from the data obtained at specific boring locations.

This study is preliminary in nature and much more detailed investigation(s) will be required in order to develop plans and specifications.

The professional services that form the basis for this report have been performed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers practicing in the same locality. No warranty, expressed or implied, is made as the professional advice set forth. Fugro's scope of work does not include the investigation, detection, or design related to the presence of any biological pollutants. The term 'biological pollutants' includes, but is not limited to, mold, fungi, spores, bacteria, and viruses, and the byproducts of any such biological organisms.

The results, conclusions, and recommendations contained in this report are directed at, and intended to be utilized within, the scope of work contained in the agreement executed by Fugro Consultants, Inc. and client. This report is not intended to be used for any other purposes. Fugro Consultants, Inc. makes no claim or representation concerning any activity or condition falling outside the specified purposes to which this report is directed, said purposes being specifically limited to the scope of work as defined in said agreement. Inquiries as to said scope of work or concerning any activity or condition not specifically contained therein should be directed to Fugro Consultants, Inc. for a determination and, if necessary, further investigation.

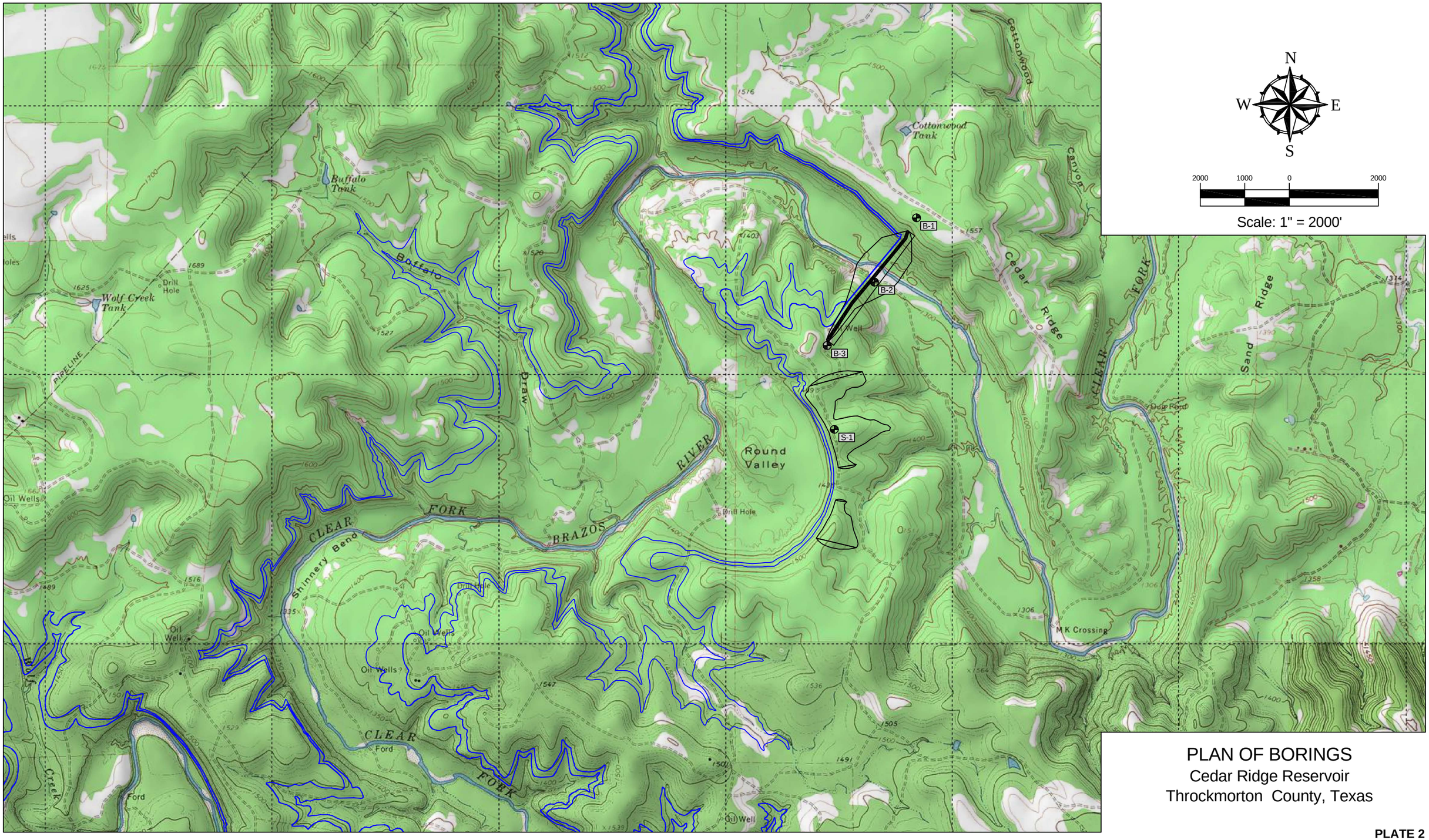
PLATES



VICINITY MAP

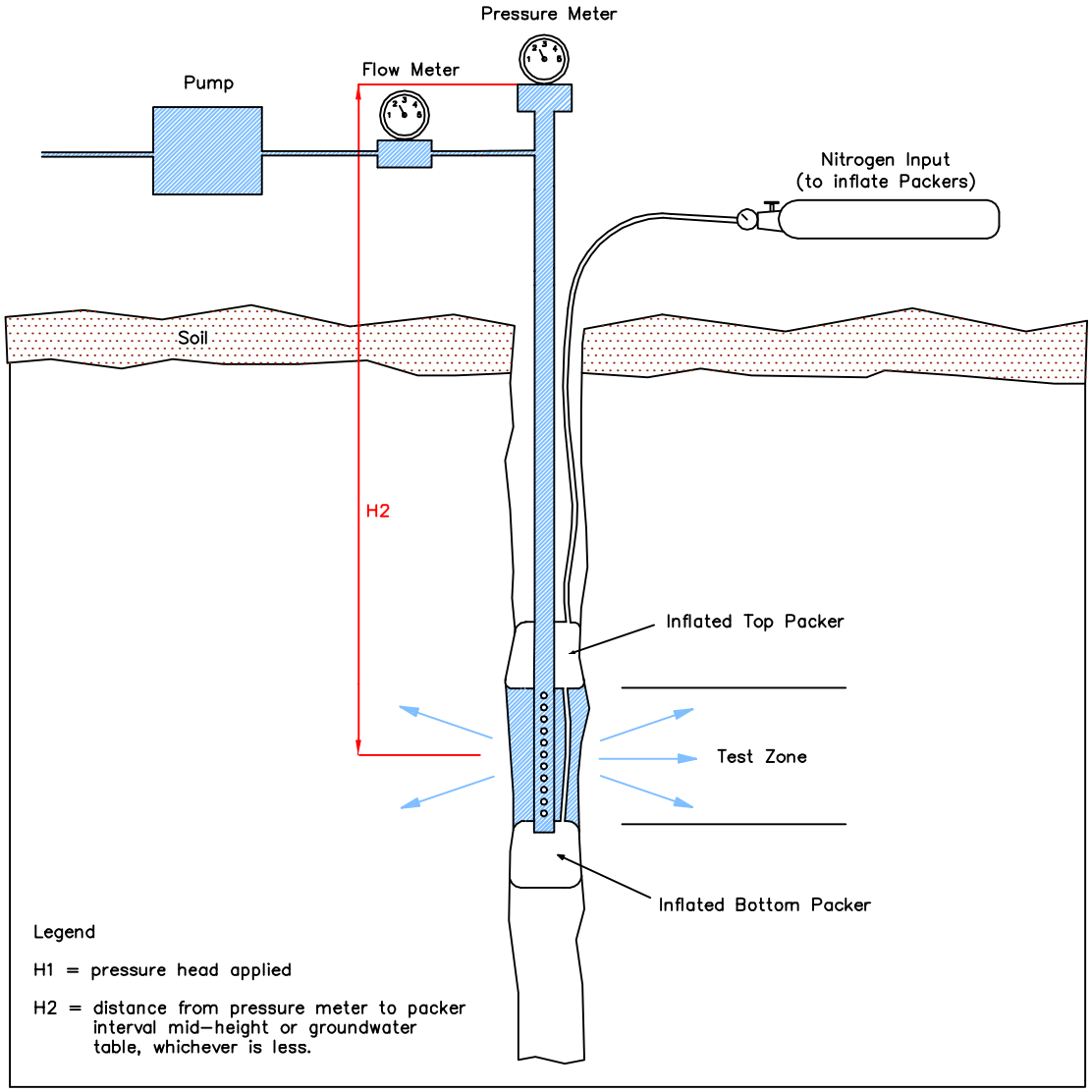
Cedar Ridge Reservoir

Throckmorton County, Texas



PLAN OF BORINGS
Cedar Ridge Reservoir
Throckmorton County, Texas

PLATE 2



DOUBLE PACKER TEST SCHEMATIC

Cedar Ridge Reservoir

Throckmorton County, Texas

Borehole	Packer Test Interval Depth (ft)	Packer Test Interval Elevation (ft)	Test Section (ft)	Test Duration (min)	Gauge Pressure (psi)	Height of Water Column (psi)	Total Head (psi)	Flow Rate (gpm)	K (ft/min)	K (cm/sec)
B-1*	112.5 - 350.0	1430.7 - 1193.2	237.5	5.0	5.0	101.11	106.11	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	112.5 - 350.0	1430.7 - 1193.2	237.5	5.0	15.0	101.11	116.11	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	112.5 - 350.0	1430.7 - 1193.2	237.5	5.0	5.0	101.11	106.11	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	150.5 - 350.0	1392.7 - 1193.2	199.5	5.0	5.0	109.35	114.35	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	150.5 - 350.0	1392.7 - 1193.2	199.5	5.0	15.0	109.35	124.35	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	150.5 - 350.0	1392.7 - 1193.2	199.5	5.0	5.0	109.35	114.35	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	200.5 - 350.0	1342.7 - 1193.2	149.5	5.0	5.0	120.19	125.19	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	200.5 - 350.0	1342.7 - 1193.2	149.5	5.0	15.0	120.19	135.19	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	200.5 - 350.0	1342.7 - 1193.2	149.5	5.0	5.0	120.19	125.19	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	250.5 - 350.0	1292.7 - 1193.2	99.5	5.0	5.0	131.03	136.03	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	250.5 - 350.0	1292.7 - 1193.2	99.5	5.0	15.0	131.03	146.03	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	250.5 - 350.0	1292.7 - 1193.2	99.5	5.0	5.0	131.03	136.03	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	300.5 - 350.0	1242.7 - 1193.2	49.5	5.0	5.0	141.86	146.86	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	300.5 - 350.0	1242.7 - 1193.2	49.5	5.0	15.0	141.86	156.86	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-1*	300.5 - 350.0	1242.7 - 1193.2	49.5	5.0	5.0	141.86	146.86	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-2	29.5 - 39.5	1270.5 - 1260.5	10.0	5.0	10.0	15.82	25.82	0.02000	$3.1x10^{-6}$	$1.6x10^{-6}$
B-2	29.5 - 39.5	1270.5 - 1260.5	10.0	5.0	15.0	15.82	30.82	0.08000	$1.0x10^{-5}$	$5.2x10^{-6}$
B-2	29.5 - 39.5	1270.5 - 1260.5	10.0	10.0	20.0	15.82	35.82	0.07000	$7.7x10^{-6}$	$3.9x10^{-6}$
B-2	29.5 - 39.5	1270.5 - 1260.5	10.0	5.0	15.0	15.82	30.82	0.02000	$2.6x10^{-6}$	$1.3x10^{-6}$
B-2	29.5 - 39.5	1270.5 - 1260.5	10.0	5.0	10.0	15.82	25.82	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-2	39.5 - 49.5	1260.5 - 1250.5	10.0	10.0	10.0	20.16	30.16	0.44000	$5.8x10^{-5}$	$2.9x10^{-5}$
B-2	39.5 - 49.5	1260.5 - 1250.5	10.0	10.0	20.0	20.16	40.16	0.73000	$7.2x10^{-5}$	$3.7x10^{-5}$
B-2	39.5 - 49.5	1260.5 - 1250.5	10.0	10.0	25.0	20.16	45.16	0.86000	$7.6x10^{-5}$	$3.8x10^{-5}$
B-2	39.5 - 49.5	1260.5 - 1250.5	10.0	10.0	20.0	20.16	40.16	0.45000	$4.4x10^{-5}$	$2.3x10^{-5}$
B-2	39.5 - 49.5	1260.5 - 1250.5	10.0	10.0	10.0	20.16	30.16	0.23000	$3.0x10^{-5}$	$1.5x10^{-5}$
B-2*	49.5 - 62.5	1250.5 - 1237.5	13.0	10.0	10.0	25.14	35.14	0.68000	$6.3x10^{-5}$	$3.2x10^{-5}$
B-2*	49.5 - 62.5	1250.5 - 1237.5	13.0	10.0	20.0	25.14	45.14	1.52000	$1.1x10^{-4}$	$5.5x10^{-5}$
B-2*	49.5 - 62.5	1250.5 - 1237.5	13.0	10.0	30.0	25.14	55.14	1.78000	$1.0x10^{-4}$	$5.3x10^{-5}$
B-2*	49.5 - 62.5	1250.5 - 1237.5	13.0	10.0	20.0	25.14	45.14	0.75000	$5.4x10^{-5}$	$2.7x10^{-5}$
B-2*	49.5 - 62.5	1250.5 - 1237.5	13.0	10.0	10.0	25.14	35.14	0.42000	$3.9x10^{-5}$	$2.0x10^{-5}$
B-3	50.5 - 60.5	1419.5 - 1409.5	10.0	5.0	5.0	24.93	29.93	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	50.5 - 60.5	1419.5 - 1409.5	10.0	5.0	15.0	24.93	39.93	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	50.5 - 60.5	1419.5 - 1409.5	10.0	5.0	5.0	24.93	29.93	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	60.5 - 70.5	1409.5 - 1399.5	10.0	5.0	5.0	29.26	34.26	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	60.5 - 70.5	1409.5 - 1399.5	10.0	5.0	15.0	29.26	44.26	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	60.5 - 70.5	1409.5 - 1399.5	10.0	5.0	5.0	29.26	34.26	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	70.5 - 80.5	1399.5 - 1389.5	10.0	5.0	5.0	33.60	38.60	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	70.5 - 80.5	1399.5 - 1389.5	10.0	5.0	15.0	33.60	48.60	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	70.5 - 80.5	1399.5 - 1389.5	10.0	5.0	5.0	33.60	38.60	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	80.5 - 90.5	1389.5 - 1379.5	10.0	5.0	5.0	37.93	42.93	0.00000	$0.0x10^{0}$	$0.0x10^{0}$

*Single Packer Test - All others Double Packer.

SUMMARY OF PACKER TEST RESULTS

Cedar Ridge Reservoir

Throckmorton County, Texas

Borehole	Packer Test Interval Depth	Packer Test Interval Elevation	Test Section	Test Duration (min)	Gauge Pressure (psi)	Height of Water Column (psi)	Total Head (psi)	Flow Rate (gpm)	K (ft/min)	K (cm/sec)
B-3	80.5 - 90.5	1389.5 - 1379.5	10.0	5.0	15.0	37.93	52.93	0.02000	$1.5x10^{-6}$	$7.6x10^{-7}$
B-3	80.5 - 90.5	1389.5 - 1379.5	10.0	5.0	5.0	37.93	42.93	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	90.5 - 100.5	1379.5 - 1369.5	10.0	5.0	5.0	42.27	47.27	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	90.5 - 100.5	1379.5 - 1369.5	10.0	5.0	15.0	42.27	57.27	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	90.5 - 100.5	1379.5 - 1369.5	10.0	5.0	5.0	42.27	47.27	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	100.5 - 110.5	1369.5 - 1359.5	10.0	5.0	5.0	46.60	51.60	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	100.5 - 110.5	1369.5 - 1359.5	10.0	5.0	15.0	46.60	61.60	0.02000	$1.3x10^{-6}$	$6.5x10^{-7}$
B-3	100.5 - 110.5	1369.5 - 1359.5	10.0	5.0	5.0	46.60	51.60	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	110.5 - 120.5	1359.5 - 1349.5	10.0	5.0	5.0	50.94	55.94	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	110.5 - 120.5	1359.5 - 1349.5	10.0	5.0	15.0	50.94	65.94	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	110.5 - 120.5	1359.5 - 1349.5	10.0	5.0	5.0	50.94	55.94	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	120.5 - 130.5	1349.5 - 1339.5	10.0	5.0	5.0	55.27	60.27	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	120.5 - 130.5	1349.5 - 1339.5	10.0	5.0	15.0	55.27	70.27	0.02000	$1.1x10^{-6}$	$5.7x10^{-7}$
B-3	120.5 - 130.5	1349.5 - 1339.5	10.0	5.0	5.0	55.27	60.27	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	130.5 - 140.5	1339.5 - 1329.5	10.0	5.0	5.0	59.61	64.61	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	130.5 - 140.5	1339.5 - 1329.5	10.0	5.0	15.0	59.61	74.61	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	130.5 - 140.5	1339.5 - 1329.5	10.0	5.0	5.0	59.61	64.61	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	140.5 - 150.5	1329.5 - 1319.5	10.0	5.0	5.0	63.94	68.94	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	140.5 - 150.5	1329.5 - 1319.5	10.0	5.0	15.0	63.94	78.94	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	140.5 - 150.5	1329.5 - 1319.5	10.0	5.0	5.0	63.94	68.94	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	150.5 - 160.5	1319.5 - 1309.5	10.0	5.0	5.0	68.28	73.28	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	150.5 - 160.5	1319.5 - 1309.5	10.0	5.0	15.0	68.28	83.28	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	150.5 - 160.5	1319.5 - 1309.5	10.0	5.0	5.0	68.28	73.28	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	160.5 - 170.5	1309.5 - 1299.5	10.0	5.0	5.0	72.61	77.61	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	160.5 - 170.5	1309.5 - 1299.5	10.0	5.0	15.0	72.61	87.61	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	160.5 - 170.5	1309.5 - 1299.5	10.0	5.0	5.0	72.61	77.61	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	170.5 - 180.5	1299.5 - 1289.5	10.0	5.0	5.0	76.95	81.95	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	170.5 - 180.5	1299.5 - 1289.5	10.0	5.0	15.0	76.95	91.95	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	170.5 - 180.5	1299.5 - 1289.5	10.0	5.0	5.0	76.95	81.95	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	180.5 - 190.5	1289.5 - 1279.5	10.0	5.0	5.0	81.28	86.28	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	180.5 - 190.5	1289.5 - 1279.5	10.0	5.0	15.0	81.28	96.28	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	180.5 - 190.5	1289.5 - 1279.5	10.0	5.0	5.0	81.28	86.28	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	190.5 - 200.5	1279.5 - 1269.5	10.0	5.0	5.0	85.62	90.62	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	190.5 - 200.5	1279.5 - 1269.5	10.0	5.0	15.0	85.62	100.62	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	190.5 - 200.5	1279.5 - 1269.5	10.0	5.0	5.0	85.62	90.62	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	200.5 - 210.5	1269.5 - 1259.5	10.0	5.0	5.0	89.95	94.95	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	200.5 - 210.5	1269.5 - 1259.5	10.0	5.0	15.0	89.95	104.95	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	200.5 - 210.5	1269.5 - 1259.5	10.0	5.0	5.0	89.95	94.95	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	210.5 - 220.5	1259.5 - 1249.5	10.0	5.0	5.0	94.29	99.29	0.00000	$0.0x10^{0}$	$0.0x10^{0}$
B-3	210.5 - 220.5	1259.5 - 1249.5	10.0	5.0	15.0	94.29	109.29	0.00000	$0.0x10^{0}$	$0.0x10^{0}$

*Single Packer Test - All others Double Packer.

SUMMARY OF PACKER TEST RESULTS

Cedar Ridge Reservoir

Throckmorton County, Texas

Borehole	Packer Test Interval Depth	Packer Test Interval Elevation	Test Section	Test Duration (min)	Gauge Pressure (psi)	Height of Water Column (psi)	Total Head (psi)	Flow Rate (gpm)	K (ft/min)	K (cm/sec)
B-3	210.5 - 220.5	1259.5 - 1249.5	10.0	5.0	5.0	94.29	99.29	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	220.5 - 230.5	1249.5 - 1239.5	10.0	5.0	5.0	98.62	103.62	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	220.5 - 230.5	1249.5 - 1239.5	10.0	5.0	15.0	98.62	113.62	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	220.5 - 230.5	1249.5 - 1239.5	10.0	5.0	5.0	98.62	103.62	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	230.5 - 240.5	1239.5 - 1229.5	10.0	5.0	5.0	102.96	107.96	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	230.5 - 240.5	1239.5 - 1229.5	10.0	5.0	15.0	102.96	117.96	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	230.5 - 240.5	1239.5 - 1229.5	10.0	5.0	5.0	102.96	107.96	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	240.5 - 250.5	1229.5 - 1219.5	10.0	5.0	5.0	107.29	112.29	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	240.5 - 250.5	1229.5 - 1219.5	10.0	5.0	15.0	107.29	122.29	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	240.5 - 250.5	1229.5 - 1219.5	10.0	5.0	5.0	107.29	112.29	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	250.5 - 260.5	1219.5 - 1209.5	10.0	5.0	5.0	111.63	116.63	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	250.5 - 260.5	1219.5 - 1209.5	10.0	5.0	15.0	111.63	126.63	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	250.5 - 260.5	1219.5 - 1209.5	10.0	5.0	5.0	111.63	116.63	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	260.5 - 270.5	1209.5 - 1199.5	10.0	5.0	5.0	115.96	120.96	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	260.5 - 270.5	1209.5 - 1199.5	10.0	5.0	15.0	115.96	130.96	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	260.5 - 270.5	1209.5 - 1199.5	10.0	5.0	5.0	115.96	120.96	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	270.5 - 280.5	1199.5 - 1189.5	10.0	5.0	5.0	120.30	125.30	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	270.5 - 280.5	1199.5 - 1189.5	10.0	5.0	15.0	120.30	135.30	0.00000	$0.0x10^0$	$0.0x10^0$
B-3	270.5 - 280.5	1199.5 - 1189.5	10.0	5.0	5.0	120.30	125.30	0.00000	$0.0x10^0$	$0.0x10^0$
B-3*	281.5 - 300.0	1188.5 - 1170.0	18.5	5.0	5.0	126.91	131.91	0.00000	$0.0x10^0$	$0.0x10^0$
B-3*	281.5 - 300.0	1188.5 - 1170.0	18.5	5.0	15.0	126.91	141.91	0.00000	$0.0x10^0$	$0.0x10^0$
B-3*	281.5 - 300.0	1188.5 - 1170.0	18.5	5.0	5.0	126.91	131.91	0.00000	$0.0x10^0$	$0.0x10^0$

*Single Packer Test - All others Double Packer.

SUMMARY OF PACKER TEST RESULTS

Cedar Ridge Reservoir

Throckmorton County, Texas

Los Angeles Abrasion
ASTM C131-03 *(Grading "B")*

Sample ID: **Zone A** (S-1 3.0 - 15.3 ft) *
Description: Upper Limestone — ***% Loss by Abrasion and Impact: 31***

* Sample was a composite and contained limestone at the following depths:
S-1: *3.0-3.8 ft, 5.9-6.4 ft, 7.4-8.0 ft, 8.5-8.9 ft, 9.3-9.5 ft, 9.5-10.0 ft, 12.0-12.4 ft, 12.9-13.3 ft, 14.0-15.3 ft*
B-3: *3.0-4.1 ft, 6.3-7.0 ft, 8.0-8.6 ft*

Sample ID: **Zone B** (S-1 19.0 - 32.0 ft) *
Description: Lower Limestone — ***% Loss by Abrasion and Impact: 30***

* Sample was a composite and contained limestone at the following depths:
S-1: *19.2-21.5 ft, 22.7-22.9 ft, 24.0-24.5 ft, 30.0-32.0 ft*
B-3: *12.4-15.6 ft*

Testing Rock Slabs to Determine Soundness of Rip Rap by Use of Magnesium Sulfate
ASTM D 5240-04 *Modified - used core samples rather than rock slabs*

Sample ID: **Zone A** (S-1 3.0 - 15.3 ft)
Description: Upper Limestone — **% Average Soundness loss: 7.2**

Depth (ft)	*Initial Weight (g)*	*Final Weight (g)*	*Weight Loss (g)*	*Percent Loss*
3.0-3.6	*669.73*	*667.20*	*2.53*	*0.4*
5.9-6.4	*648.66*	*567.76*	*80.90*	*12.5*
7.4-8.0	*660.13*	*645.46*	*14.67*	*2.2*
9.5-10.0	*650.31*	*645.41*	*4.90*	*0.8*
4.3-5.0	659.27	527.54	131.73	20.0

Sample ID: **Zone B** (S-1 19.0 - 32.0 ft)
Description: Lower Limestone — **% Average Soundness loss: 11.3**

Depth (ft)	*Initial Weight (g)*	*Final Weight (g)*	*Weight Loss (g)*	*Percent Loss*
19.5-20.0	*651.95*	*618.81*	*33.14*	*5.1*
22.0-22.7	*665.82*	*647.55*	*18.27*	*2.7*
25.3-26.0	*671.61*	*659.92*	*11.69*	*1.7*
28.0-28.6	*635.79*	*388.45*	*247.34*	*38.9*
26.0-27.1	663.74	610.56	53.18	8.0

Standard Test Method for Specific Gravity and Absorption of Rock For Erosion Control
ASTM D6473 - 99(2005)

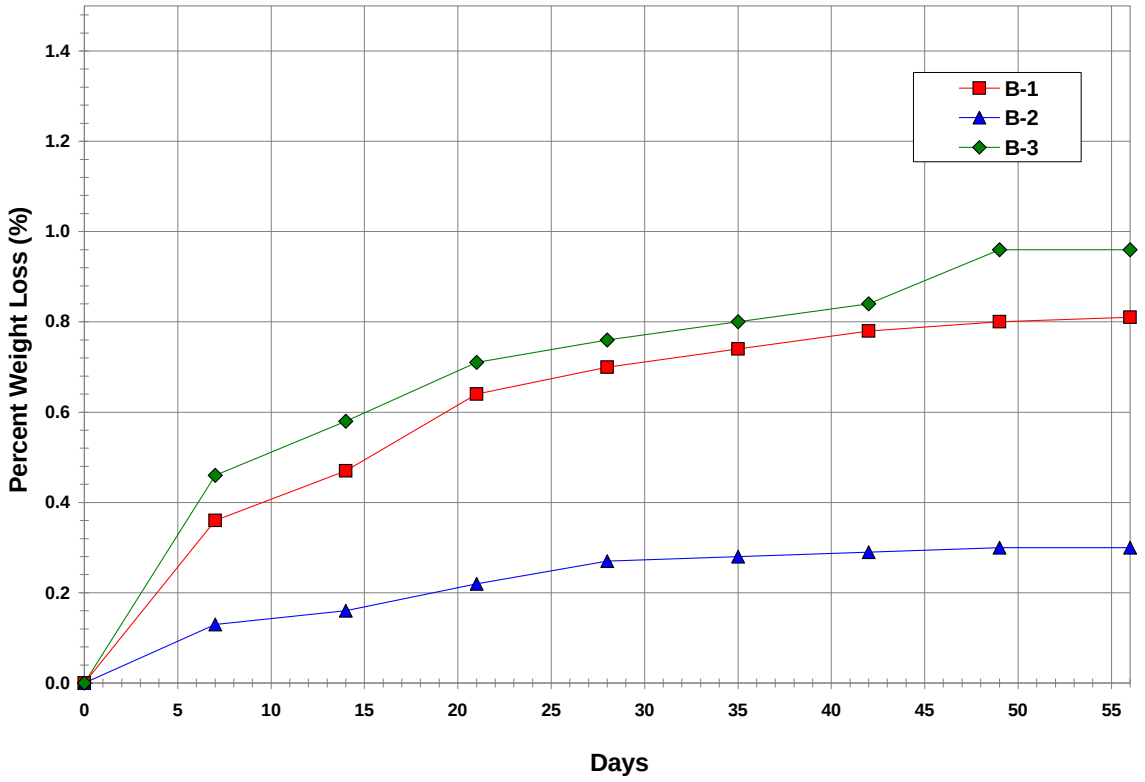
Sample ID: **Zone A** (S-1 3.0 - 15.3 ft) — **Average G_b: 2.589**
Description: Upper Limestone — **% Average Absorption: 1.73**

Depth (ft)	*Weight in Air (g)*	*Weight in Water (g)*	*Weight Saturated Surface Dry (g)*	*Specific Gravity (G_b)*	*Absorption (%)*
3.0-3.6	*650.13*	*409.80*	*661.40*	*2.584*	1.73
5.9-6.4	*266.03*	*168.30*	*270.60*	*2.600*	1.72
7.4-8.0	*430.55*	*271.30*	*438.10*	*2.581*	1.75
9.5-10.0	659.00	415.70	670.20	2.589	1.70

Sample ID: **Zone B** (S-1 19.0 - 32.0 ft) — **Average G_b: 2.589**
Description: Lower Limestone — **% Average Absorption: 3.26**

Depth (ft)	*Weight in Air (g)*	*Weight in Water (g)*	*Weight Saturated Surface Dry (g)*	*Specific Gravity (G_b)*	*Absorption (%)*
19.5-20.0	*650.13*	*409.80*	*661.40*	*2.584*	1.97
22.0-22.7	*266.03*	*168.30*	*270.60*	*2.600*	2.71
25.3-26.0	*430.55*	*271.30*	*438.10*	*2.581*	2.37
28.0-28.6	659.00	415.70	670.20	2.589	5.98

SUMMARY OF DURABILITY TESTS
Cedar Ridge Reservoir
Throckmorton County, Texas



Boring	Depth (ft)	Initial Weight 07/31/08 (gm)	Final Weight 10/06/08 (gm)	Total Weight Percent Loss (%)	Sample Description
B-1	224.3 to 224.5	240.4	238.46	0.81	White to light gray Gypsum
B-2	50.4 to 50.6	236.23	235.51	0.30	White to light gray Gypsum
B-3	207.8 to 208.0	285.33	282.58	0.96	White to light gray Gypsum

GYPSUM IMMERSION TEST RESULTS
Cedar Ridge Reservoir
Throckmorton County, Texas

APPENDICES

LOG OF BORING B-1

Cedar Ridge Reservoir
Throckmorton County, Texas

TYPE: Sample/Wet Rotary LOCATION: See Plate 2

SURF. EL. 1543.2 ft± Job No. 04.10013715

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT OR REC/(RQD),%	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	UNIT DRY WEIGHT, PCF	COMPRESSIVE STRENGTH, TSF
			17	Brown fat CLAY with sand, w/gravel and limestone cobbles. CH (Residual Soil)		25	73	45	91	84		
			50/3"		1539.7 3.5							
5			31	Tan lean CLAY with sand, w/scattered limestone fragments. CL (Completely Weathered Limestone)	1537.7 5.5							
			96 (43)	Tan and gray LIMESTONE, moderately weathered, hard, fractured, w/abundant fossil fragments, vugs, and shale seams and layers. (Grape Creek)								
				-w/multiple healed vertical fractures from 5.5 to 6.1 ft								
				-tan shale from 6.7 to 7.0 ft								
				-w/numerous open vugs (up to 1/4") from 7.8 to 8.6 ft								
10			100 (88)	*-w/numerous open vugs (up to 1/4") from 10.0 to 16.3 ft*								
15			100 (100)		1526.9 16.3							
				Tan and bluish-gray SHALE, moderately weathered, low hardness, non-calcareous, w/pale yellow and reddish brown silt seams and limestone layers. (Grape Creek)								
20			98 (88)									
25			100 (95)	*-gray limestone from 25.1 to 25.4 ft*								
				-tan limestone from 26.0 to 26.7 ft								
				-gray limestone from 27.0 to 27.5 ft								
				-gray limestone from 28.7 to 30.0 ft								
30			100 (78)									
				-red, brown and bluish gray from 32.0 to 34.9 ft								
35			100 (65)									
				-red, brown and bluish gray from 37.0 to 41.0 ft								

COMPLETION DEPTH: 350.0 ft DEPTH TO WATER: See Note

DRILL DATE: 06/07/08

U = Unconfined
Q = Unconsolidated Undrained Triaxial
P = Pocket Penetrometer
T = Torvane

LOG OF BORING B-1

Cedar Ridge Reservoir
Throckmorton County, Texas

TYPE: Sample/Wet Rotary LOCATION: See Plate 2

SURF. EL. 1543.2 ft± Job No. 04.10013715

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT OR REC/(RQD),%	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	UNIT DRY WEIGHT, PCF	COMPRESSIVE STRENGTH, TSF
			100 (90)	Tan and bluish-gray SHALE, moderately weathered, low hardness, non-calcareous, w/pale yellow and reddish brown silt seams and limestone layers. (Grape Creek) *-dark bluish-gray shale layer from 41.0 to 44.6 ft*								
45			100 (97)	Gray LIMESTONE, slightly weathered, hard, slightly fractured, w/abundant fossil fragments and shale seams and layers. (Bead Mountain) *-dark gray shale layer from 46.6 to 49.4 ft* *-healed vertical fracture from 49.4 to 49.7 ft*	1497.9 45.3							
50			100 (100)	*-dark gray shale layer, w/siltstone laminations from 51.1 to 52.7 ft*								
55			100 (98)	*-w/very close horizontal discontinuities from 54.5 to 55.6 ft* *-dark gray shale layer from 55.6 to 56.0 ft* *-w/very close horizontal discontinuities from 56.6 to 57.7 ft*								
60			100 (95)	*-dark gray shale layer (unctuous) from 60.0 to 61.4 ft* *-dark gray shale layer (unctuous) from 55.6 to 56.0 ft*								
65			100 (90)	*-dark gray shale layer from 55.6 to 56.0 ft* *-w/very close horizontal discontinuities, slightly nodular from 67.6 to 70.7 ft*		3					155	193(U)
70			98 (92)	*-dark gray shale layer from 73.8 to 74.4 ft*								
75			100 (83)	*-dark gray shale layer from 74.4 to 76.2 ft*								

COMPLETION DEPTH: 350.0 ft DEPTH TO WATER: See Note

DRILL DATE: 06/07/08

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LOG OF BORING B-1

Cedar Ridge Reservoir
Throckmorton County, Texas

TYPE: Sample/Wet Rotary LOCATION: See Plate 2

SURF. EL. 1543.2 ft± Job No. 04.10013715

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT OR REC/(RQD),%	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	UNIT DRY WEIGHT, PCF	COMPRESSIVE STRENGTH, TSF
			100 (85)	Gray LIMESTONE, slightly weathered, hard, slightly fractured, w/abundant fossil fragments and shale seams and layers. (Bead Mountain)								
				-w/very close horizontal discontinuities from 81.5 to 82.7 ft								
				-dark gray shale layer from 83.0 to 86.5 ft								
85			100 (67)									
90			100 (82)	*-dark gray shale layer (unctuous) from 90.0 to 91.4 ft*		12					109	6.9(U)
95			100 (97)									
				-bluish-gray shale layer from 98.7 to 101.6 ft								
100			100 (90)		1441.6 101.6							
				Gray LIMESTONE, slightly weathered, hard, fractured, w/numerous dark gray horizontal discontinuities and shale seams and layers. (Bead Mountain)								
				-open vertical fracture from 102.2 to 103.0 ft								
105			100 (65)	*-bluish-gray shale layer from 105.3 to 106.2 ft*								
110			100 (88)			3					156	177(U)
				-w/very close horizontal discontinuities from 112.0 to 117.4 ft								
115			100 (90)									
				-w/multiple healed vertical fractures from 119.2 to 119.5 ft								

COMPLETION DEPTH: 350.0 ft DEPTH TO WATER: See Note

DRILL DATE: 06/07/08

U = Unconfined
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LOG OF BORING B-1

Cedar Ridge Reservoir
Throckmorton County, Texas

TYPE: Sample/Wet Rotary LOCATION: See Plate 2

SURF. EL. 1543.2 ft± Job No. 04.10013715

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT OR REC/(RQD),%	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	UNIT DRY WEIGHT, PCF	COMPRESSIVE STRENGTH, TSF
			100 (85)	Gray LIMESTONE, slightly weathered, hard, fractured, w/numerous dark gray horizontal discontinuities and shale seams and layers. (Bead Mountain)								
				-dark gray shale layer, w/siltstone laminations and nodules from 121.5 to 125.2 ft								
125			100 (100)									
				-tan from 126.4 to 129.3 ft								
				-open vug (1/4") at 128.5 ft								
130			100 (100)			3					151	233(U)
				-dark gray shale layer from 133.1 to 133.6 ft								
135			93 (90)	*-bluish-gray shale layer from 136.0 to 140.0 ft*								
140			100 (87)	*-dark gray shale layer from 140.0 to 141.6 ft*								
				-w/very close horizontal discontinuities from 141.6 to 144.4 ft								
145			100 (92)	*-dark gray shale seam from 145.5 to 145.7 ft* *-open vug (1/2") at 145.9 ft*								
				-dark gray shale seam from 147.7 to 148.3 ft								
				-tan from 148.7 to 150.6 ft		3					149	259(U)
150			100 (67)									
				-dark gray shale layer from 151.4 to 152.0 ft								
					1389.2 154.0							
155			98 (42)	Grayish-brown DOLOMITIC LIMESTONE, slightly weathered, hard, slightly fractured, w/numerous micro-vugs and shale seams and layers. (Bead Mountain)								
				-dark gray shale layer from 157.7 to 158.4 ft								

COMPLETION DEPTH: 350.0 ft DEPTH TO WATER: See Note

DRILL DATE: 06/07/08

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LOG OF BORING B-1

Cedar Ridge Reservoir
Throckmorton County, Texas

TYPE: Sample/Wet Rotary LOCATION: See Plate 2

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT OR REC/(RQD),%	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	UNIT DRY WEIGHT, PCF	COMPRESSIVE STRENGTH, TSF
				SURF. EL. 1543.2 ft± Job No. 04.10013715								
			90 (35)	Grayish-brown DOLOMITIC LIMESTONE (--see previous page--)	1381.6							
				-dark gray shale seam from 160.4 to 160.6 ft	161.6							
				Dark bluish-gray SHALE, fresh, low hardness, non-calcareous, w/limestone seams and layers. (Jagger Bend/Valera)								
165			100 (100)									
						6					138	67(U)
170			98 (80)									
				-grayish-brown dolomitic limestone from 172.6 to 172.9 ft								
175			100 (68)	*-grayish-brown dolomitic limestone from 175.0 to 177.2 ft*								
				-light gray fossiliferous limestone from 179.1 to 179.7 ft								
180			100 (40)	*-grayish-brown dolomitic limestone, w/numerous micro-vugs from 180.0 to 183.7 ft*								
185			97 (85)	*-red, brown and bluish-gray from 185.2 to 192.6 ft*								
						8					140	6.0(U)
190			100 (83)									
195			100 (82)									
				-grayish-brown dolomitic limestone, w/multiple healed vertical fractures from 199.0 to 199.5 ft								

COMPLETION DEPTH: 350.0 ft DEPTH TO WATER: See Note

DRILL DATE: 06/07/08

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LOG OF BORING B-1

Cedar Ridge Reservoir
Throckmorton County, Texas

TYPE: Sample/Wet Rotary LOCATION: See Plate 2

SURF. EL. 1543.2 ft± Job No. 04.10013715

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT OR REC/(RQD),%	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	UNIT DRY WEIGHT, PCF	COMPRESSIVE STRENGTH, TSF
			100 (60)	Dark bluish-gray SHALE (--see previous page--)	1342.4							
				Grayish-brown to gray DOLOMITIC LIMESTONE, slightly weathered, hard, slightly fractured, w/gypsum and shale seams and layers. (Jagger Bend/Valera)	200.8							
				-w/pink gypsum nodules (up to 2.0") from 201.6 to 202.3 ft								
				-healed vertical fracture from 203.6 to 203.8 ft								
205				*-pink gypsum nodule (up to 1.0") at 204.2 ft*								
			100 (65)	*-w/numerous gypsum seams (up to 1.0") from 206.0 to 206.6 ft*								
				-pink, white to light gray GYPSUM layer, low hardness, vitreous from 206.6 to 207.2 ft	1336.6 206.6							
						8					138	37(U)
210			95 (83)	***-pink, white to light gray GYPSUM layer, low hardness, vitreous from 210.0 to 210.9 ft***	1333.2 210.0							
				-gypsum seam (1.5") at 213.0 ft								
				-pink gypsum nodule (1.5") at 213.2 ft								
215			100 (67)	***-pink, white to light gray GYPSUM layer, low hardness, vitreous from 216.0 to 217.9 ft***	1327.2 216.0							
				-gypsum seam (1.0") at 219.0 ft								
220			97 (85)			5					152	304(U)
					1319.8 223.4							
225			100 (73)	***-white to light gray GYPSUM layer, low hardness, vitreous from 223.4 to 228.0 ft***								
					1315.2 228.0							
					1313.4 229.8							
230			100 (63)	Dark bluish-gray SHALE, fresh, low to moderately hard, non-calcareous, w/gypsum and limestone seams and layers. (Jagger Bend/Valera)								
235			100 (88)	*-red, brown and bluish-gray from 234.9 to 240.0 ft*								

COMPLETION DEPTH: 350.0 ft DEPTH TO WATER: See Note

DRILL DATE: 06/07/08

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LOG OF BORING B-1

Cedar Ridge Reservoir
Throckmorton County, Texas

TYPE: Sample/Wet Rotary LOCATION: See Plate 2

SURF. EL. 1543.2 ft± Job No. 04.10013715

DEPTH, FT	SAMPLES	BLOWS PER FOOT OR REC/(RQD),%	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	UNIT DRY WEIGHT, PCF	COMPRESSIVE STRENGTH, TSF
		100 (58)	Dark bluish-gray SHALE, fresh, low to moderately hard, non-calcareous, w/gypsum and limestone seams and layers. (Jagger Bend/Valera)								
			-red, brown and bluish-gray from 242.0 to 243.2 ft								
245		98 (68)	*-w/multiple gypsum-coated slickensided joints (~30°) from 244.2 to 244.4 ft*								
			-red, brown and bluish-gray from 245.3 to 252.0 ft								
			-gypsum seam (1/4") at 246.5 ft		6					156	32(U)
250		100 (58)									
			-gypsum seam (1/8") at 252.2 ft								
255		100 (93)	*-gypsum seam (1/4") at 254.7 ft*								
260		100 (73)									
			-pink, white to light gray GYPSUM layer, low hardness, vitreous from 262.5 to 263.2 ft	1280.7 262.5							
			-grayish-brown dolomitic limestone, w/open vugs (up to 1/4") from 263.2 to 263.5 ft		6					147	64(U)
265		100 (62)									
			-fossiliferous from 267.2 to 267.3 ft								
270		93 (65)									
275		100 (67)									
			-white to light gray GYPSUM layer, low hardness, vitreous from 276.6 to 282.4 ft	1266.6 276.6							
			-hard from 278.6 to 280.7 ft								

COMPLETION DEPTH: 350.0 ft DEPTH TO WATER: See Note

DRILL DATE: 06/07/08

U = Unconfined
Q = Unconsolidated Undrained Triaxial
P = Pocket Penetrometer
T = Torvane