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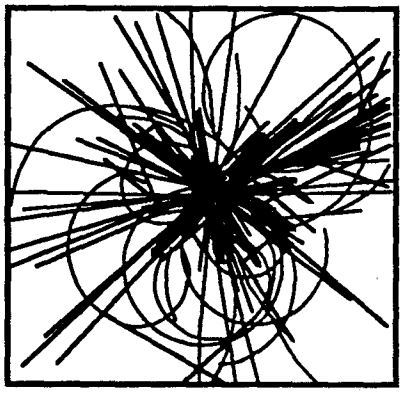
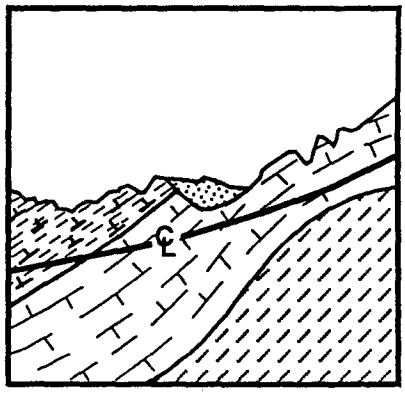
A Plan for Startup Geotechnical Characterization of the Texas Superconducting Super Collider Site





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FOREWORD

A plan for Startup Geotechnical Characterization of the Texas Superconducting Super Collider Site was developed by RTK Joint Venture and The Earth Technology Corporation in consultation with the SSC Laboratory. The plan was finalized on March 22, 1989, before starting site characterization field activities, and supplemented on November 15, 1989.

A PLAN FOR

STARTUP GEOTECHNICAL CHARACTERIZATION

OF THE TEXAS SSC SITE

This plan provides an overall summary of the Startup Geotechnical Characterization. Procedures for drilling, hydrologic testing, geophysical testing, laboratory testing and other activities are described separately in individual work descriptions. Specific Work Instructions will also be developed for the various specific activities as scopes of work are planned.

Office, field, and laboratory-based geotechnical studies will begin at the Texas SSC site in early 1989. These Startup Geotechnical Studies will have the immediate objective of gathering sufficient data to support concurrent efforts to (1) validate the footprint -- thereby helping the start of Land Acquisition -- and (2) begin the Site-Specific Conceptual Design. Both Land Acquisition and Conceptual Design must begin in the first quarter of CY89. Because of the obviously short time period for the supporting geotechnical studies, planning and preparing for them must begin now.

1. WHY GEOTECHNICAL?

Underground works are notorious for the regularity with which the unexpected occurs. Most large underground contracts will encounter some unforeseen "problem ground" which may necessitate new or modified excavation/support techniques, and changes that in all probability will have a direct impact on schedules and costs. The best and easiest path to avoid such impacts is to minimize the potential for geology-caused problems by 1) identifying and characterizing the geologic constraints at the site, and 2) optimizing the constructibility by locating away from the constraints.

A&E Responsibility

A clear and detailed description of the site ground conditions should be produced before the design is made and the construction contract is awarded. The margin of confidence with which the geological nature and geotechnical properties are known should be high enough to allow design, planning, and contract costing to be done with a minimum of risk from geological surprises.

The geotechnical characterization strategy described is a first step toward this necessary geological understanding of the SSC site.

2. PRIORITIES

#1 The Footprint:

The most immediate priority of the geotechnical studies will be to indicate whether individual components of the collider footprint, or indeed the entire footprint, need to be relocated because of geotechnical constraints. Constraints that might require shifts in the locations of shafts, tunnels, interaction halls or injector could occur due to the following:

- too-thin cover (over the tunnel)
- excessive cultural vibrations (close to tunnel)
- difficult ground due to sheared rock (for interaction halls)
- weak ground (as where the tunnel or an experimental hall might penetrate weak shale).

It is important to identify needed relocations early-on and minimize further impacts to the already short-fused land acquisition process.

Footprint-validating studies described herein are optimistic, in that they only test whether geotechnical constraints exist and characterize them if they do; if the constraints are great enough that the footprint must be shifted, a further plan will be written, based on the data then available, to evaluate potential revised locations.

#2 Global Data:

The next priority is to expand the existing, broadly based, broadly distributed geotechnical database for the site by gathering selected data as follows:

- drilling data from gaps in the prior drilling program
- more rock-strength data from rocks that were little-sampled in prior tests (e.g., Eagle Ford Shale)
- more data on such rock properties as elastic moduli and time-dependent behavior that were little- (or not) tested previously
- structural geologic data where the tunnel will pass from one rock type to another (e.g., is the contact simple, or repeated by faulting)
- data on the geomechanical and geohydrological characteristics of faults postulated to cross the tunnel alignment.

#3 Structure-Specific Data:

The short-term priority is to assemble SSC structure-specific geotechnical data by focusing field tests on the locations of experimental halls and the injector. Backed by the global data set, these geotechnical and geohydrological data are needed to allow conceptual designs of construction methods and structural supports for key underground structures.

These three priorities, and the data needs they engender, are obvious drivers in the characterization plan described in Section 5, below.

3. PROPOSAL DATA

The Texas site proposers selected their site for its good general construction characteristics and host formations that are relatively consistent throughout the site region (among other factors). To demonstrate this, geological, geohydrological, and geotechnical data were assembled from a number of published and unpublished sources for the proposal (and subsequent amendments). This included sinking numerous proposal-specific boreholes to establish the large-scale structural competence and ground characteristics of the region.

During the planning phase, it will be important to identify proposal data that can make a valid contribution to the design process. All of the proposal data will help to form a context within which new geotechnical characterizations can be interpreted. Additionally, the proposal data have frequently been important in identifying geotechnical issues that need further evaluation.

Kick-off Geotechnical Workshop

Clearly, the geoscientists and geoengineers of the Texas proposer team have done an heroic job in characterizing and understanding their site. Volumes of site-specific data and interpretations now reside in state agencies, and many more interpretations exist most lucidly in the minds of key individuals. It would be most appropriate to tap this wealth of data and understandings before beginning the site field work. Workshops and field trips are the usual methods among geoscientists and geoengineers for effecting such data transfers.

The workshop agenda should include discussions of both discipline-specific and interdisciplinary topics. Discipline-specific (i.e., geology, geophysics, groundwater, surface-water, soil engineering or rock engineering) agendas should cover: data and sample availability; acquisition and analysis procedures and criteria; region-scale overviews; and site-specific issues and uncertainties. Interdisciplinary topics will

cover: local geoenvironmental issues and concerns; local geohazards; local geotechnical construction practices; and local regulations and regulating agencies. It will also be important to learn of other federal, state and academic groups in the region who also have pertinent data.

4. STRATEGY AND TECHNIQUES FOR CHARACTERIZATION

Footprint Studies

Footprint-deliminating geotechnical studies, as highest priority, will be the first begun. Items that need to be identified are as follows:

- Areas on the western side of the footprint where the geologic structure brings the Eagle Ford Shale close to the depth of the tunnel and experimental halls, thus presenting potential constraints due to weak, deformable rock.
- Areas where the tunnel placement is shallow and/or there are nearby sources of vibration such as major highways and railroads that may represent a problem due to unacceptable vibrations at tunnel depth.
- Zones of potentially poor rock quality and high water inflow in the rock that should be avoided for the experimental hall excavations.

Areas where the top of the Eagle Ford Shale appears to be shallow (along the ring alignment) will be probed by several core holes into the top of the formation. The holes will be located at the most likely places where the tunnel might enter the shale; data from these borings, together with existing data will further refined our understanding of the structure in this region. Areas where vibrations may be a problem will be monitored to measure actual background noise at tunnel depth. Probable faulted areas at experimental halls will be evaluated by air photo (stereo) interpretation and geologic mapping, blind-bored or trenched, and if a structure is identified, it will be core-drilled and hydrologically tested.

Global Data

Because of the short time available for field efforts, conceptual design-supporting geotechnical studies will be performed by concurent expansion of both the global database and the structure-specific database.

Core drilling and laboratory and inhole testing will be the heart of the global-data program. Drillholes to and beyond the depth of the collider tunnel will give a basic stratigraphic characterization. Hydrologic testing and monitoring will also be done in the boreholes. Samples of rock core and soil will be taken from the same holes for laboratory geomechanical tests. In this manner, geological, geohydrological, and geotechnical data will be tied to the same stratigraphy. Faults and shear zones to be crossed by the tunnel will be identified by geologic mapping and probed by drilling and testing.

Drilling, sampling, and testing already done by the proposer goes a long way toward filling the global data need. Consequently, the plan for acquiring global data, described in Section 5 below, has a limited scope focused principally on filling gaps in the existing coverage.

Structure-Specific

At the same time, a similar, but more focused suite of field activities will be performed at the locations of specific structures. The most complex of these will center on the experimental halls. Several holes will be drilled, logged, and hydrologically tested at each hall site to depths below the planned floor of the excavation. Rock samples will be laboratory-tested. Cross-hole geophysical techniques will be used to probe the excavation site in three dimensions.

Studies for the injector will be, in effect, an extension of the global database into a new area of the site. Drillhole-based geological, geohydrological, geophysical, and geotechnical test will add new control points on the side of the injector facing away from the ring, with several tie-lines crossing the injector areas.

The following section expands on this basic strategy and gives more details on how the techniques are applied.

5. PLAN FOR GEOTECHNICAL CHARACTERIZATION

The startup geotechnical activities at the Texas SSC site should allow the geologist and engineer to build their level of knowledge and confidence about the geological structures and geotechnical properties of the site materials to the point where there remains only a realistically small risk of encountering a geologic surprise. The objectives of this phase are:

- To confirm the site's suitability and optimize the ring and hall positions within it
- To provide data for a preliminary structural design
- To provide a rational framework within which construction contracts and schedules can be formulated
- To maximize the use of the site-specific data already gathered by the proposer.

A program of geotechnical activities to meet these objectives, as well as the priorities described above, is outlined in the tables that follow. These tables cover the following:

- Table 1 Footprint Location
- Table 2 Global Data
- Table 3 Structure-Specific Data - Experimental Halls
- Table 4 Structure-Specific Data - Injector Complex.

In each table, the basic investigative program is explained first, then the techniques to be used are described.

Summary

In summary, the planned field activities will be as follows:

- To validate the footprint (Table 1), there will be:
  - 4 coreholes, into the top of Eagle Ford Shale, will be drilled, logged, and tested;
  - up to 3 structure (fault) zones probed by several blind-drilled rotary wash holes and one core hole each;
  - 5 ambient vibration monitoring locations, each of which will have one boring monitored at 2 or 3 depths.

- To complete the global data base (Table 2):
  - 4 core holes will be drilled near shaft locations;
  - 3 potential structure (fault) zones will be probed by blind-drilled rotary wash holes and one core hole each.

- For specific SSC structures (Tables 3 and 4):
  - 2 hall locations will have 6 coreholes and 2 trenches each;
  - 2 other hall locations will have 4 coreholes each;
  - 2 potential hall locations will have 1 corehole each;
  - the injector vicinity will be probed by two new coreholes and several tie lines of blind-drilled rotary holes.

TABLE 1

FOOTPRINT LOCATION

BASIC PROGRAM: Evaluate whether the tunnel or experimental halls should be moved to avoid weak or problem ground conditions, or a high level of vibrations, or too-thin cover. Core-drill (with logging, wire-line logging, in-hole testing and laboratory testing) locations where the tunnel or experimental hall might intercept Eagle Ford Shale. Measure ambient vibrations at tunnel depth beneath major highways and railroads. Locate, and core drills faults if they intersect experimental hall sites.

TECHNIQUES:

1. Stratigraphic Constraints

For excavation stability, ideally, the tunnel should not enter the Eagle Ford Shale beneath the Austin Chalk. Where the Eagle Ford/Austin contact is near tunnel depth, it will be probed by additional borings. Coreholes are planned at BE1, BE1.7, BF1.6, and at an alternative interaction hall location, BK1′ (see Map GC-2).

2. Structural Zones

Structural Zone Studies: Filed verify locations of possible faults relative to locations of experimental halls; use blind-bored rotary wash holes (logged geophysically) or trenches to delimit zone; drill (with N-coring) to intercept zone at tunnel depth (angled boring is preferred), logging core and hole; packer-test whole zone or several intervals to measure permeability. Presently, such studies are expected to be needed near K2, K4, and K5; study during initial field mapping may eliminate these concerns, or identify additional areas to be studied.

5. Vibration

Ambient Vibration: Measure vibrations at tunnel depth caused by cultural noise such as road and railroad traffic, quarry operations and heavy equipment operations. Where the tunnel is shallow, holes will be bored to tunnel depth immediately adjacent to rail lines and major highways where they intersect the tunnel alignment. Single component seisometers and a triaxial accelerometer, positioned in the borehole at tunnel depths and two or three shallower depths, will monitor the frequency and displacement characteristics of the vibrations, and will give an indication of the local vibration-attenuation characteristics. Presently, these studies are expected to be needed at 5 locations around the ring (see Map GC-2). At one such location, attenuation of surface waves will be measured by 6 or 8 shallowly-emplaced geophones.

TABLE 2

GLOBAL GEOTECHNICAL DATA

BASIC PROGRAM: Sample several as-yet-undrilled shaft locations by drilling (with sampling and coring), logging, hydro-testing and laboratory testing. The drill holes will be control points for collider tunnel characterization. Probe a small number of probable faults with angle drilling and in-situ hydrologic testing.

TECHNIQUES:

1. Drilling

Sample Curation: For logistical reasons, it will be desirable for DOE to take custody of some existing site cores -- say particularly good reference stratigraphic sections for correlation purposes -- in a storage area near the site.

Drilling: Drill 4 holes, at shaft locations, each providing 100 percent coverage of the tunnel strata between it and the next adjacent shaft location, on both sides (see Map GC-2). Sixteen other shaft locations probably will not need a boring during this phase because adequate proposer borings exist nearby.

Rock Coring: Continuously N-core; use standard lithologic, RQD, and fracture logging; special preservation of Taylor Marl and Eagle Ford Shale for laboratory tests.

Borehole Logs: Use SP, R(short), R(long), natural gamma, compensated density, Vp, and caliper. Vs may also be measured by uphole seismic velocity survey or full-wavetrain wireline logging.

2. Hydrology

Bedrock Slug Test: Test all holes; install 6-inch blank conductor casing, clean N-hole in rock, and perform low pressure slug injection test.

Bedrock Packer Tests: Test all holes; guarded straddle packers; test 2 intervals near tunnel depth plus one additional interval (fractured zone or weathered rock) in each hole; collect water samples; complete hole as single or multiple-point piezometer; and monitor water levels.

3. Laboratory

Laboratory Rock Tests: Test 40 samples; tests will include bulk density, moisture content, swell potential, slake durability, abrasion, hardness, permeability, unconfined compressive strength, triaxial strength, Brazilian strength, stress-strain relationships for Young's modulus and Poisson's ratio, bulk mineralogy, clay mineralogy, cement petrography, and discontinuity shear tests.

Water Chemistry: Test Eh, pH, TDS, sulfate, chlorinity, major anions, and TOC for up to 8 samples.

4 Structural Zones

Structural Zones Studies: Locate structural zone on ground by field mapping, trenching, and blind-bored rotary wash borings (geophysically logged). Drill (with N-coring) to intercept structure at tunnel depth (angle boring is preferred). Log core and hole as for access shaft holes. Packer-test sheared zone with straddle-packer to assess permeability. It is presently expected that 3 of the 11 fault locations along the tunnel will be evaluated to establish a "worst case" for tunnel construction.

TABLE 3

STRUCTURE SPECIFIC DATA FOR EXPERIMENTAL HALLS

BASIC PROGRAM: Prove-out the experimental hall locations -- roof, side-walls, and subfloor -- by drilling (with sampling and coring), logging, in-situ hydrologic tests, up-hole and cross-hole geophysics, and laboratory testing. Roof strata will receive special attenuation for underground excavations.

TECHNIQUES:

1 Drilling

Full-Depth Drilling: Drill 3 coreholes at each hall location (K1, K2, K5, and K6) to depths 20 to 30 feet below planned excavation invert. One of these holes at each hall will be angle-bored into the predominant fracture trend. See drawing 21-M-01 for typical layout and depth of borings.

Roof Strata Drilling: Drill 3 additional holes at halls K1 and K2 for which wholly underground excavation is being considered; drill to the depth of the planned excavated crown.

Alternate Hall Drilling: Drill 1 corehole each at hall locations K3 and K4 to depths 20 to 35 feet below planned excavation invert.

Soil Sampling: Sample every 10 feet with drive sampler (ring or tube sampler) or Pitcher sampler; standard geotechnical soil logging; only expected to be needed at halls K5 and K6.

Rock Coring: Continuously N-cored; use standard lithologic, RQD, and fracture logging; special preservation of Taylor Marl and Eagle Ford Shale samples for laboratory tests.

Boreholes Logs: Use SP, R(short), R(long), natural gamma, compensated density, Vp, and caliper. Borehole televiewer at K1 and K2.

2. Geophysics

Geophysical Surveys: Use uphole velocity, and cross-hole velocity (halls K1, K2, K5, and K6).

3. Hydrology

Bedrock Packer Tests: Test 2 intervals in each full-depth borehole, including fractured zones in particular; straddle packer; collect water samples; complete one borehole each at K1, K2, and K5 as single- or multiple-point piezometer, and monitor water level.

Soil Pump Tests: Test in 2 boreholes at K5 and two at K6. Install 4-inch steel casing with up to 10 feet long screen in minimum 6-inch diameter hole at each location, filter-pack annulus, and conduct 8-hour pump test; collect water samples; monitor borehole as piezometer, and monitor water level.

4. Mapping

Surface Mapping: Map 1 square mile each at K1 and K2 for faults and sheared zones. Do statistical sampling of joint trends and density, and characterize joint roughness, fillings, etc.

Trenching: At K1 and K2, machine-excavate trenches up to 3 feet into top of bedrock. Characterize joint trend, spacing, roughness, fillings, etc.

5. Laboratory

Laboratory Soil Tests: Test all samples; sieve, Atterberg, moisture density, specific gravity, permeability, unconfined compressive strength, direct shear, triaxial strength, soil chemistry, swell potential.

Laboratory Rock Tests: Test 10 samples per hole; density, moisture content, swell potential, slake durability, abrasion, hardness, permeability, unconfined compressive strength, triaxial strength, Brazilian tensile strength, bulk mineralogy, clay mineralogy, cement petrography, and discontinuity shear tests.

Water Chemistry: Test Eh, pH, TDS, sulfate, chlorinity, major anions, and TOC for 6 samples.

TABLE 4

STRUCTURE SPECIFIC DATA FOR THE INJECTOR COMPLEX AND TRANSFER TUNNELS

BASIC PROGRAM: Tie injector area stratigraphy with stratigraphy at nearby access shafts using drilling (with sampling and coring), logging, hydro-testing, and laboratory testing,. Blind-bored rotary wash borings (geophysically logged) will be used to tie with shaft borings, and to assess near-surface conditions for cut-and-cover injector.

TECHNIQUES:

1. Drilling

Drilling: Core-drill 2 holes, on the side of the HEB alignment facing away from the near cluster providing 50 percent stratigraphic overlap with each other as well as with the boreholes at J1, K1', and F10 -- at a minimum of 25 feet deeper than the planned injector depth (see map in pocket for details). Blind bore (rotary wash), a number of shorter holes along tie lines between injector area core holes and from injector area core holes to existing core holes at J1 and F10.

Soil Sampling: Sample core holes every 10 feet (vertically) in overburden soils with drive sampler (ring or tube sampler) or Pitcher sampler; standard geotechnical soil logging.

Rock Coring: Continuously N-core two core holes; use standard lithologic, RQD and fracture logging.

Borehole Logs: Use SP, R(short), R(long), natural gamma, compensated density, Vp, and caliper.

2. Hydrology

Bedrock Packer Tests: Test three holes; straddle packers; test two intervals near tunnel depth; collect water samples, complete 2 holes as piezometers; and monitor water level.

3. Laboratory

Laboratory Soil Tests: test all samples; sieve, Atterberg, moisture density, specific gravity, permeability, unconfined compressive strength, direct shear, triaxial strength, soil chemistry, swell potential.

Laboratory Rock Tests: Test all samples; density, moisture content, swell potential, slake durability, abrasion, hardness, permeability, unconfined compressive strength, discontinuity shear tests, bulk mineralogy, clay mineralogy, cement petrography.

ADDENDUM

ADDENDUM TO

A PLAN FOR STARTUP GEOTECHNICAL CHARACTERIZATION

OF THE TEXAS SSC SITE

1. PURPOSE

This addendum describes five elements of geotechnical work to be added to the Plan for Startup Geotechnical Characterization. These are: 1) characterization of initial tunnel sections; 2) development of a geotechnical data base; 3) design, excavation, and monitoring of a special geotechnical instrumentation shaft (large-diameter drill hole); 4) in-situ stress and modulus measurements in shaft borings; and 5) measurement of piezometric levels in the Woodbine and Twin Mountain aquifers. The first four elements of work are part of the site-specific adaptation of the Conceptual Design to the Texas SSC site. Characterization of the initial tunnel sections will support a valid site-specific conceptual design for that portion of the tunnel (comparable to the support given by the experimental hall borings). The geotechnical data base will document the data used for the site-specific adaptation of the conceptual design, as well as provide data for subsequent design phases. Testing in a special shaft into the Eagle Ford Shale will help to validate conceptual designs for subgrade support systems which likely will be needed in experimental halls in that rock type. In-situ measurements of stress and rock moduli are important additions to the ongoing characterization program.

Piezometric measurements in the deep aquifers will provide a baseline against which future declines in pressure level may be compared. A concern was raised by UTAP regarding the potential for regional subsidence as pressures decline, due to increased usage in these aquifers by municipalities and industries in the region; irregular subsidence could affect machine performance, so a baseline is essential to assess the cause should subsidence occur.

2. STRATEGY AND TECHNIQUES FOR CHARACTERIZATION

2.1 Initial Tunnel Sections

Borings will be drilled approximately every 1,000 feet along the tunnel alignment between E1 and F1 and between F1 and E2, where the tunnel is expected to be in shale near the chalk/shale interface; these borings will be cored and logged to 35 feet below centerline. Several will be hydrologically tested, and several will be geomechanically tested in-situ. Rock samples will be laboratory-tested. Additionally, two holes will be drilled beyond E1 and E2 (pilots for potential construction shafts), three angle holes will cross the shaft boots, and one boring will probe a potential geotechnical instrument bay/adit location. These additional holes will be cored and tested like the on-alignment borings. (See Table 1.)

2.2 Geotechnical Data Base

Several data bases will be created to store and transmit geotechnical data obtained from the State and acquired in the site characterization studies of which this project is a continuation. Currently, four data bases are envisioned as shown in Table 2.

The data bases are intended to summarize all the available geotechnical data for the site in a retrievable format; the intent of the SSC Laboratory is to support the AE/CM by helping to reduce the volume of new data needed for its most urgent design efforts. The emphasis will be on readily retrieved formats and established pedigrees for all data.

2.3 Large-Diameter Geotechnically Instrumented Drill Hole (LDD)

An 8-foot-diameter instrumented drilled hole will be excavated near IR3 (preferred) or IR2 (alternate) to evaluate the geomechanical performance of the Eagle Ford Shale in-situ. At both locations, the excavated floor of the hall will be in Eagle Ford Shale, which, because of its strength and deformation properties may deflect undesirably beneath the weight of the heavy detectors (L-star or LSD). It is expected that some subgrade modification may be needed to reduce the deflections to acceptable tolerances. An

TABLE 1

INITIAL TUNNEL SECTIONS CHARACTERIZATION

BASIC PROGRAM: Prove-out E1 to E2 section by drilling (with sampling and coring), logging, in-situ hydrologic tests, in-situ geomechanical tests, geophysical logging, and laboratory testing to probe the proposed tunnel alignment along the chalk/shale interface.

TECHNIQUES:

1. **DRILLING**

   On-Alignment Borings: Rotary wash and core-drill holes on approximately 1,000-foot centers, between E1 and F1 and between F1 and E2 (drilling at E1, F1, and F2 shafts is described in the 3/22/89 plan). The holes will extend 35 feet below tunnel centerline. The holes may be offset up to 30 feet off of the alignment.

   Construction Shaft Pilot Borings: Core-drill two borings up to 1,500 feet south and north of E1 and E2, respectively, at potential locations for construction-only shafts. The holes will extend 35 feet below tunnel centerline.

   Angle Borings: Core-drill three angle holes at each E1, F1, and E2 to probe the zone of the proposed boot structure at these shafts; to 35 feet below tunnel centerline.

   Boring at Geotechnical Test Location: A tail-tunnel, adit or bay is planned for evaluating constructability/serviceability of the tunnel. Core-drill a boring to characterize this location.

   Coring and Logging: Continuously N-core (on-alignment borings will be partially rotary wash); use standard lithologic, RQD, and fracture logging. Run SP, R (short, long, and single-point), natural gamma, compensated density, velocity, and caliper tools.

   Completion and Abandonment: Completion and abandonment will be done so as not to interfere with later tunnel/shaft excavation and performance.

2. **HYDROLOGY**

   Bedrock Packer Tests: Test five holes; straddle packers; test two intervals near tunnel depth.

   Piezometers: Complete four holes as piezometers and monitor water levels; develop monitoring wells; if possible, collect samples of formation water.

3. **GEOMECHANICS**

   Laboratory Rock Tests: Focus on interval around tunnel; density, moisture content, Atterberg Limits, specific gravity, swell potential, slake durability, unconfined compressive strength, discontinuity shear, bulk, and clay mineralogy, carbonate content, drained and undrained triaxial strength, elastic moduli.

   In-Situ Tests: In four borings, measure stress, deformation moduli.

TABLE 2

GEOTECHNICAL DATA BASES

BASIC PROGRAM: Assemble pertinent geotechnical data in standard formats for turnover to the SSC Laboratory. Several distinct data bases are anticipated to fill specific needs.

DATA BASES:

1. **Data Base I:** Pre- and post-proposal site geotechnical data in an "electronic filing cabinet" format. This will be indexed by boring and data type suitable for graphical and spreadsheet output. Lithologic, index property, and strength property data will be input. Post-proposal data, in particular, will be validated and hard copy maintained for its pedigree.

2. **Data Base IA:** This will be similar in format and content to Data Base I, but will be limited to data from the E1 to E2 investigations which will be available to turn over to the SSC Laboratory for that tunnel segment.

3. **Data Base II:** Case history data on experience excavating and constructing in the Eagle Ford Shale, Austin Chalk, and Taylor Marl elsewhere in the region. This will be a hard-copy data base. Standardized guidelines will be prepared on the type of data sought and the organization for input. This will be gathered from geotechnical contractors with experience in the region.

4. **Data Base III:** Hard-copy record of post-proposal geotechnical investigations and results. This is an extension of Earth Technology's field activity files ("boring data packs") which contain the complete documentation of each field and laboratory activity and resulting report. The data packs contain the following:

    - Specific work instruction
    - Access agreements and use settlements
    - Lithologic logs (field and final)
    - Core photographs
    - Sample inventories and transfer records
    - Wire-line logs
    - Hydrologic test results
    - Laboratory test results
    - Completion and abandonment records
    - Surface mapping results.

    Geotechnical drawings, profile maps, and fence diagrams will also be kept in this file with supporting documentation. Other data bases may be added as needed.

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instrumented large-diameter drill hole--LDD--is needed to validate the shale's performance in-situ (versus in-laboratory testing which has been done to date); the LDD will also allow some observation of time-dependent characteristics (not tested to date in the laboratory). Instruments will measure displacement and stress conditions while the LDD is being excavated and after the excavation is completed. Development of the LDD will follow the steps outlined in Table 3.

2.4 In-Situ Stress and Modulus Measurements

Borings at the shafts and injector locations are described in the 3/22/89 plan. Stress and deformation moduli will be measured in some of these borings. The measuring instruments/techniques will be selected based on the character of the rock, and drilling methods will be adjusted accordingly. Ultimately, measurements will be made at several depths in the Eagle Ford Shale, Austin Chalk, and Taylor Marl.

TABLE 3

STEPS FOR INSTRUMENTED LARGE-DIAMETER DRILL HOLE (LDD) IN EAGLE FORD SHALE

Step 1	Identify potential response of shale to unloading (excavation) and reloading (detector construction) and long-term loading (time-dependent), and identify data needed to quantify response of the rock and suitability of remediative treatment.
Step 2	Prepare description of LDD and instrumentation in concept, with desired objectives, adequate to identify potential excavators and equipment vendors.
Step 3	Identify site and start gaining access/clearance/permits.
Step 4	Prepare test plan describing objectives, types of instrumentation, test schemes, data acquisition schemes, and analytical methods.
Step 5	Select and procure or fabricate instrumentation and data acquisition systems.
Step 6	Prepare excavation and test specifications describing instruments, configurations, excavation/testing sequences, calibrations, recording and monitoring needs, contingency plans, excavation/lining sequence, responsibilities, safety measures, inspection hold points, and reporting.
Step 7	Select and procure excavation contractor.
Step 8	Bench-calibrate and system-test instruments.
Step 9	Fence site and run in utilities.
Step 10	Install peripheral instrumentation in bore holes drilled and sampled around LDD location and test.
Step 11	Excavate and instrument LDD. Excavation and lining will proceed in stages, installing instruments and monitoring responses as excavation proceeds. Block samples may be taken for laboratory determination of mechanical properties. The LDD will reach 25 feet below the planned excavated grade for the hall.
Step 12	Enclose LDD and install environmental controls and monitors. Install electronic data acquisition.
Step 13	Prepare as-built descriptions.
Step 14	Analyze and report short-term results.
Step 15	Continue monitoring.

2.5 Piezometric Levels in Deep Aquifers

A search of records in state agencies has yielded information on 35 to 40 water wells in Ellis County that tap the Woodbine or Twin Mountains aquifers. Owners will be contacted to determine if water levels have been monitored and to obtain permission to do water level measurements. As many wells as possible will be resounded. The resulting piezometric data will be contoured to sow both current levels and time trends. Statistical techniques will be used to determine whether additional monitoring wells need to be drilled to establish the desired baselines.