GLO1930

PHASE I

PRELIMINARY DRILLING PLAN

PROGRAM FOR SCIENTIFIC DRILLING IN THE CASCADES (PSDC)

Submitted to:

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ABSTRACT

PHASE I - PRELIMINARY DRILLING PLAN - PROGRAM FOR A SCIENTIFIC PROGRAM FOR DRILLING IN THE CASCADES

One essential element of the resolution of the major scientific problems of the Cascades requires subsurface data. The approach proposed is to drill arrays of wells and coreholes across the volcanic axis of the Cascades Range. These drill holes are directed toward the basic measurements of deep thermal gradients, hydrology and *in situ* stress. This data base should aid resolutions of issues of the hydrothermal and thermal regimes of the Cascades. In addition, core, cuttings, geophysical logs, and fluid samples will provide supporting data for surface investigations and resolution of these major questions.

These preliminary drilling plans are devised to satisfy the scientific requirements in a cost-effective manner. In the choices of well re-entry, drilling, and core drilling, the nominal geologic and hydrologic conditions were factored in. The use of the existing Sunedco well and a nearby drilled hydrologic test well are evidence of the application of this approach. Core holes will yield significant geologic structure and rock property data.

These small diameter, diamond drilled holes will be lower cost, can tolerate the severe lost drilling fluid zones anticipated, and offer optimum borehole wall qualilty for *in situ* stress determinations by the hydraulic fracturing technique.

It should be realized that the drilling plans and scoping cost estimates are very preliminary. Detailed schedule, drilling programs, and improved cost estimates will be developed when the project is initiated. Detailed drilling and scientific planning will require close coordination and an intense effort to prepare drill rig specifications and requirements for each subsurface campaign. It is judged that conventional hardware and drilling equipment can be adapted and used for the proposed Phase I drilling effort. Some engineering preparation and equipment modifications will be needed. However, with sufficient time spent by knowledgable and experienced engineering personnel, these matters can be anticipated and accomodated within the procurement and contracting process. Most of the problems we anticipated to arise from potential high temperatures, up to 200°C (440°F) and by the proposed coring to a depth of 4 Km (13,000 ft). During the detailed drilling planning, development of field procedures and schedules, the project scientists with data, test equipment, and support requirements will be directly and closely involved in reviewing, revising and preparation of all drilling plans and specifications.

I. CASCADE PHASE I DRILLING AND CORING PLAN

The scientific requirements for the Phase I activities have been developed above and by Priest (1985). The resolution of the scientific issues of the structure and stratigraphy under the active Cascade volcanic arc; the heat flow, nature of the thermal source and hydrothermal systems, and the nature and properties of the pre-Cascade crust will require detailed studies of sections across the Cascade Range, roughly perpendicular to the volcanic axis. This can best be done by transects across the Cascades. The researchers involved have determined that needed subsurface data can best be obtained by a series of drill hole transects across the Cascade Range.

The first transect, the so-call Santiam Pass area, has been selected as the initial priority, i.e., the highest scientific yield option from a drilling operations standpoint. This area is characterized by a layer of younger volcanics overlaying with older volcanic rocks. It is generally anticipated that boreholes on the flanks of the pass will encounter about 300 m (1000 ft) of these younger rocks. This cover would be expected to increase to 1200 m (4000 ft) in the crest on volcanic axis locations. The younger volcanics are known to be difficult to drill, and can have zones of severe lost circulation and unstable borehole conditions.

A. Basis for the Estimates and Schedules

The following brief summary of the proposed drilling plan is based upon a preliminary, scoping analysis of the coring and drilling operations, scientific well tests, and related procedures needed to collect the desired data. Rough estimates only are presented. These were based upon past experience with similar projects. These schedule and cost estimates will be refined as the project definition, review, drilling plan scope, and scientific goals are refined.

B. Summary of Drilling/Coring Plan

Four types of drilling and coring are proposed to conduct the Phase I scientific transect across the Cascades. These consist of

(1) Testing and deeping of an existing 2.4 Km (8,000 ft) commercial (Sunedco) well to 4 Km (13,000 ft).

(2) Drill a 2-Km (6000 ft-) hydrologic test well near the Sunedco well.

(3) Diamond core-drill four, slim holes to 1.2 Km (4000 ft) depth on the flanks of Cascades in the Santiam Pass area.

(4) Drill and core a 2.7 Km (9000 ft) combined drill hole and core hole near the crest region of the Cascades; i.e, on the volcanic axis of the range.

Table I records these four major subsurface scientific efforts. A conceptual sketch of these boreholes located across the Santiam Pass is shown in Fig. 1. The individual scientific drilling projects are outlined in Table II, where the four types of drilling projects are organized within each drilling project in a sequential order of operations and procedures.

Figures 2 through 6 indicate the well bore configurations, borehole diagrams, and drilling and testing plans for the four proposed types of drilling/coring projects. Such first cut scoping type cost estimates will be refined as the PSDC scientific plan matures, and through review and refinement. Development of detailed costs of each element of the drilling/coring projects should then be performed. Finally as rig specifications and field operating plans and procedures are prepared, cost estimates will represent mature, engineering cost estimates based on evaluation of detailed local conditions, prices, and the current prices for the specific supplies, subcontractors, services, materials, and rentals needed for each drill site.

C. Preliminary Cost Scoping Estimates

Using the drilling/coring and testing plans outlined above, very preliminary cost estimates were derived. Table III is a summary of these estimates. These estimates doe not include the full suite of logs, except they do include the time to run the logs within the operationing times. Very rough estimates of the in situ stress measurements are included. They are expected to be very costly in the larger diameter holes, and much less costly in the H-size core holes.

TABLE I: SUMMARY OF PROPOSED
CASCADE PHASE I DRILLING/CORING PLAN

Drilling Activity	Depth km	(ft)	Operations	Primary Tests, Research and Procedures
1. Sunedco Well a. Clean out and test	2.4	(8000)	Workover rig sample and test	+ Geophysical logs and VSP + Sidewall core + Fluid sample aquifer + *In situ* stress determinations + Set protective 4 1/2 CSG string
b. Core deeper, and test	4.0	(13000)	Deep core rig; continuous core to T.D.	+ Geophysical logs + Fluid samples + *In situ* stress determinations + Set 2" protective pipe
2. Drill test well	2.0	(6000)	Air drill, small rotary rig	+ Rotary drill for hydrologic test + Core major aquifers + Geophysical logs + Hydrologic test of aquifer + *In situ* stress determination + Set 2" protective pipe
3. Core drill slim holes	1.2	(4000)	Intermediate depth core rig, H-size	+ Top to bottom core + Geophysical logs + Fluid sample + *In situ* stress determinations + Set 2" protective pipe
4. Drill/core crest hole	2.7	(9000)	Rotary to approx. 1.2 km (4000 ft); continuous core H-size to TD	+ Geophysical logs + Fluid sample + *In situ* stress determinations + Set 2" protective pipe

TABLE II

SUMMARY OF CORE/DRILLING AND TESTING

PSDC Phase I - Preliminary Sequential Operations and Procedures

I. TESTING AND DEEPING SUNEDCO 58-Z8

A. Outline of Workover Operations - Requires intermediate size workover rig with 3 1/2" work/drill string. (Refer to Fig. 2).

1. Relocate wellhead.
2. Clear back fill.
3. Remove cover plate and weld new casing head in place.
4. Excavate and line sump/reserve pit.
5. Mobilize workover rig.
6. Install blow-out preventor (BOP) stack.
7. Clearn out wellbore plugs (2) and heavy fluid.
8. Fish temperature probe.
9. Run geophysical logs -- full suite:

   a. gamma-gamma and spectral gamma
   b. density
   c. resistivity
   d. 4-arm caliper
   e. televiewer
   f. neutron
   g. sonic
   h. temperature
10. Conduct VSP survey.
11. Sidewall coring of major stratigraphic units (for example, twelve 15/16" by 1 3/4" cores from a single run of the Gearhart Hard Rock Coring Tool)
12. Bail or lift hole and get downhole samples of fluid from open-hole areas at about 4,027', 5,680', and 7,325'.
13. Set packer near the end of casing at about 2,600' and perforate, acidize, and bail (utilizing a cable tool rig) the cemented and cased aquifer at about 2,500' to 2,540'. Take a downhole water sample after bailing.
14. Recement the aquifer and clean hole.
15. Conduct *in situ* stress tests.
16. Set 4.5" casing to 8.060', cement bottom 200'.
17. Clean hole.
18. Rig down and demobilized workover rig.

B. Deep Coring Operations - Requires largest-size slim hole diamond core rig. (Refer to Fig. 3.)

1. Change out wellhead and BOP; clean sump.
2. Mobilize core rig.
3. Continuous core at H-size (3.782 x 2.500").
4. Deepen from 8,060' ± to 13,124' (k km) (temperature should be in the range of 160-250°C).
5. Run full suite of logs.
6. Bail or lift hole to clean and clear and obtain

downhole fluid samples.

7. Conduct VSP survey.
8. Conduct in situ stress tests of the lower part of the well.
9. Set 2" pipe with bottom cap; fill with waer and surround with heavy mud.
10. Rig down and demobilizing.
11. Take temperature logs during the next year. Then abandon, pulling the 2" pipe and putting cement plugs at aquifers and at 0 to 50', cut off well head, weld cover plant, backfill and restore site.

C. Current Status of Sunedco 58-Z8 Well - Detailed well data are available to project. (Refer to Figure 2.)

1. Total depth = 8,080' according to one log; 8,060' according to completion forms (drilled 10/1/81 - 12/18/81).
2. Casing record:
   0-85' = 30" diameter, 156 lbs/ft line pipe in 36" hole,
   0-288' = 20" diameter, 94 lbs/ft K55 casing in 26" hole
   0-2,622' = 13 3/8" diameter, 61 lbs/ft K55 casing in 17 1/4" hole (cut off 6' below ground level with steel plate welded on top).
3. Plugging record: 0-50' and 2,522 - 2,772'; completed 8/19/82.
4. Thermistor probe lost due to very viscous mud (8/12/82) somewhere below 5,625' - this must be fished out.
5. Available logs:
   a. daily drilling workover log
   b. NL Baroid mud log
   c. Gearhart temp. log - differential temperature
   d. Gearhart dual induction laterolog - B.H.C. sonic log
   e. Schlumberger dual induction-SFL with linear correlation log
   f. Schlumberger temp. log
   g. Detailed lithologic log by on-site geologist
   h. Thermistor temperature log by Dave Blackwell to 5,625' (stabilized temperature -- taken on 8/12/82)
   i. MRT and Pruett Kuster tool temperatures taken during and shortly after drilling

II. DRILL HYDROLOGIC TEST WELL

A. Location - 1.2 km (4000') deep, rotary air-mud drilled, located east of Sunedco Well 58-28 (depths developed for a possible location at T9S, R7E, Section 36.

B. Drilling Method - Air-mud rotary selected because severe lost circulation is anticipated and major purpose is hydrologic tests, and lithologic information is available from Sunedco 4.8-28 well.

C. Drilling Operations - Refer to Figure 4.

1. Prepare site with cellar ans sump.
2. Set surface conductor.
3. Mobilize rig and rig up.
4. Drill at 12 1/4" to 600-700'.
5. Set about 600-700' of 10" casing.
6. Air rotary at 7 7/8" to the aquifer (projected to be at about 4,000-5,000').
7. Core the aquifer and air lift or swab a water sample.
8. Take a downhole water sample.
9. Drill about 1,000-1,500' past the aquifer.
10. Run full suite of logs.
11. Clean hole.
12. Conduct VSP.
13. Conduct *in situ* stress determinations.
14. Set 2" pipe, capped, filled with water, and surrounded by heavy mud.
15. Rig down and demobilize rig.
16. Conduct sequential temperature logs during following year.
17. Plug and abandon after pulling pipe. Cement aquifers and put in a 50' surface plug.
18. Restore site.

III. CORE DRILL SLIM HOLES

A. Drilling Method - (Requires intermediate size diamond core rig.) Top to bottom H-size (3.782 x 2.500"). Four coreholes are required.

B. Coring Operations - Refer to Figure 5.

1. Prepare site with 4' x 6' diameter cellar with cement floor.
2. Excavate sump and prepare water supply system.
3. Mobilize rig and rig up.
4. Drill PQ (4.62") to 400-450'.
5. Team to 5" and set 4.5" casing.
6. Drill HQ to 4000'.
7. Run full suite of logs.
8. Air lift any deep aquifers and take downhole fluid samples of aquifers.
9. Run VSP survey.
10. Conduct _in situ_ stress tests.
11. Set 2" pipe (water-filled, capped, and surrounded by heavy mud).
12. Rig down and demobilize rig.
13. Monitor temperatures over following year.
14. Pull pipe and abandon, cement any aquifers, and put in 50' surface plug.
15. Restore site.

IV. DRILL AND CORE DEEP HOLE

A. Location - Figure 1 illustrates the location of this combined drill and corehole. It is at or near the crest of the Cascade Range.

B. Drilling Method - The young volcanics at the top of the hole are anticipated to cause fluid loss problems, and hole stability can be expected. Air or mud rotary is selected for the top approximately 1.2 km (4,000 ft). These rocks are likely not suitable for *in situ* stress measurements and the thermal regime is distributed by the aquifers. Water for drilling may be a problem also.

C. Drilling Operations - Because the top section of the hole is to be rotary drilled, two alternate strategies are possible:

(a) use a small rotary rig to drill to 4,000', demobilize
(b) mobilize a large core rig to do the 5000' of continuous coring to 9000 ft.

or,

(c) select a large core rig that has rotary capability for the 4000 ft intervalto T.D.

A detailed technical (and cost) trade-off analysis is necessary to select from these two options. Therefore, only a selection sequence outline is provided for (c) above. Refer to Figure 6.

1. Establish water supply at site.
2. Prepare site with sump and cellar.
3. Mobiilze rig and rig up.
4. Set surface conductor.
5. Set 4 1/2" protective casing to 4000'.
6. Clean hole and switch over to core-drilling.
7. Diamond core H-size to 9,000; be prepared to conduct drill stem tests, air lift, or swabbing should major thermal aquifers be encountered.
8. Run full suite of logs.
9. Lift the hole and take downhole fluid samples.
10. Do *in situ* stress tests.
11. Run VSP surveys.
12. Set 2" pipe capped and filled with water and surrounded by heavy mud.
13. Rig down and demobilize rig.
14. Conduct sequential temperature logs for the following year.
15. Plug and abandon, pulling the pipe, cementing major aquifers, and setting a 50' surface plug.
16. Restore site.

TABLE III: PSDC PHASE I - SUMMARY OF PRELIMINARY SCOPING OF DRILLING/CORING AND TESTING COST ESTIMATES

Drilling/Coring Activity	Depth km	Depth (ft)	Day/Hole	Estimated Cost[a] (K$)	Comments
1. Sunedco 58-28 A. Testing using workover rig	2.4	(8000)	90	600	Intermediate size workover rig required. Clean out and packer runs
B. Continuous coring deeper	2.4 to 4.0	(8000) to (13000)	80	1400	Largest size core rig required
2. Drill Test Well	2.0	(6000)	85	600	Medium size rotary rig required
3. Slim Core Holes	1.2	(4000)	45 each	600 each 2400 total	H-size core holes, four required. Intermediate size core rig required
4. Drill & Core Deep Crest Hole					Rig type and strategy to be determined. Coring to 3 km will require large size core rig.
A. Drill 4000'	1.2	(4000)	45	450	
B. Core to 9000'	2.7	(9000)	90	1200	
			TOTAL K$	6650	

[a] Excluding cost of geophysical logs and VSP surveys, but including hydraulic fracturing operations for *in situ* stress determinations.

SCHEMATIC SECTION OF PHASE I PSDC BOREHOLE LOCATIONS

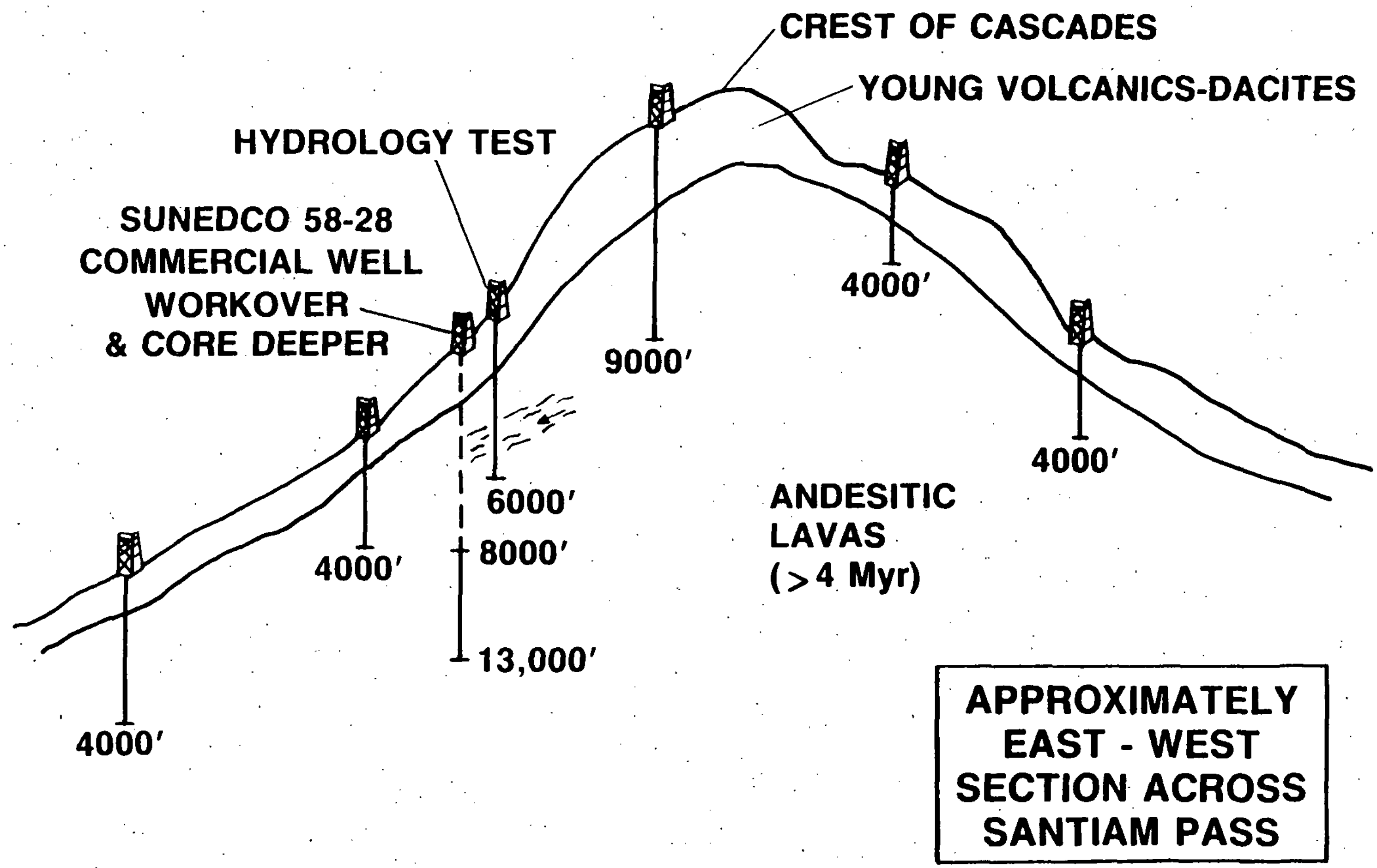


FIGURE 1

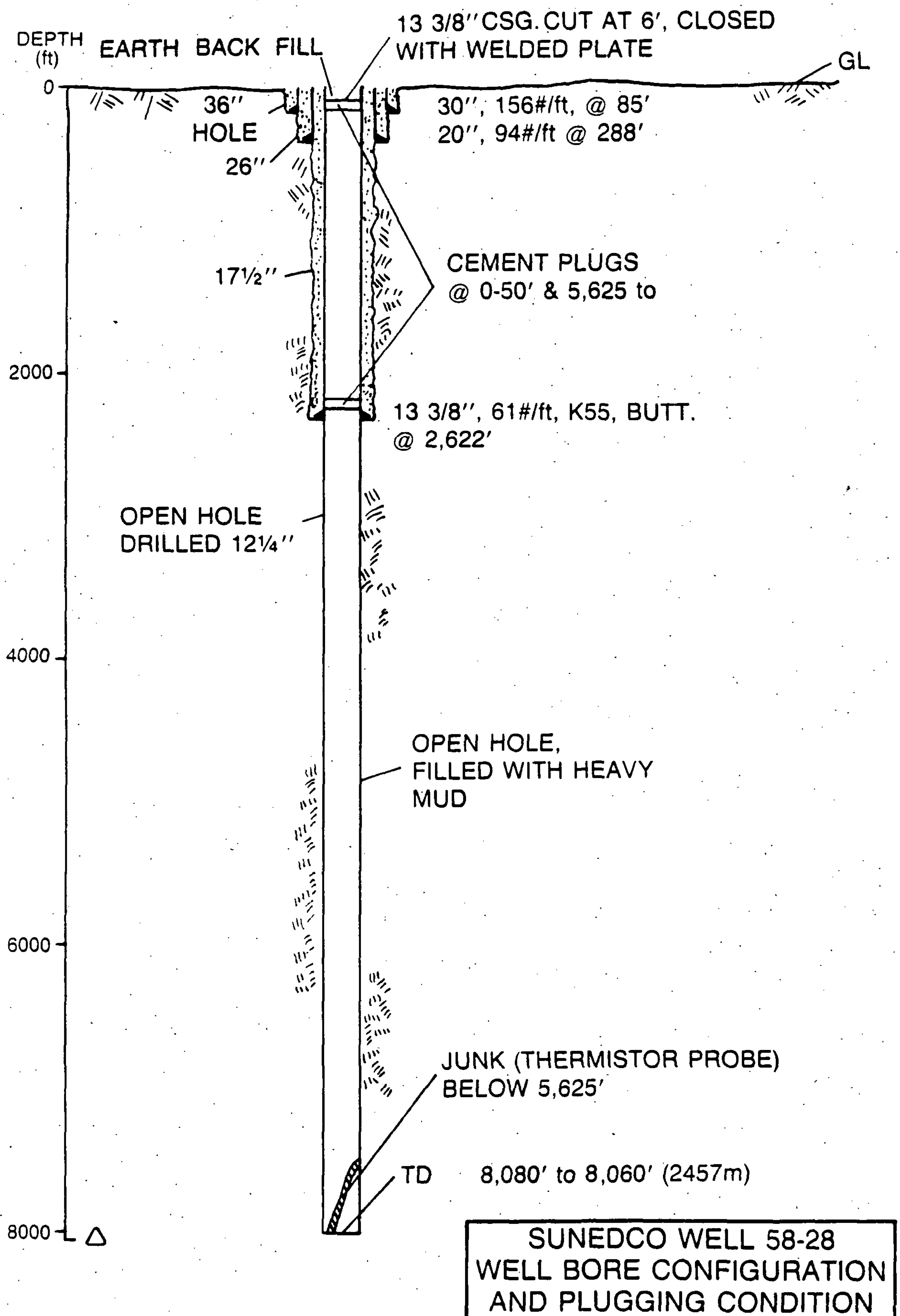
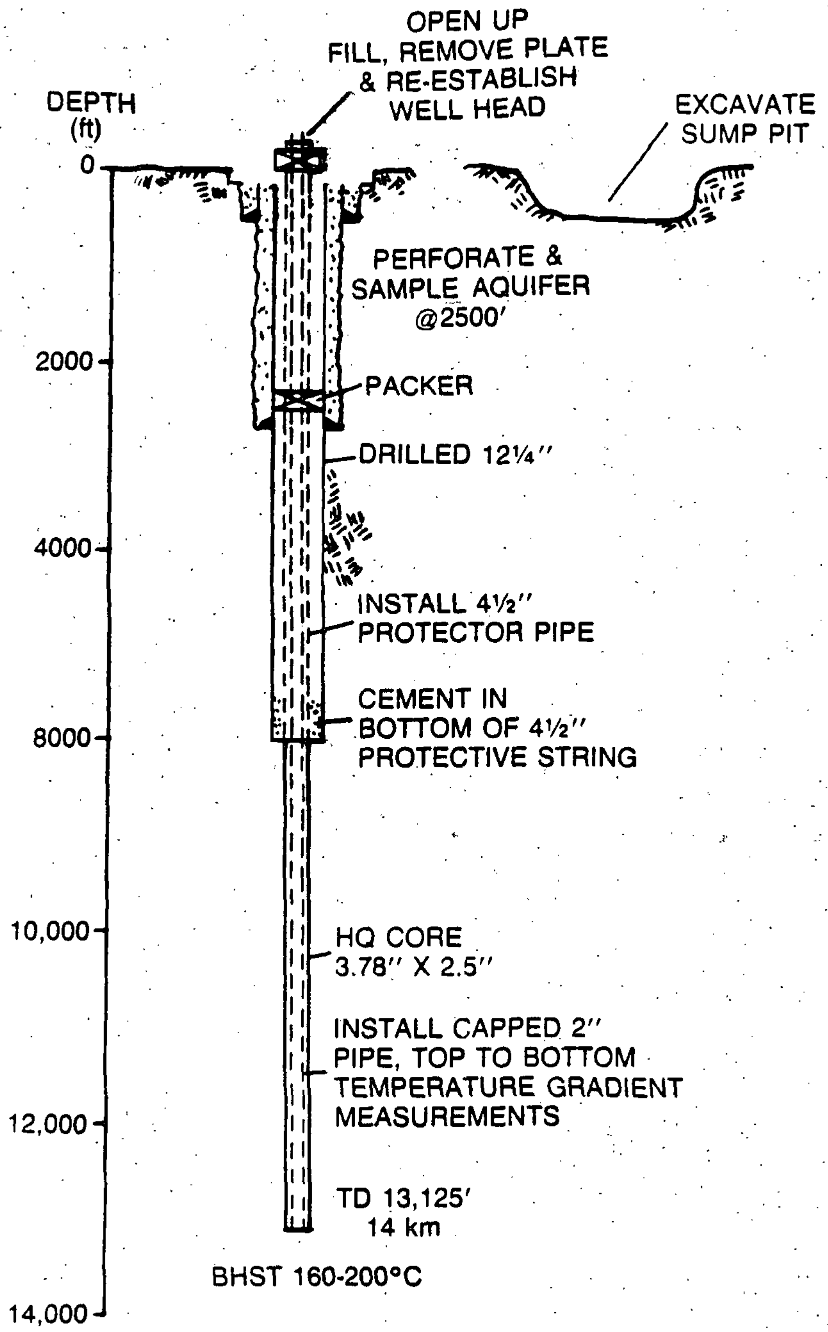

DEPTH (ft)
EARTH BACK FILL
13 3/8" CSG. CUT AT 6', CLOSED WITH WELDED PLATE
GL
0
36" HOLE
26"
30", 156#/ft, @ 85'
20", 94#/ft @ 288'
17½"
CEMENT PLUGS @ 0-50' & 5,625 to
2000
13 3/8", 61#/ft, K55, BUTT. @ 2,622'
OPEN HOLE DRILLED 12¼"
4000
OPEN HOLE, FILLED WITH HEAVY MUD
6000
JUNK (THERMISTOR PROBE) BELOW 5,625'
TD 8,080' to 8,060' (2457m)
8000
SUNEDCO WELL 58-28
WELL BORE CONFIGURATION
AND PLUGGING CONDITION

FIGURE 2



PROPOSED SCIENTIFIC OPERATIONS FOR SUNEDCO WELL 58-28

FIGURE 3

PHASE A-MAJOR WORKOVER OPERATIONS

1. CLEAN OUT PLUGS & HEAVY MUD
2. FISH JUNK
3. GEOPHYSICAL LOGS & SIDE WALL CORE
4. OPEN HOLE FLUID SAMPLE
5. SET PACKER AT 2,600′, PERFORATE AND ACID TREAT AQUIFER AT ±2500-2540′
6. SQUEEZE CEMENT PERFORATIONS & PULL PACKER, CLEAN HOLE
7. CONDUCT *IN SITU* STRESS TESTS
8. INSTALL 4½″ PROTECTIVE CASING AND CEMENT BOTTOM

PHASE B-DEEPEN WELL BY CORE DRILLING

1. CONTINUOUS CORE AT HQ BIT SIZE TO 4 km (13.1)
2. *IN SITU* STRESS DETERMINATIONS
3. TAKE FLUID SAMPLES
4. RUN GEOPHYSICAL LOGS
5. INSTALL 2″ PIPE & FILL ANNULUS WITH HEAVY MUD.

FIGURE 3 (continued)

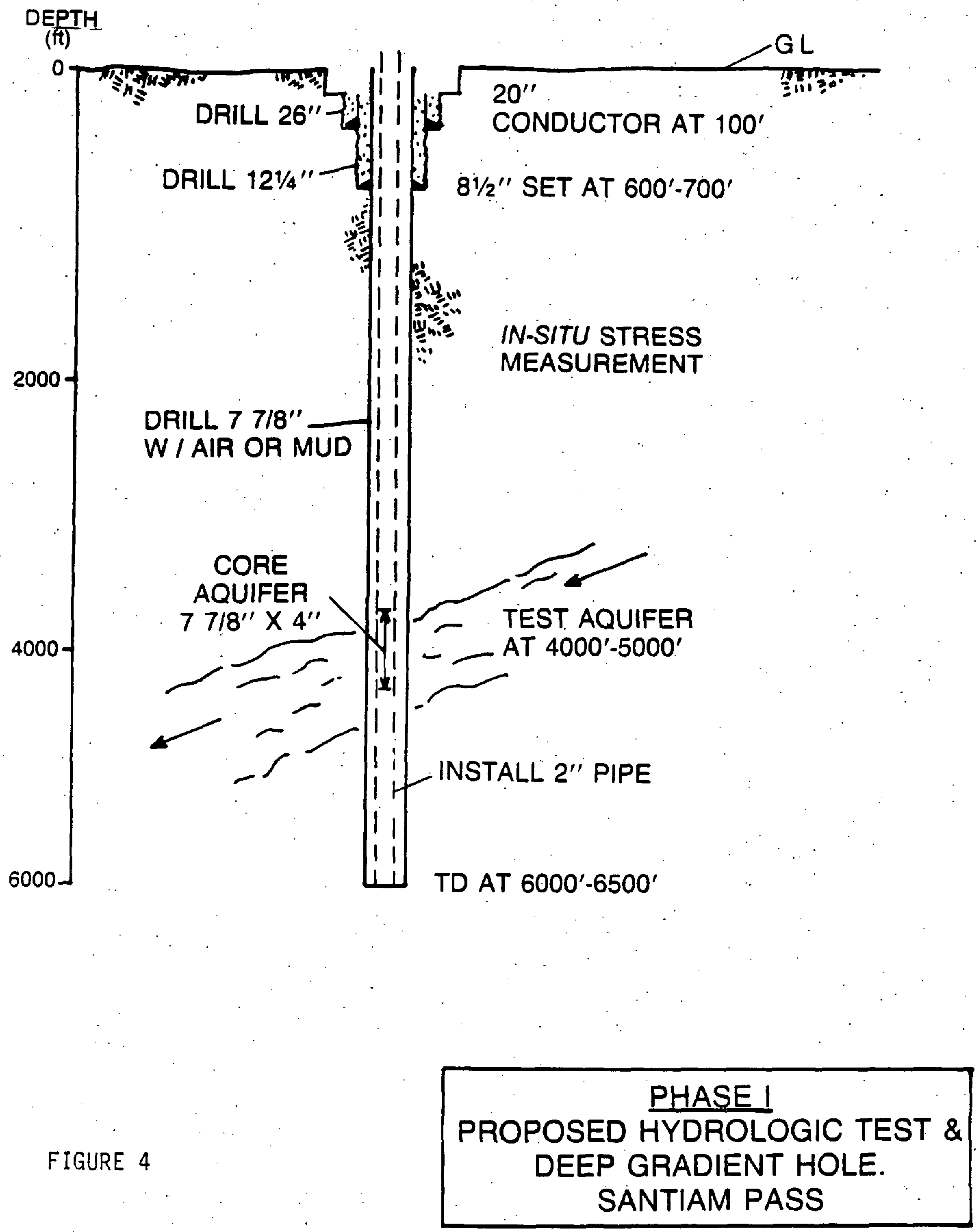
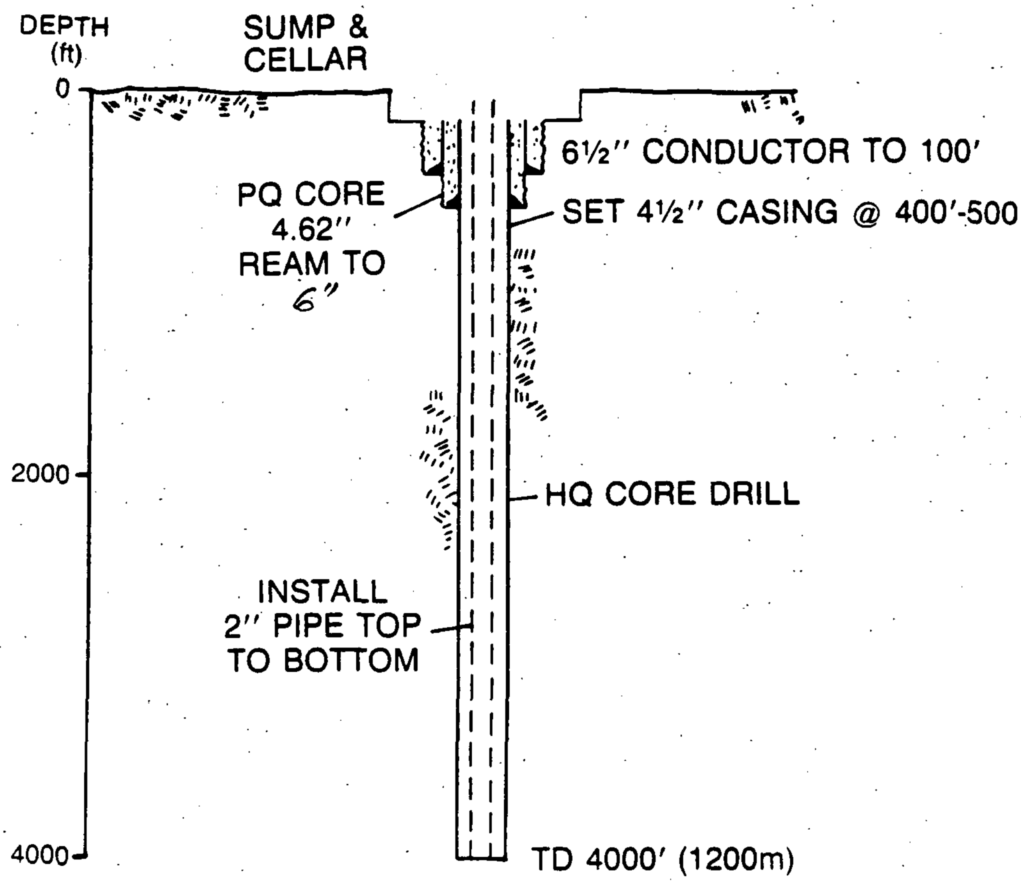

DEPTH
(ft)
0
2000
4000
6000
G L
DRILL 26″
20″
CONDUCTOR AT 100′
DRILL 12¼″
8½″ SET AT 600′-700′
IN-SITU STRESS
MEASUREMENT
DRILL 7 7/8″
W / AIR OR MUD
CORE
AQUIFER
7 7/8″ X 4″
TEST AQUIFER
AT 4000′-5000′
INSTALL 2″ PIPE
TD AT 6000′-6500′
PHASE I
PROPOSED HYDROLOGIC TEST &
DEEP GRADIENT HOLE.
SANTIAM PASS

FIGURE 4



TESTS PROPOSED

1. GEOPHYSICAL LOGS
2. LIFT & SAMPLE DEEP AQUIFERS
3. *IN-SITU* STRESS DETERMINATION
4. LONG TERM TEMPERATURE GRADIENT MONITORING

FIGURE 5

PHASE I
PROPOSED HYDROLOGY, STRESS AND THERMAL GRADIENT HOLES; FOUR PLANNED AS TRANSECT ACROSS SANTIAM PASS

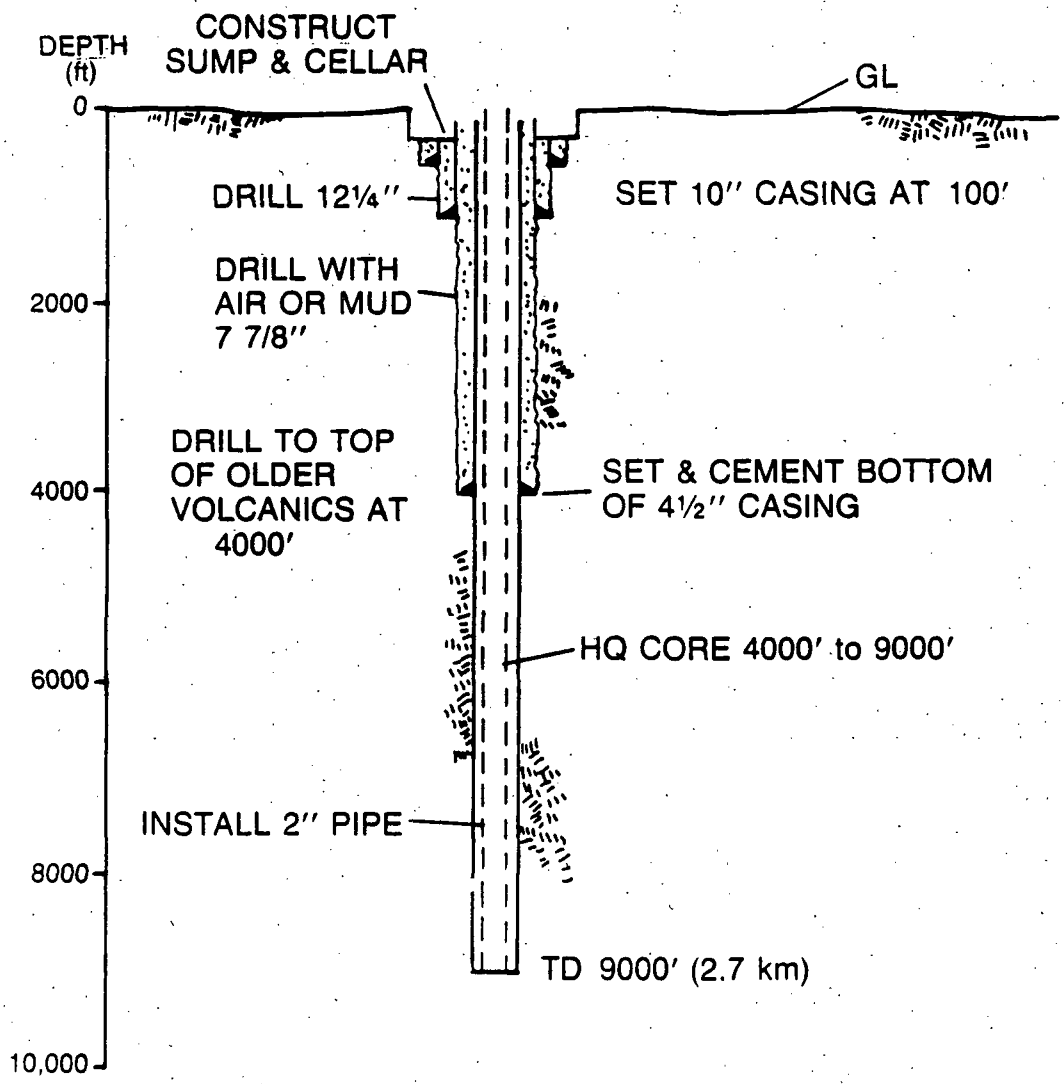


FIGURE 6

PHASE I
DEEP COREHOLE AT VOLCANIC AXIS OF CASCADES - SANTIAM PASS TRANSECT.