

PUNA GEOTHERMAL VENTURE
DRILLING PROGRAM
INJECTION WELL KS-7

WELL DATA:

Location: Wellpad F (See Figure 1)
Datum: Approximately 650' above MSL
Projected Depth: 5,000 feet TVD
Well Type: Injection Well
Objective: Fractured Basalt
Well Completion: See Figure 4

GEOLOGY:

FORMATION	DEPTH	LITHOLOGY
Alluvium	Surf-150'	Alternating layers of silt, clay, and unsorted basalt gravel.
Sub-aerial Basalt	150' - 1300'	Dense basalt with alternating layers of vent tubes. Severe lost circulation from 300' to 1000'.
Water Table	560' - 600'	Depth of sea level.
Submarine Basalt	1000' - TD	Dense basalt with alternating layers and volcanic ash. Lost circulation below 4300'.

CONDUCTOR PIPE AND CELLAR:

Twenty inch (20") 94# K-55 BT&C will be set in a 36" hole that was drilled by a dry hole auger rig to a depth of 50' below ground level. The conductor is to be cemented in place with a Type II portland concrete cement placed down the backside of the 20" conductor pipe. Order out 20 yds³ of ready-mix concrete (.57 W/C ration, 3" - 4" slump, 4% - 5% air, 1" maximum aggregate size).

An 18" rathole will be drilled to rig's dimensions by the same auger rig. See contractor's rig specifications for the rathole dimensions. Boot the rathole with a 18' section of 13 3/8" casing. A mousehole is not required.

Following the setting of the conductor pipe, dig a 12' x 12' x 11' earthen cellar and construct a reinforced concrete cellar according to civil contractor's design and specifications (Figure 2).

DRILLING - 17-1/2" HOLE:

Rig up Parker #231 as shown in Figure 3. Following rig up of Parker #231, weld on 20" pitcher nipple or William 20" rotating head. Spud in with 17-1/2" bit. Anticipate losing total returns at 150' below surface. Continue drilling ahead on water, aerated mud or foam without returns. Reduce pump rate by 50% or a rate sufficient enough to clear annulus and flush away drill cuttings. Run mud sweeps on at least every connection. Drill ahead with caution noting torque and drag; pick up and check for fill every 10' to 15' or as often as hole conditions dictate. Drill to a depth of 650'.

At this depth rig up bailer and bail continuously or as required to get a representative ground water sample. Collect samples and send to lab for analysis. Have state witness sampling procedure. Notify state 24 hours prior to taking samples.

Resume drilling 17-1/2" hole on water, aerated mud, or foam. Drill to a depth of 1000' - casing point for 13-3/8" casing. At casing point sweep hole until no further fill is encountered. Short trip to drill collars to check for fill.

SURFACE CASING:

Approximately 1000' of 13-3/8" 54# K55 BT&C casing is to be run and cemented in place. Float equipment should consist of a single load carrying screw-in sleeve cement float shoe. Tack or strap weld on the float shoe. Centralize the casing with three centralizers - one in the middle of the first joint, one on the third collar and one on the fifth collar. Run casing while filling on every second joint.

Set casing in slips. Make up screw-in tool on drill pipe. Run in hole with drill pipe for inner string cement job. Screw into float shoe. Test cement lines to 1200 psi prior to cementing. Establish rate through inner string. Anticipate cementing without returns. Maximum cementing pressure 1200 psi.

Cement 13-3/8" casing through drill pipe with 950 sacks (1505 ft³) of type II + 40% silica flour + 2% calcium chloride + .65% CFR-3. Excess is calculated at 100%. Reciprocate casing 10' - 15' through out job. Cut displacement 10 bbls short. Release from float shoe. Allow cement to U-tube inside of casing. Cement slurry should be mixed and pumped at a rate of 5 bpm. Trip out with inner string drill pipe leaving cement on top of float shoe. Hookup elevators to top of casing. Pull 80% of string weight and hold.

Wait on cement for 12 hours. Have at least 200 yds³ of sand, gravel, and/or volcanic cinders.

Pick up and run 1" tubing down backside of 13-3/8" casing. Tag fill. Mix and pump type II cement + 40% silica flour + 2% calcium chloride + .65% CFR-3. Circulate to surface. Pull tubing and wash shield laying down. Wait on cement for 12 hours. Should the cement settle, top out with batched ready-mix poured down the backside of the 20" casing. Ready-mix can be accelerated with 2% by weight of calcium chloride. Wait on cement for 12 hours.

Release weight on casing.

BLOWOUT PREVENTION EQUIPMENT - 12 1/4" HOLE (Figure 5):

Blowout prevention equipment to drill a 12-1/4" hole should consist of 13 5/8" - 3M x 13 5/8" - 5M DSA, 13 5/8" - 5M DG ram preventers and a 13 5/8" - 5M Hydril annular preventer. Lay 2" kill line. Test blind rams to 1000 psi. Make up 12 1/4" mill tooth bit and slick bottom hole assembly. Trip in to top of cement. Test pipe rams to 1000 psi. Close annular preventer and pressure test to 600 psi (as per regs). Notify appropriate state regulatory agency 24 hours prior to testing.

Pipe rams should be function tested daily and on trips. All BOP tests are to be recorded in the IADC tour report and noted on morning report.

DRILLING 12 1/4" HOLE:

Pre-treat mud with soda ash prior to drilling out shoe joint. Drill out the shoe joint with a 12 1/4" mill tooth bit and slick bottomhole assembly. Conduct leak-off test by pressuring wellhead to 1250 psi with 8.8#/gal mud in hole (equivalent to 11#/gal cement column). Trip for bit change and recommended bottomhole assembly.

Continue drilling ahead on mud to casing point at 2000'. Should any losses be encountered while drilling, zones will be cemented. Previous wells drilled through this section have not reported any mud loss.

INTERMEDIATE CASING:

Approximately 2000' of 9 5/8" 40# K-55 BT&C casing is to be run and cemented in a single stage. Land casing three to four feet off bottom. Float equipment for the 9 5/8" casing will consist of float shoe and a single shoe joint followed by a float collar.

Thread lock the float equipment and the bottom three joints. Centralize the casing as determined by cementer's maximum stand-off computer program. Fill casing on every 5th joint. Pressure test cement lines to 2000 psi. Maximum cementing pressure limit is to be 2000 psi.

Close annular preventer to divert returns through 2" casing head valve, if required to maintain cement pump pressure. Circulate casing bottoms up. Cement with 100 bbls water followed by (1) 10 bbls of CaCl_2 , (2) 40 bbls of Super Flush and (3) 10 bbls of water spacer. Cement casing with 694 sacks (2600 ft³) of type II cement + 40% silica flour + 0.50 lb/sk of spherulite + 4% gel + 1.25% CFR-3 + 1.5% HALAD 22A. Excess is calculated at 30%. Do not over displace. Reciprocate casing 10' - 15' throughout job. Mix and pump at a rate of 5 - 6 bpm. Displace with water. Hang casing in slips. After plug is bumped immediately unbolt and raise BOPS at casing head flange. Drain casing head and set 9 5/8" casing alignment bowl. Wait on cement for 12 hours. After WOC, cut off the 9 5/8" casing. Dress casing 8" above casing head flange with 27 1/2" chamfer. Nipple up 13 5/8" - 3M x 10" - 3M Type S WKM Expansion Spool with packing sleeve.

BLOWOUT PREVENTION EQUIPMENT 8 1/2" HOLE (Figure 6):

Blowout prevention equipment to drill a 12-1/4" hole should consist of 13 5/8" - 3M x 13 5/8" - 5M DSA, 13 5/8" - 5M DG ram preventers and a 13 5/8" - 5M Hydril annular preventer. Pressure test blind rams to 1000 psi. Make up 8 1/2" mill tooth bit with slick bottomhole assembly and trip into top of cement. Test upper and lower set of pipe rams to 1000 psi. Next close annular preventer and test to 600 psi. Notify appropriate state regulatory agencies 24 hours prior to testing.

The annular preventer and pipe rams should be functioned tested daily. Function blind rams on trips. Note BOP tests in the IADC tour report as well as in the daily morning report.

DRILLING 8 1/2" HOLE:

*Per end
1/31/91
1600'
K.O.P.*

Drill out from underneath the 9 5/8" casing on water with an 8 1/2" mill tooth bit and slick bottomhole assembly. Drill to 2200' with mud before tripping for a mud motor and directional tools. Build hole angle at a rate of 2°/100' on a course direction that is TBA. The hole will be displaced 650' at a 5000' TVD.

Ream out the motor run with an 8 1/2" BHA that is packed with IBS's. After the proper amount of angle and direction has been obtained, trip for angle building or angle holding assembly as needed. Displace to storage tanks and continue drilling ahead on water. Losses can be combated with LCM products.

Should differential sticking occur, rig up the air compressor with the degasser to free the stuck string.

At 5000' TVD circulate out mud with fresh water. Trip -out of hole laying down pipe and rig up injection test. If test is successful, run production liner.

PRODUCTION CASING:

(solid casing)

Run approximately 4000' of 7" 23# SM-22 Cr-65 casing with Vam Ace threads. Run casing with Mountain States 7" Pay Zone Tm packer with 20' seal length, 23# L-80, 7" subset, 8' top sub Vam Ace box facing up with 2' bottom sub Vam Ace pin facing down.

Land pipe with collar at ground level, circulate hole clean, drop bomb, set packer, open ports on top of packer, cement with 212

sacks (790 ft³) of Type II Portland Cement + 40% silica flour + 50 lb/sk cement spherulite +4% gel + 1.25% CFR-3 + 1.5% Halad 22. Excess is calculated at 30%.

W.O.C. 12 hours.

Nipple down 13-5/8" BOP. Cut off 13-5/8" casing head and install 8" API 2000# casinghead with 8" ANSI 400 valve.

Run in hole with 6" bit, drill out cement and clean hole to bottom.

MUD PROGRAM:

36" Hole

Mud System: Drilled dry with auger rig.

17 1/2" Hole

Mud System: Low solids non-dispersed. Mud up with 15 - 20 lb/bbl of bentonite and 0.5 lb/bbl of caustic. Lo-Sol can be used to extend the yield of bentonite while selectively flocculating low yield native solids.

Mud Weight: 8.8 - 9.0 ppg. Run solids control equipment

Viscosity: 38 - 42 sec/qt

Water Loss: 15 cc/30 sec

Total Hardness: Maintain hardness below 150 ppm with soda ash

Filtrate: No Control

pH: Maintain pH of 9.5 - 10.5 for H₂S

Comments: Mud losses may be encountered below the casing shoe. Losses below 1300' are not anticipated.

12 1/4" Hole

Mud System: Low solids non-dispersed

Mud Weight: 8.8 - 9.0 ppg. Maintain weight as low as possible with water and mechanical solids control equipment. Run contractor's desander and desilter. Dump shale tanks as required.

Viscosity: 38 - 42 sec/qt. Maintain viscosity with gel and caustic. Drispac at a ratio of 8:1 may be used to increase viscosity if needed. As mud temperature increases drispac will become less effective. Alcomer 120L, which is recommended, is an effective viscosifier in the higher temperature ranges.

Water Loss: 15 cc/30 sec or less. Strict water loss control through the basalt is not required. However, lenses of clay may be encountered from time to time. While drilling with a mud motor, a water loss below 15 cc/30 sec is recommended.

Total Hardness: Keep hardness below 150 ppm with soda ash.

pH: 9.5 - 10.5. Maintain with caustic soda

Comments: Loss circulation is not anticipated through this interval of hole. Should minor losses occur the can best be treated with LCM fiber products. For total loss of returns a cement squeeze is recommended.

8 1/2" Hole

Mud System: Low solids, non-dispersed.

DEVIATION:

INTERVAL	MAXIMUM DEVIATION	MAXIMUM DOGLEG	MAXIMUM DOGLEG
0' - 500'	200'	1°	1°/100'
500' - 1000'	250'	1°	1°/100'
1000' - 2000'	250'	2°	1°/100'
2000' - 5000'	1000'	As required by target	1°/100'

KOP will be two hundred feet below the 9-5/8" casing shoe. The bottomhole target along with the directional plan will be supplied before the well spuds.

Take advantage of bit trips to run a survey. Report accurately the actual instrument depth of the survey along with the corrected course direction.

BOTTOMHOLE ASSEMBLY:

17 1/2" Hole

Holding Assembly:

17 1/2" Bit
 17 1/2" Integral Blade Stabilizer (IBS)
 or
 17 1/2" 3-point Roller Reamer
 10" Monel Drill Collar
 17 1/2" Integral Blade Stabilizer
 1 - 10" Drill Collars

17 1/2" Integral Blade Stabilizer
 10 - 8" Drill Collars

12 1/4" Hole

Holding Assembly:

12 1/4" Bit

12 1/4" 3-point Roller Reamer
8" Monel Drill Collar
12 1/4" Integral Blade Stabilizer
11 - 8" Drill Collars
7 3/4" Drilling Jars
6 - Heavy Weight Pipe

8 1/2" Hole

Building Assembly:

8 1/2" Bit
8 1/2" 3-point Roller Reamer {UG IBS may be more desirable
depending upon angle and course
direction}

6 1/2" Monel Drill Collar
11 - 6 1/2" Drill Collars
7 3/4" Drilling Jars
6 - Heavy Weight Pipe

8 1/2" Hole

Holding Assembly:

8 1/2" Bit
8 1/2" 3-point Roller Reamer
6 1/2" Monel Drill Collar
8 1/2" 3-point Roller Reamer
1 - 6 1/2" Drill Collar
8 1/2" Integral Blade Stabilizer
16 - 6 1/2" Drill Collars
6 3/4" Drilling Jars
6 - Heavy Weight Pipe

SAMPLES:

Collect drill cuttings as follows:

- 26" Hole every 30'
- 17 1/2" Hole every 30'
- 12 1/4" Hole every 10'
- 8 1/2" Hole every 10'

Formation samples are to be caught as above or as directed by Ormat representative. Samples to be collected by mud loggers for analysis.

SUMMARY OF DRILLING PROCEDURE.

1. Construct location. Move in dryhole digger and drill conductor hole. Set 50' of 20" conductor pipe. Concrete in with 10 yards of ready mix. Civil contractor to dig and construct cellar 12' x 12' x 11'.
2. Move in and rig up Parker #231. Spud in well with 17-1/2" bit. Drill to a depth of 1000'. Anticipate upon losing complete returns as shallow as 150'.
3. At 650', rig up bailer and bail well until clean. Collect a representative sample of ground water. State of Hawaii should witness sampling procedure. Notify 24 hours prior to sampling.
4. Resume drilling. Drill to a depth of 1000'. Run 13-3/8" 54# K55 BT&C casing. Cement with 1043 sacks (605 ft³) of Type II Hawaii cement + 40% silica flour + 2% CaCl₂ + .65% CFR-3. Cement calculated at 100% excess. WOC.
5. At 1000' run 13-3/8" 54# K-55 BT&C casing. Cement casing ft³) of Type II Portland Cement = 40% silica flour = .65% CFR-3. WOC 12 hours.
6. Cut off 13-3/8" casing and weld on casing head flange. Nipple up BOP stack. Test rams to 1000 psi and hydril to 500 psi.
7. Drill out from underneath the 13-3/8" casing to a depth of 2000'. Maintain hole as straight as possible. At 2000' prepare to run 9-5/8" casing.
8. Run 2000' of 9-5/8" 40# K-55 BT&C casing. Cement with 540 sacks (2020 ft³) Type II Portland Cement + 40% silica flour + 50 lb/sk spherulite + 4% gel + 1.25% CFR-3 + HALAD 22A. WOC
9. Nipple up BOP stack. Test rams to 1000 psi and annular hydril to 600 psi. Nipple up flow line, mud-gas separator and rotating head.
10. Drill ahead in the 8 1/2" hole with mud to a depth of ^{1600'} 2200'.
^{1600'} At ~~2200'~~, pick up mud motor and directional tools. Kick well off at 2"/100' toward bottomhole target. Displace hole 865' in a TBA course direction to a depth of 5000' TVD.

Drill to a total depth of 5000' on water. Mud up if hole begins to get tight or develops drag. After doing directional work, cut mud back to clear water. Continue building angle with BHA and/or lock in angle with recommended BHA.

11. At 5000' or lost circulation displace mud with water, lay down 5" drill pipe and run injection test.
12. Run 4000' of 7" 23# SM-22 Cr-65 Vam Ace casing with open hole packer and DV tool. Cement back to surface. Cut off 13-3/8" wellhead and install 8" API 2000# casinghead and 8" ANSI 400 valve on 7" casing.
13. Pick up 5000' of 3 1/2" drill pipe. Run in hole, clean out to BTM, circulate hole with clean water, and come out laying down drill pipe.
14. Tear out and move rig.

CASING AND CEMENT SUMMARY

20" 94# K55 BT&C:

Surface - 50'

20 yds³ of Ready Mix concrete, .57 w/c ratio, 3"-4" slump, 4%-5% air, 1" maximum aggregate size.

13 3/8" 54# K55 BT&C:

Surface - 1000'

3090 ft³ (1955 sacks) of Type II portland cement + 40% silica flour + .65% CFR-3

Calculated Excess: 60%
Slurry Weight - 15.7 ppg
Slurry Yield - 1.58 ft³/sk

9 5/8" 40# K-55 BT&C:

Surface - 2000'

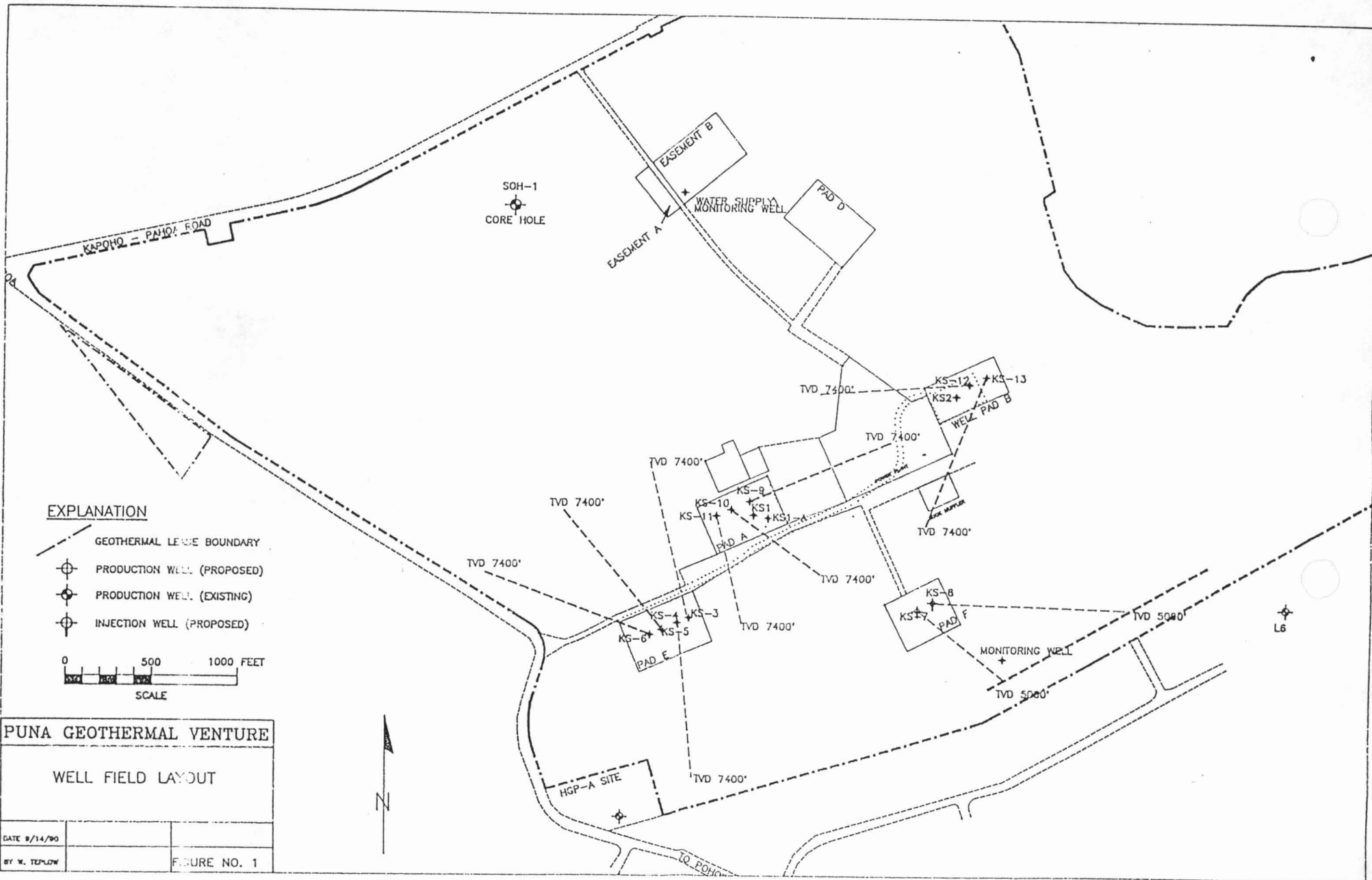
2020 ft³ (540 sacks) of Type II portland cement + 0.50 lb/sk cement of spherulite + 4% gel + 1.25% CFR-3 + 1.5% HALAD - 22A

Calculated Excess: 60%
Slurry Weight - 11 ppg
Slurry Yield - 3.72 ft³/sk

7" 23# SM-22 Cr65:

Surface - 4000'

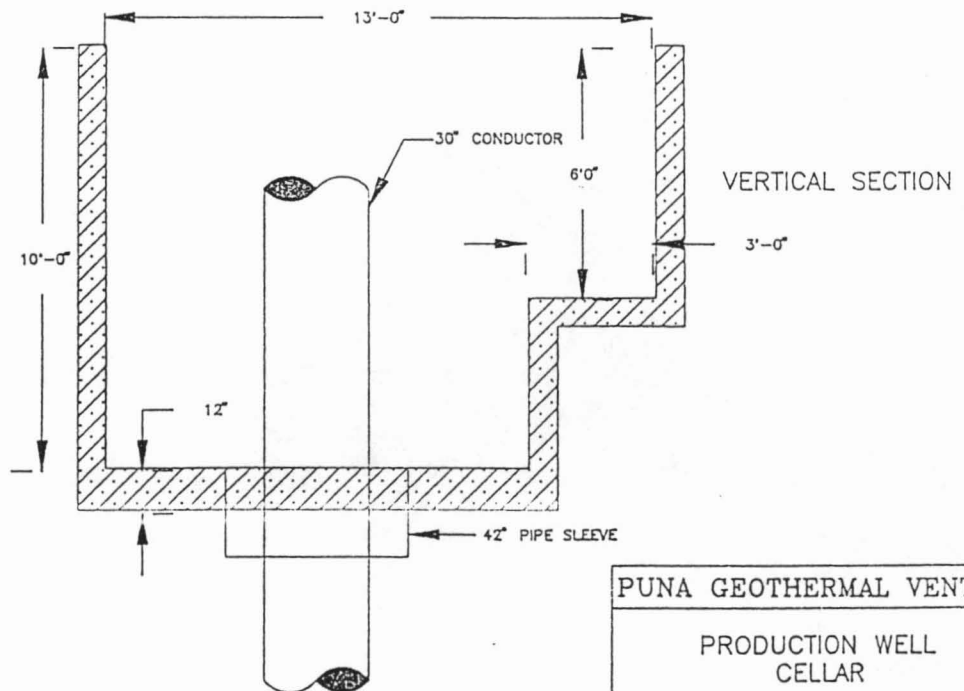
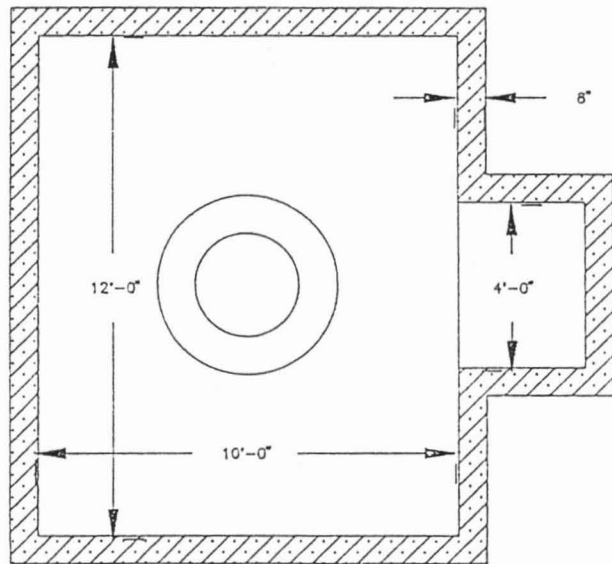
790 ft³ (212 sacks) of Type II
Portland cement + 40% silica flour
+0.50 lb/sk cement spherulite + 4%
gel +1.25% CFR-3 + 1.5% Halad 22.
Slurry wgt. 11 ppg, slurry yield
3.72 ft³, calculated excess 30%.



PUNA GEOTHERMAL VENTURE

WELL FIELD LAYOUT

DATE 9/14/90	
BY W. TEPLow	FIGURE NO. 1



PUNA GEOTHERMAL VENTURE

PRODUCTION WELL
CELLAR

DATE 3/12/90

SCALE 1" = 4'

BY W. TEPLow

FIGURE NO. 2

8.403.40 N
10,575.21 E

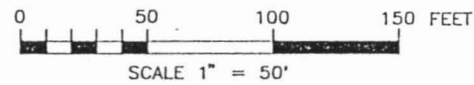
242' 58" 20" 350.00

152' 58" 20" 300.00

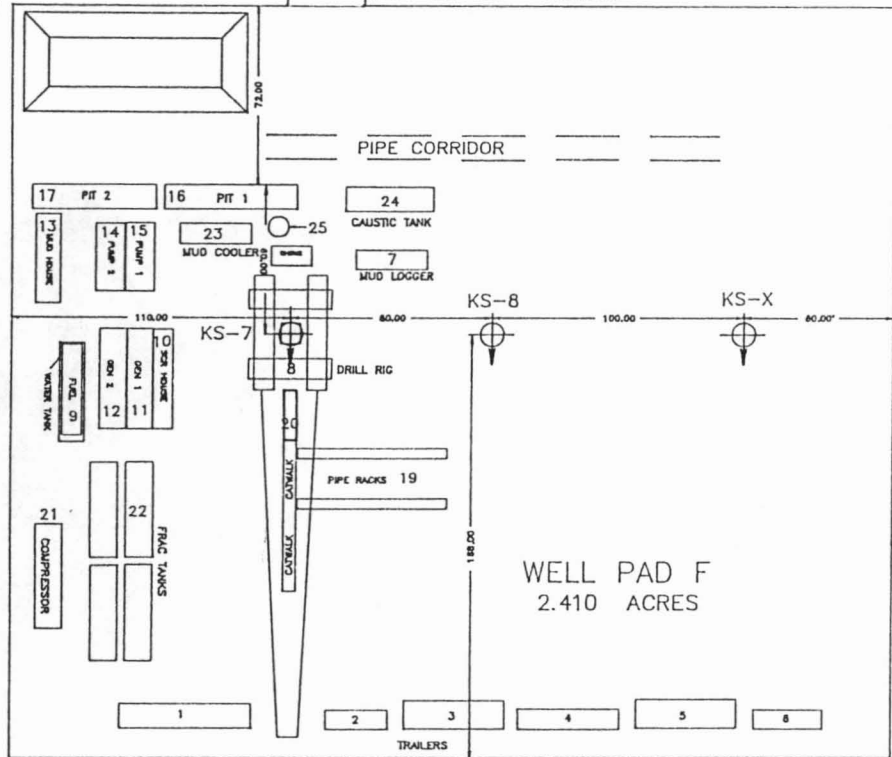
332' 58" 20" 300.00

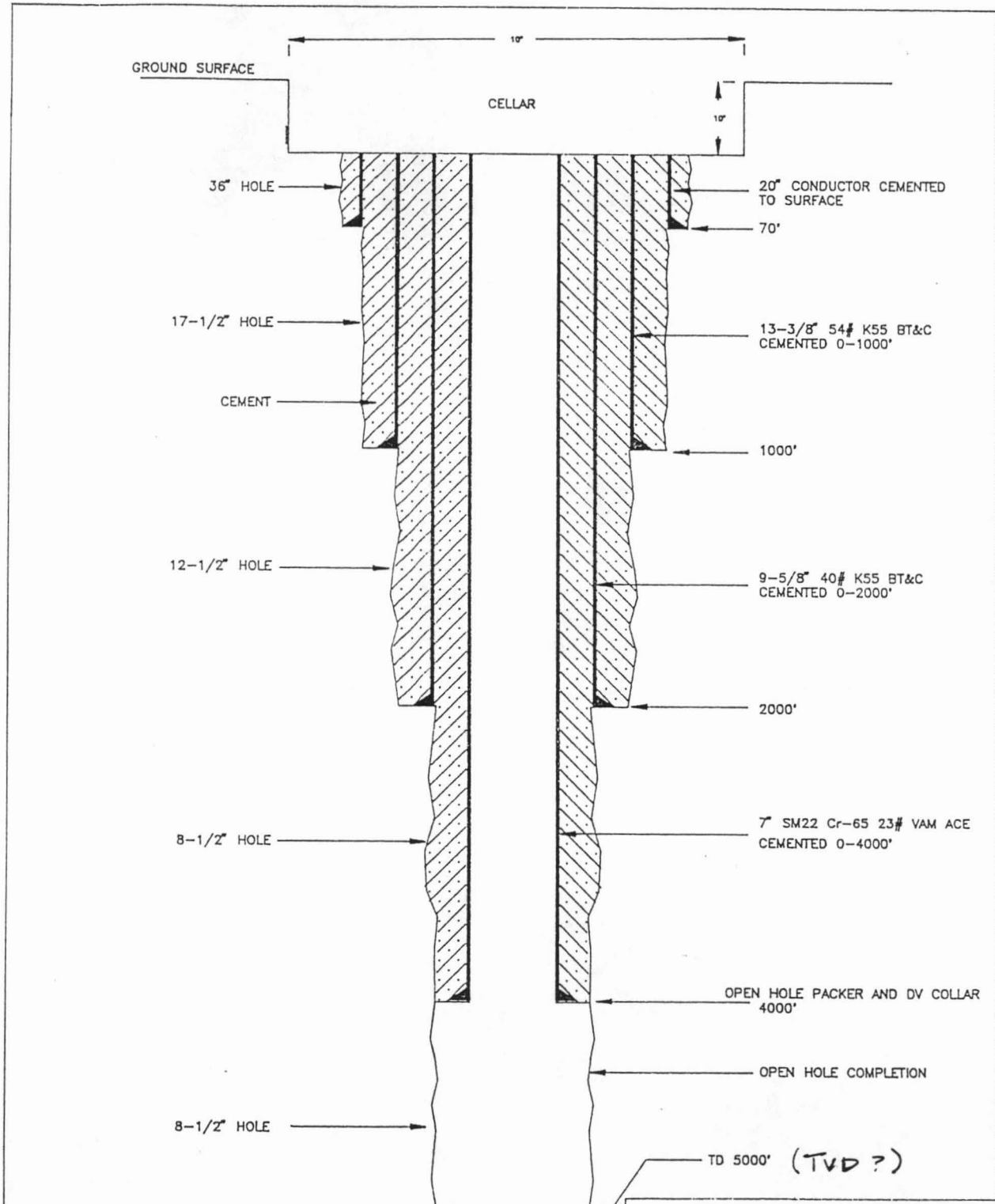
62' 58" 20" 350.00

WELL PAD F
2.410 ACRES



PUNA GEOTHERMAL VENTURE		
WELL PAD F RIG LAYOUT		
DATE 9/25/90		
BY W. TELOW		FIGURE NO. 3





PUNA GEOTHERMAL VENTURE

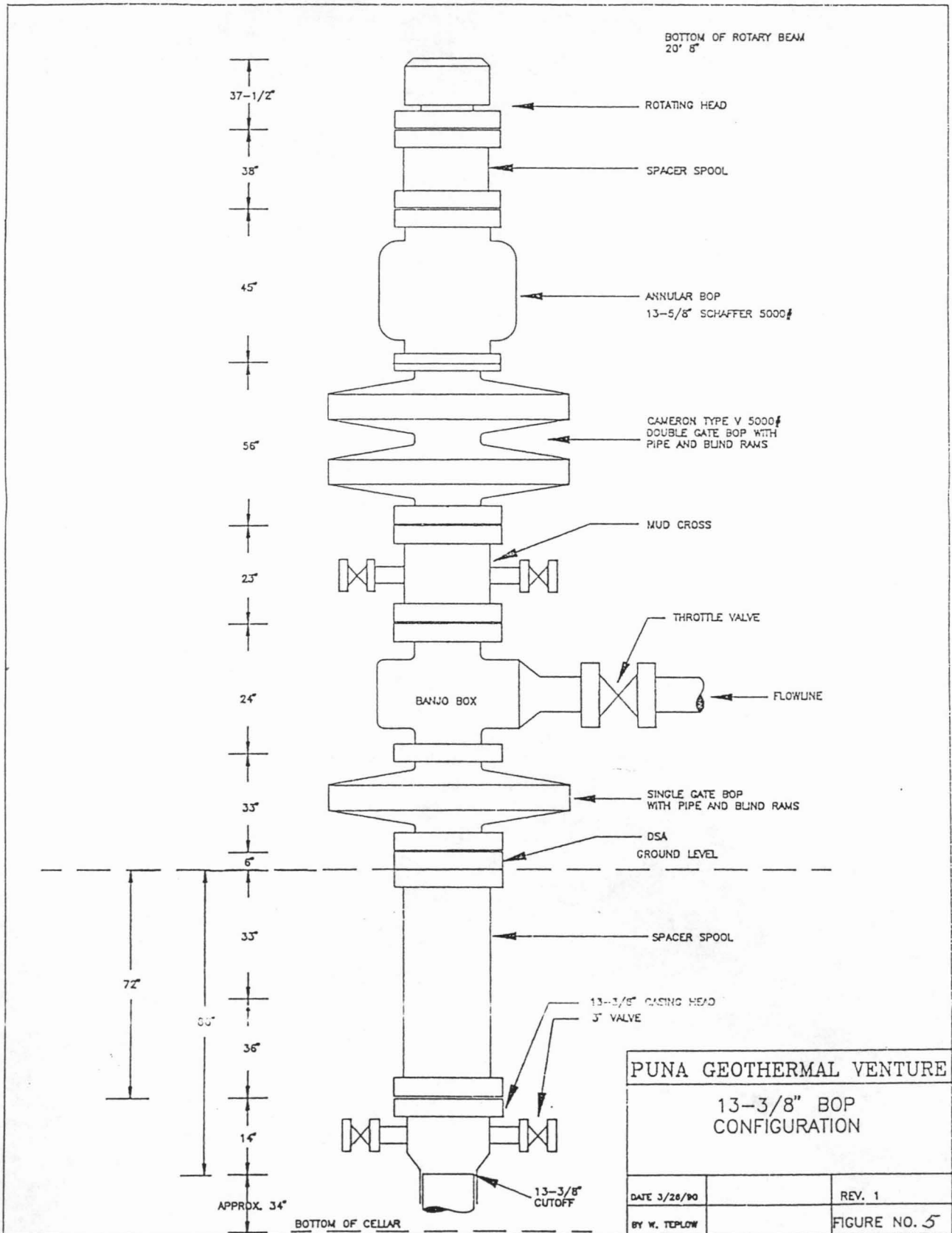
INJECTION WELL CASING DESIGN

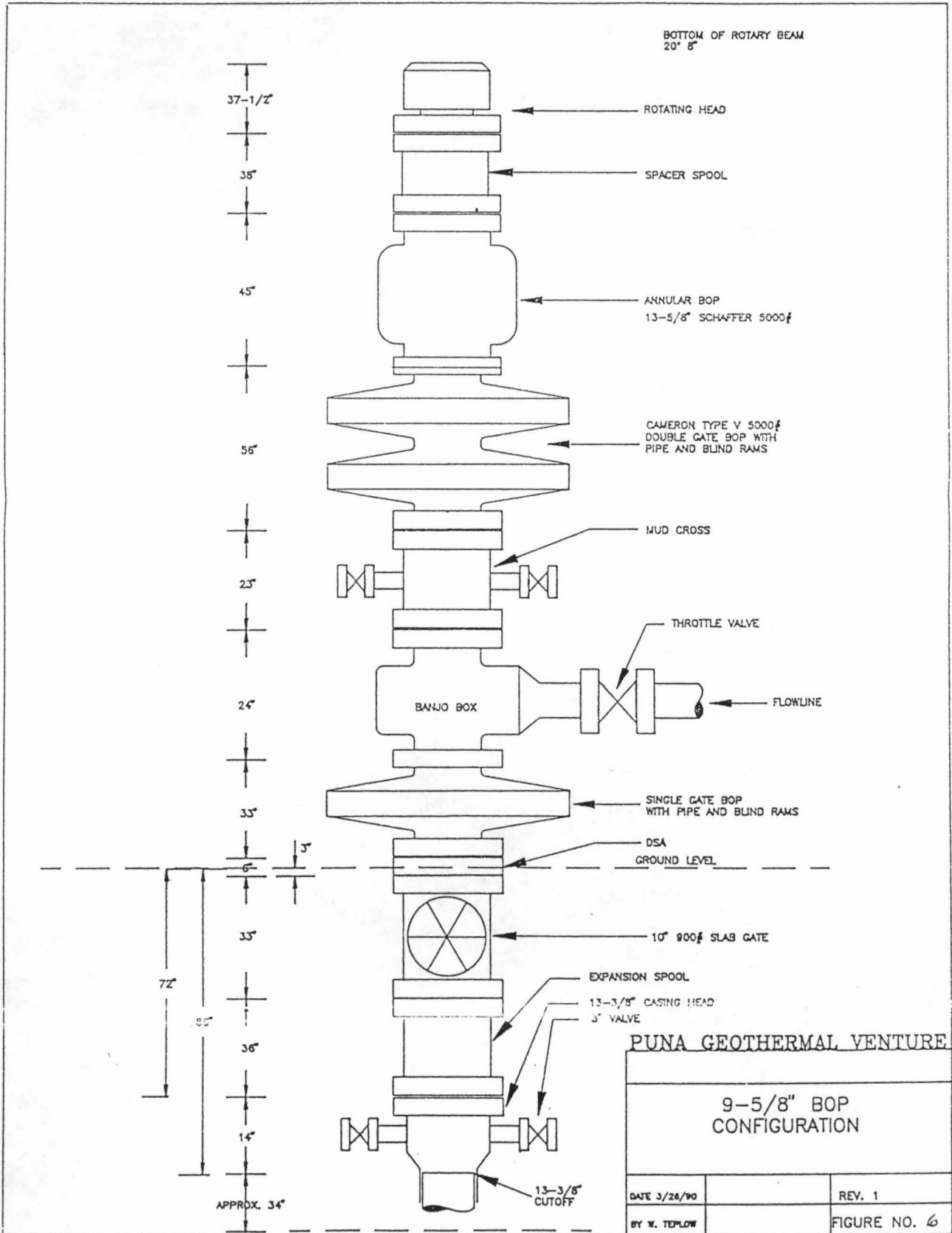
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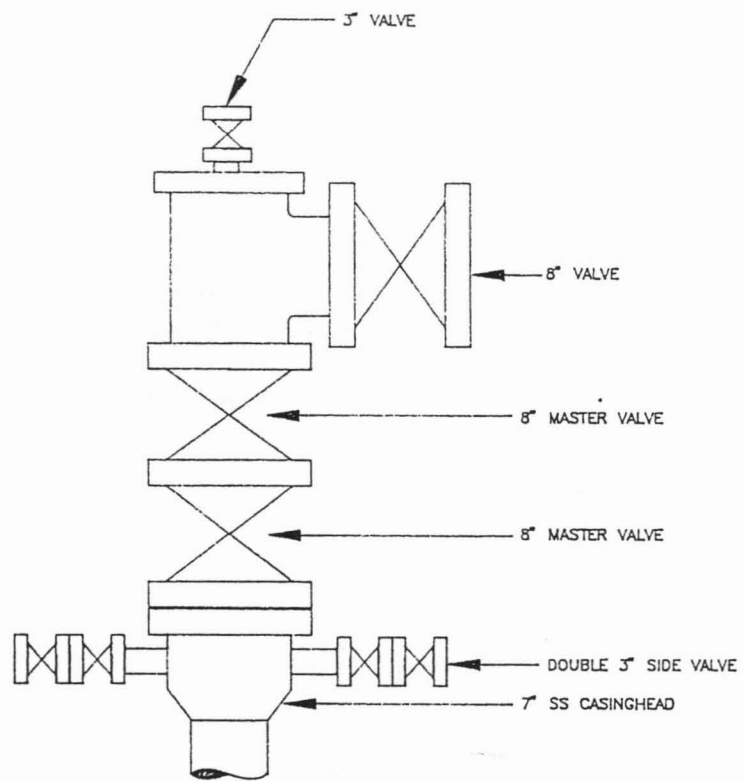
REV. 1

BY W. TEPLow

FIGURE NO. 4







PUNA GEOTHERMAL VENTURE

PRODUCTION WELLHEAD
CONFIGURATION

DATE 3/28/90

REV. 1

BY W. TEPLow

FIGURE NO. 7