

KS-6

- ① ~~PGV to DLNR to Transmit Application for Permit to Drill KS-6~~ *Geothermal Well Kapiho, State 6. State Geothermal* 4/6/90
KS-2
- ② ~~DLNR to PGV to Approve Geothermal Well Drilling Permit KS-6~~ *Kapiho State 6* 6/13/90
Re:
- ③ ~~PGV to DLNR Notification of Modification of Drilling Program, Puna Geothermal Venture.~~ 9/18/90
NO SUBJECT (DLNR to P.G.V. William J. Teplov)
- ④ ~~DLNR to PGV to Approve Modification for KS-3,4,5,6~~ 10/8/90



STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

P. O. BOX 621
HONOLULU, HAWAII 96809

OCT 8 1990

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTY
KEITH W. AHUE
MANABU TAGOMORI
RUSSELL N. FUKUMOTO

AQUACULTURE DEVELOPMENT
PROGRAM
AQUATIC RESOURCES
CONSERVATION AND
ENVIRONMENTAL AFFAIRS
CONSERVATION AND
RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

Mr. William J. Teplow
Field Manager
Puna Geothermal Venture
P.O. Box 1337
Hilo, Hawaii 96721-1337

Dear Mr. Teplow:

The Department of Land and Natural Resources hereby approves your request for modification of the well drilling programs for geothermal wells Kapoho State # 3, 4, 5, and 6.

With respect to your plans for directional drilling, please be advised that the production or injection interval (i.e. bottom hole location) of any well must be located more than 100 feet from the outer boundary of the parcel of land into which it is drilled. In addition, directional/deviation surveys shall be filed with the Department for all wells directionally drilled.

We would like to thank you for the copy of your construction plans as submitted to the County of Hawaii and request that you keep us informed of the progress of your project.

Should you have any questions, please contact me at 548-7533.

Sincerely,

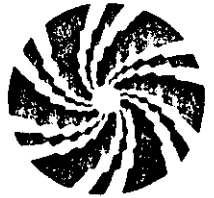
A large, stylized handwritten signature in black ink, appearing to read "Manabu Tagomori".

MANABU TAGOMORI
Deputy Director

DN:mh

RECEIVED

ORMAT®



90 SEP 24 AM 1:00

September 18, 1990

Mr. Manabo Tagomori, Director
Department of Land and Natural Resources
P.O. Box 621
Honolulu, HI 96809

RE: Notification of modification of drilling program, Puna Geothermal Venture.

Dear Mr. Tagomori:

The PGV drilling staff have made several modifications to the KS-3 production well drilling program since its submittal as part of the drilling permit application. These modifications are summarized as follows:


1. The maximum target depth of the well has been increased to 7,400' true vertical depth (TVD). This change was instituted after careful review of drilling records from KS-1 and KS-2. The review indicates that there is a production zone with relatively high permeability at a depth of 7,200' to 7,300'. By increasing the planned drilling depth, we insure that this zone will be intersected. The basic casing program is not affected by this change. Only the 7" slotted liner string will be lengthened to accommodate the deeper completion.
2. The setting depth for the 20" casing string has been increased to 1200'. This is to insure that all major lost circulation zones are placed behind the 20" casing. This will facilitate obtaining a good cement job on the 13-3/8" string.
3. The drill pad layout has been reversed with the reserve pit now placed along the north side of the pad. This was done to facilitate pipeline construction while drilling is taking place on the pad and to increase efficiency of the piping system.
4. The directional drilling will be started after the 9-5/8" casing has been installed instead of midway through the 12-1/4" drilling interval as previously planned. This change was made because the geologic target is more advantageously approached with a deeper kick-off point (KOP). Also, casing wear during directional drilling will be significantly reduced by moving the KOP to a point below the 9-5/8" casing shoe. This will insure maximum casing integrity upon completion of the well.

PUNA GEOTHERMAL VENTURE CONSTRUCTION

The enclosed drilling program for KS-3 should also be considered as an update for production wells KS-4, KS-5, and KS-6 which will be drilled according to the same program. The directional course and bottom hole location for each of the four wells located on Well Pad E are shown in Figure 1 of the attached program.

If you have any questions regarding the attached program, please give me a call.

Sincerely,
PUNA GEOTHERMAL VENTURE


William J. Teplow
Field Manager

cc: Butch Clark
Zvi Reiss
Maurice Richard
Terry Crowson

attachment: KS-3 Drilling Program

PUNA GEOTHERMAL VENTURE
DRILLING PROGRAM
PRODUCTION WELL KS-3

WELL DATA:

Location: Wellpad E (See Figure 1)

Datum: Approximately 650' above MSL

Projected Depth: 7,400 feet TVD

Well Type: Development 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	1300' - TD	Dense basalt with alternating layers and volcanic ash. Lost circulation below 4300'.

CONDUCTOR PIPE AND CELLAR:

Thirty-inch (30") A53 Schedule 40 (.375" wall) Grade A or B 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 30" conductor pipe. Order out 10 yds³ of ready-mix concrete (.57 W/C ratio, 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 - 26" HOLE:

Rig up Parker #231 as shown in Figure 3. Following rig up of Parker #231, weld on 30" pitcher nipple or William 30" rotating head. Spud in with 26" 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 26" hole on water, aerated mud, or foam. Drill to a depth of 1000' to 1200', the casing point for 20" casing. At casing point sweep hole until no further fill is encountered. Short trip to drill collars to check for fill.

SURFACE CASING:

Approximately 1200' of 20" 94# 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 20" casing through drill pipe with 1900 sacks (3010 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 20" 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 - 17 1/2" HOLE (Figure 5):

Cut off casing and weld on 20" - 2M slip on RTJ flange. Weld on two opposing 2" - 2M or 3" - 2M weld neck flanges for side outlet below flange. Valve the outlets with a 2" x 6" standard nipple and a 2" x 2M ball valve or 3" - 2M RTJ gate valve.

Blowout prevention equipment to drill a 17 1/2" hole should

consist of one 21-1/4" - 2M MSP Hydril Type Annular Preventer. Nipple up annular preventer to 20" - 2M flange. Run 2" or 3" diverter line from wing valve outlets on casing to choke manifold and then to reserve pit. Stake and hobble line.

Annular BOP to be tested prior to drilling out the 20" shoe to a pressure of 600 psi. Hold test for 30 minutes. Notify appropriate state regulatory agencies 24 hours prior to testing.

Should the well at anytime begin to flow, the 2"/3" divert line should be opened prior to closing in the annular preventer. The well should be allowed to flow to the pit until enough weighted mud can be mixed to kill the flow.

The annular preventer should be function tested daily. Test should be noted in the IADC tour report as well as in the morning report.

DRILLING 17 1/2" HOLE:

Drill out from underneath the 20" surface casing on pre-treated mud with a 17 1/2" mill tooth bit and slick bottomhole assembly. Dull bit and trip for insert type bit and recommended bottomhole assembly.

Should lost circulation persist. Loss interval(s) should be cemented. Mud sweeps with 40-50% (50 lb/bbl) of LCM may be attempted but should not be continued if returns are not regained after two sweeps.

The 17 1/2" hole is to be drilled to a depth of 2200' where 13 3/8" casing is to run. At casing point, circulate bottoms up and short trip to the collars. Trip back to bottom and check for fill. Note torque and drag. Circulate bottoms up and trip out to run pipe.

INTERMEDIATE CASING:

Approximately 2200' of 13 3/8" 61# K55 NEW VAM casing is to be run and cemented in place in a single stage. The float equipment should consist of a cement guide shoe, a single shoe joint followed by a load carrying screw-in sleeve float collar. Weld and strap the float equipment and the bottom three joints. Centralize the casing with three centralizers - one midway up the shoe joint, a second on the third collar and a third centralizer on the fifth collar. Fill casing on every second joint.

Land casing one to three feet off bottom. Set casing in slips and make up

screw-in stinger on drill pipe. Run inner string drill pipe and screw into float collar. Circulate casing as required for hole conditioning. Full returns should be obtained before commencing the cement job. Pressure test cement lines to 2000 psi prior to cementing. Maximum cementing pressure 2000 psi.

Cement with 100 bbls of water followed by (1) 10 bbls of CaCl_2 water, (2) 40 bbls of Super Flush and (3) 10 bbls of water. Mix and pump 1955 sacks (3090 ft^3) of type II cement + 40% silica flour + .65% CFR-3. If losses are encountered below the 20" casing shoe, it may be advisable to cement the 13 3/8" string with a light weight spherlite cement slurry tailed by 200 sacks of type II slurry. Pump 60% excess. Cut cement short if cement returns are obtained at the surface. Reciprocate casing 30' throughout job. Displace cement slurry with water. Bump drill pipe plug before releasing from float collar. Cement slurry should be mixed and pumped at a rate of 5 - 6 bpm. Trip out with inner string drill pipe. Hookup elevators to top of casing. Pull 80% of string weight and hold. Wait on cement for 12 hours. Release weight on casing.

BLOWOUT PREVENTION EQUIPMENT - 12 1/4" 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. (See Figure 6). 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 (as per regs) psi. 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 3900'. Should any losses be encountered while drilling, heal the loss zones as described in the 17 1/2" section of hole before drilling deeper. Previous wells drilled through this section have not reported any mud loss.

PRODUCTION CASING:

Approximately 3900' of 9 5/8" 47# C90 NEW-VAM 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 2200 psi. Maximum cementing pressure limit is to be 2200 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 540 sacks (2020 ft³) of type II cement + 40% silica flour + 50 lb/sk of spherulite + 4% gel + 1.25% CFR-3 + 1.5% HALAD 22A. Excess is calculated at 60%. Do not over displace. Reciprocate casing 10' - 15' throughout job if annular preventer is not closed. 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.

In the event that loss of circulation is encountered while drilling the 12 1/4" hole or the formation leakoff pressure is below 1250 psi (see leak-off test above) the 9 5/8" casing will be run as a liner and tie back according to the following procedure.

Pick-up 1950' 9 5/8" 47# C-90, NEW VAM with float shoe, single shoe joint and float collar.

Thread lock float equipment and bottom three joints. Pick-up Hyflo 9 5/8" x 13 3/8" L-80 liner hanger with Brown type 6' extension, 9 5/8" setting sleeve and landing collar.

Pick-up 1980' of 5" drill pipe. Trip in hole and circulate liner with mud. Set liner hanger. Sting out of liner and sting back in. Circulate preflush as above. Cement with 790 ft³ type II cement + 40% silica flow & 50 lb/sk Spherulite + 4% gel + 1.25% CFR-3 + 1.5% HALAD-22. Excess is calculated at 30%.

Sting out of liner hanger. Pull 1 stand up and reverse circulate excess cement out of hole. Wait on cement 8 hours.

Run in hole with 12-1/4" tooth bit and drill out cement to top of liner hanger. Pull out of hole and run in hole with 10.563" mill and drill collars. Clean-out to top of liner hanger. Pressure test to 1000 psi.

Displace hole with air and foam. Pick-up 1970' 9 5/8", 47#, C-90, new VAM with float collar 1 joint from bottom. Sting into top of liner hanger and open ports. Cement to surface with 790 ft³ type II cement + 40% silica flour 2% gel + 0.65% CFR-3. Maintain cement weight of >16.2 lb/gal. Excess is calculated at 30%.

Displace with water. 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 12 hours. After WOC, cut off 9 5/8" casing. Dress casing above casing head with 27 1/2 deg. 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 7):

Blowout prevention equipment to drill the 8 1/2" section of hole should consist of a 10" - 3M WKM gate valve, 10" - 3M x 12" - 5M DSA or cross-over spool, 12" - 5M SG ram preventer, 12" - 5M diverter spool (banjo box), 12" - 5M DG ram preventers, 12" - 5M annular preventer, 12" - 5M x 30" - 300 ANSI crossover spool followed by a 30" Williams rotating head.

Blank off 8" outlet on banjo box with 8" - 5M blind flange. 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 test 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:

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 4100' 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 865' at a 7400' 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 combatted with LCM products.

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

At 7400' TVD circulate out mud with fresh water. Trip-out of hole and rig up injection test. If test is successful, run production liner.

PRODUCTION LINER:

Trip in hole with slick BHA and check for fill. If hole is opened, run approximately 3792' of 7" 29# L80 BT&C casing slotted with 1/4" x 2" slots on 24 row pattern. Run liner with cement guide shoe on bottom. Make up casing on 7" x 9 5/8" single slip cone type liner hanger. No float equipment or centralizers are to be run. Hang liner at 3780'. Top three joints should be blank (no slots). Release from hanger and trip out laying down.

If mud is in the hole, pick up 3 1/2" drill pipe and run to bottom. Displace hole with water. Trip out of hole laying down 3 1/2" pipe. Trip in with remainder of 5" drill pipe. Trip out laying down.

Nipple down BOP and install final wellhead (Figure 8).

MUD PROGRAM:

26" Hole

Mud System: Water

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 viscofier 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 of circulation is not anticipated through this interval of hole. Should minor losses occur they can 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' - 3000'	250'	3°	1°/100'
3000' - 4000'	250'	4°	1°/100'
4000' - 7400'	100' - 200'	As required by target	4°/100'

KOP will be 150 feet below the 13 3/8" 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:

26" Hole

Holding Assembly:

26" Bit
 Rubber Sleeve Stabilizer
 10" Monel Drill Collar
 Rubber Sleeves Stabilizer
 2 - 10" Drill Collars
 10 - 8" Drill Collars

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'

Puna Geothermal Venture

Update: September 15, 1990

- 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 30" 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 26" bit. Drill to a depth of 1200'. 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 1200'. Run 20" 94# K55 BT&C casing. Cement with 1900 sacks (3010 ft³ of Type II Hawaii cement + 40% silica flour + 2% CaCl₂ + .65% CFR-3. Cement calculated at 100% excess. WOC.
5. Cut off casing and weld on casing head flange. Nipple up 21 1/2" annular hydril. Test BOP to 600 psi.
6. Drill out from underneath the 20" casing with a 17 1/2" bit. Drill to a depth of 2200'. Some mud losses may occur from 1000' to 1300'. Combat losses with LCM products.
7. At 2200' run 13 3/8" 61# K55 NEW VAM casing. Cement casing with 1955 sacks (3090 ft³/sk) of Type II portland + 40% silica flour + .65% CFR-3. WOC
8. 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.
9. Drill out from underneath the 13 3/8" casing to a depth of 3900'. Maintain hole as straight as possible. At 3900' prepare to run 9 5/8" casing.
10. Run 3900' of 9 5/8" 47# C90 NEW VAM casing. Cement with 540 sacks (2020 ft³/sk of Type II portland + 40% silica flour + 50 lb/sk of spherlite + 4% gel + 1.25% CFR-3 + HALAD 22A. WOC.
11. 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.
12. Drill ahead in the 8 1/2" hole with mud a depth of 4100'. At 4100', 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 7400' TVD. Drill to a total depth of 7400' 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.

13. At 7400' displace mud with water and run injection test.
14. Run 3792' of 7" 29# L80 BT&C slotted casing liner. Hang liner off at 3780'. Top three joints are to be left blank.
15. Pick up 3850' of 3½" drilling pipe + 3150' of 5½" drilling pipe. Run in hole, clean out to BTM, circulate hole with clean water, and come out laying down drill pipe.
16. Lay down 5" drill pipe. If mud is in the hole pick up 3½" drill pipe. Trip to bottom. Displace any mud that is in the hole.
17. Tear out and move rig., Nipple up wellhead assembly.

CASING AND CEMENT SUMMARY

20" 94# K55 BT&C:

Surface - 1200'

3010 ft³ (1900 sacks) of Type II portland cement + 40% silica flour + 40% silica flour + 2% CaCl₂ + .65% CFR-3

Calculated Excess: 100%

Slurry Weight - 15.7 ppg

Slurry Yield - 1.58 ft³/sk

13 3/8" 61# K55 NEW VAM:

Surface - 2200'

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" 47# C90 NEW VAM:

Surface - 3900'

2020 ft³ (540 sacks) of Type II portland cement + 50 lb/sk of spherlite + 4% gel + 1.25% CFR-3 + 1.5% HALAD - 22A

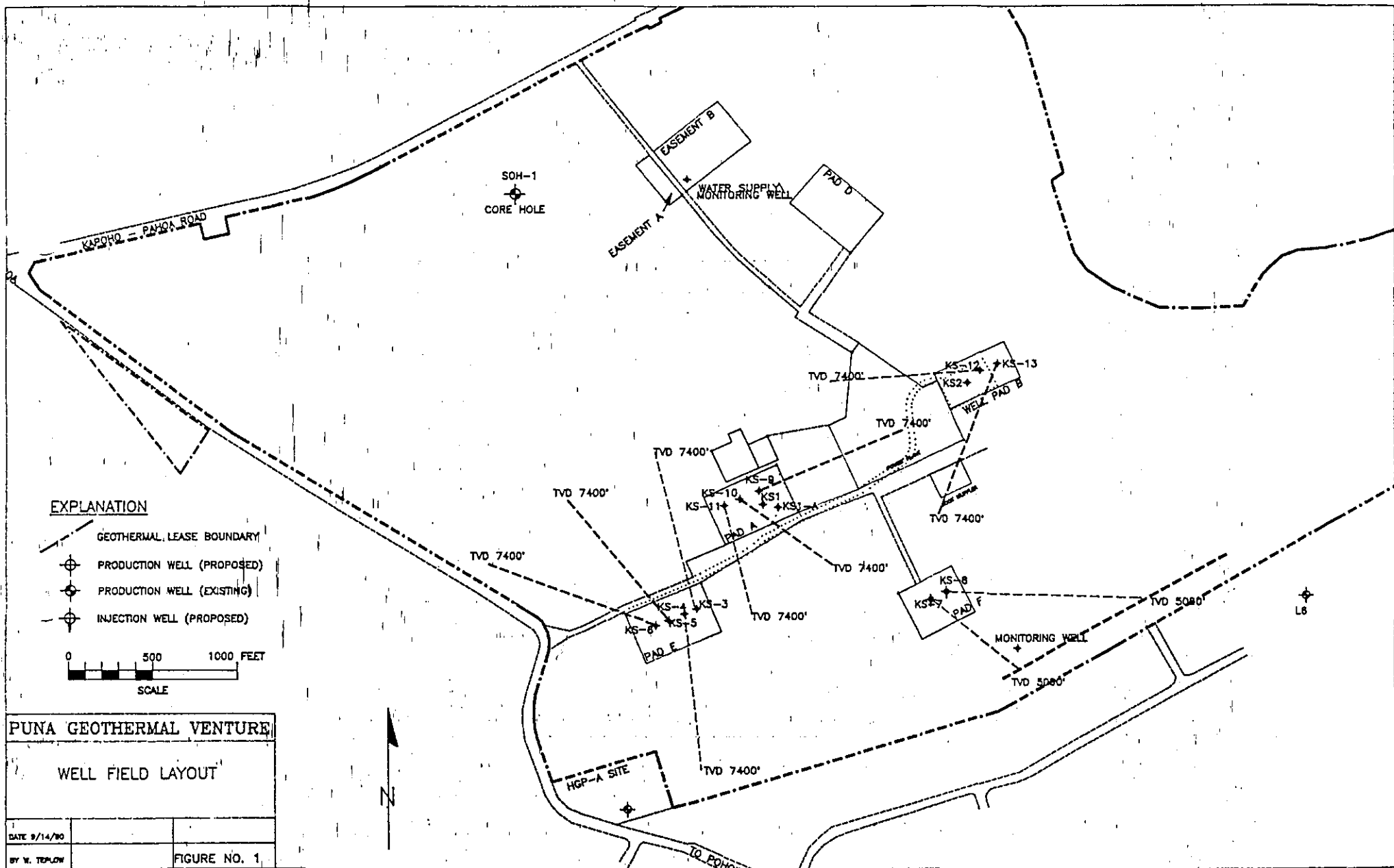
Calculated Excess: 60%

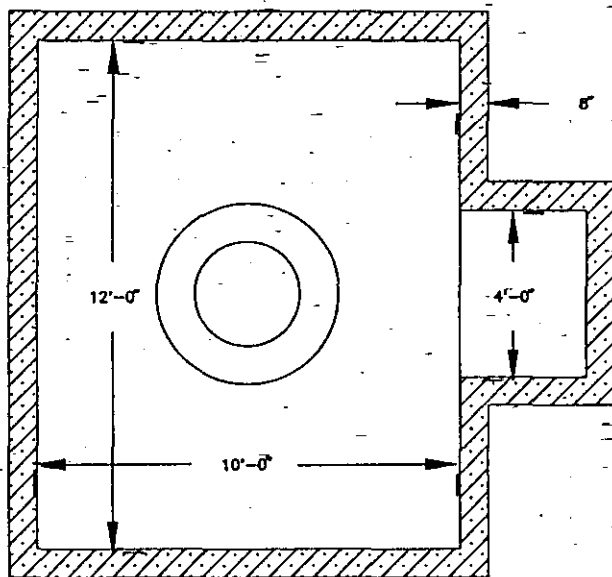
Slurry Weight - 11 ppg

Slurry Yield - 3.72 ft³/sk

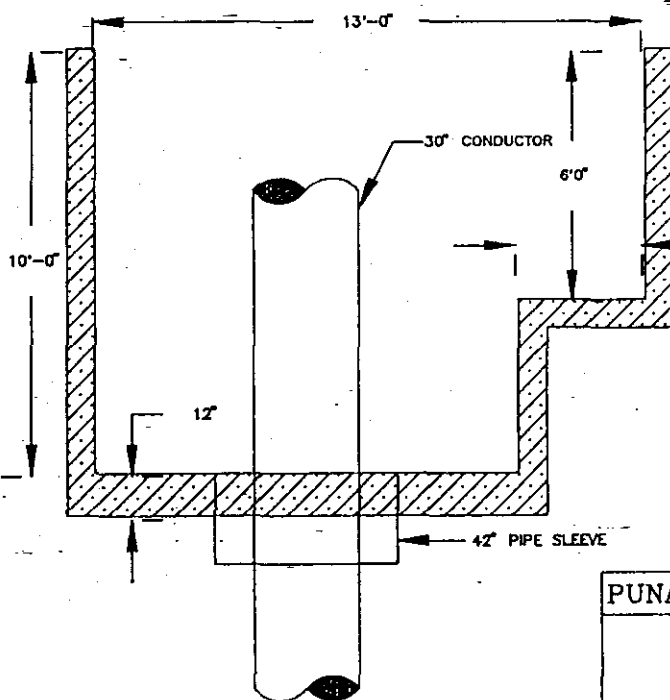
7" 29# L80 BT&C Casing Liner 3780' - 7400' TVD

slotted with 1/4" x 2" slots on 24 row pattern, top three joints blank.





PLAN



VERTICAL SECTION

PUNA GEOTHERMAL VENTURE

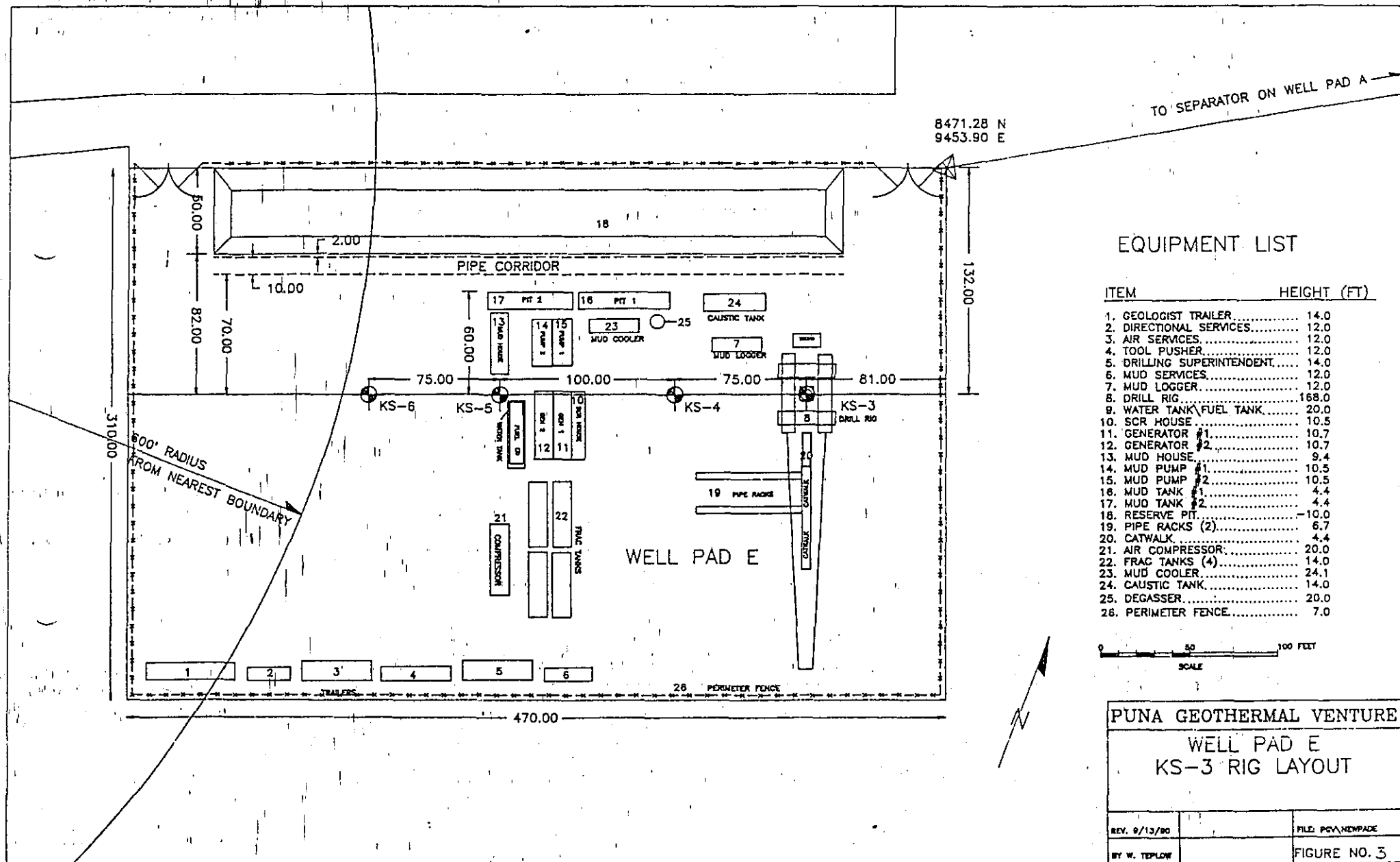
PRODUCTION WELL
CELLAR

DATE 3/12/90

SCALE 1" = 4'

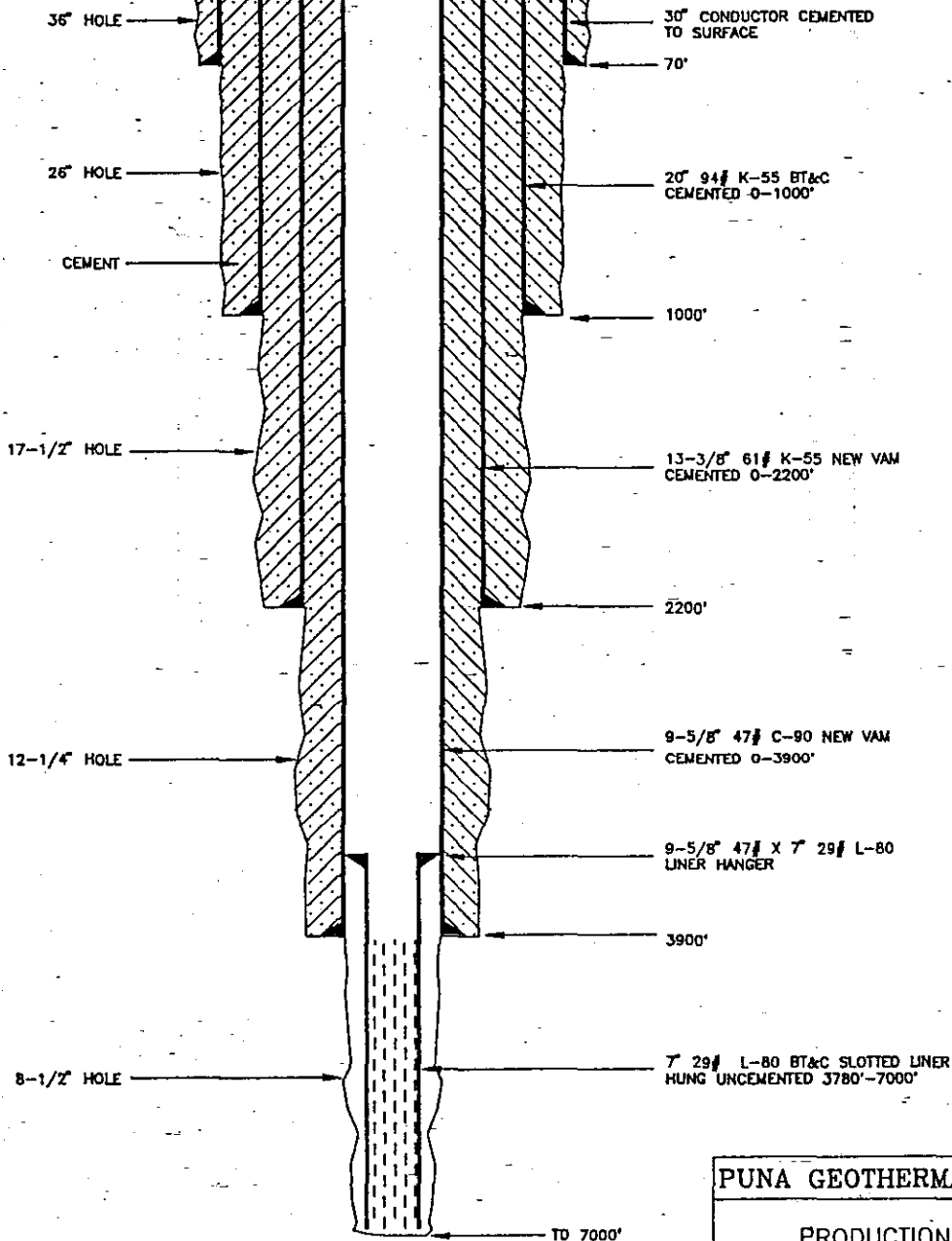
BY W. TEPLow

FIGURE NO. 2



GROUND SURFACE

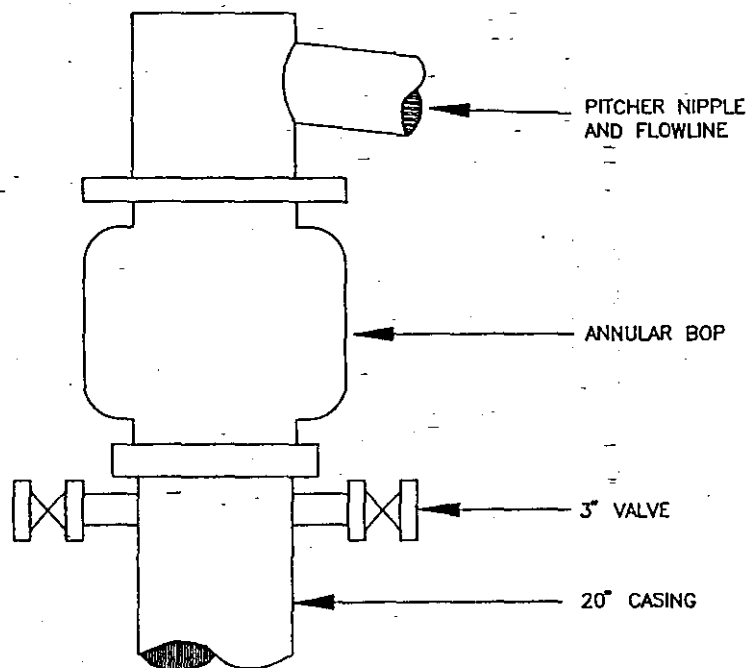
CELLAR



PUNA GEOTHERMAL VENTURE

PRODUCTION WELL
CASING DESIGN

DATE 3/16/90		REV. 1
BY W. TEPLow		FIGURE NO. 4



PUNA GEOTHERMAL VENTURE

20" BOP CONFIGURATION

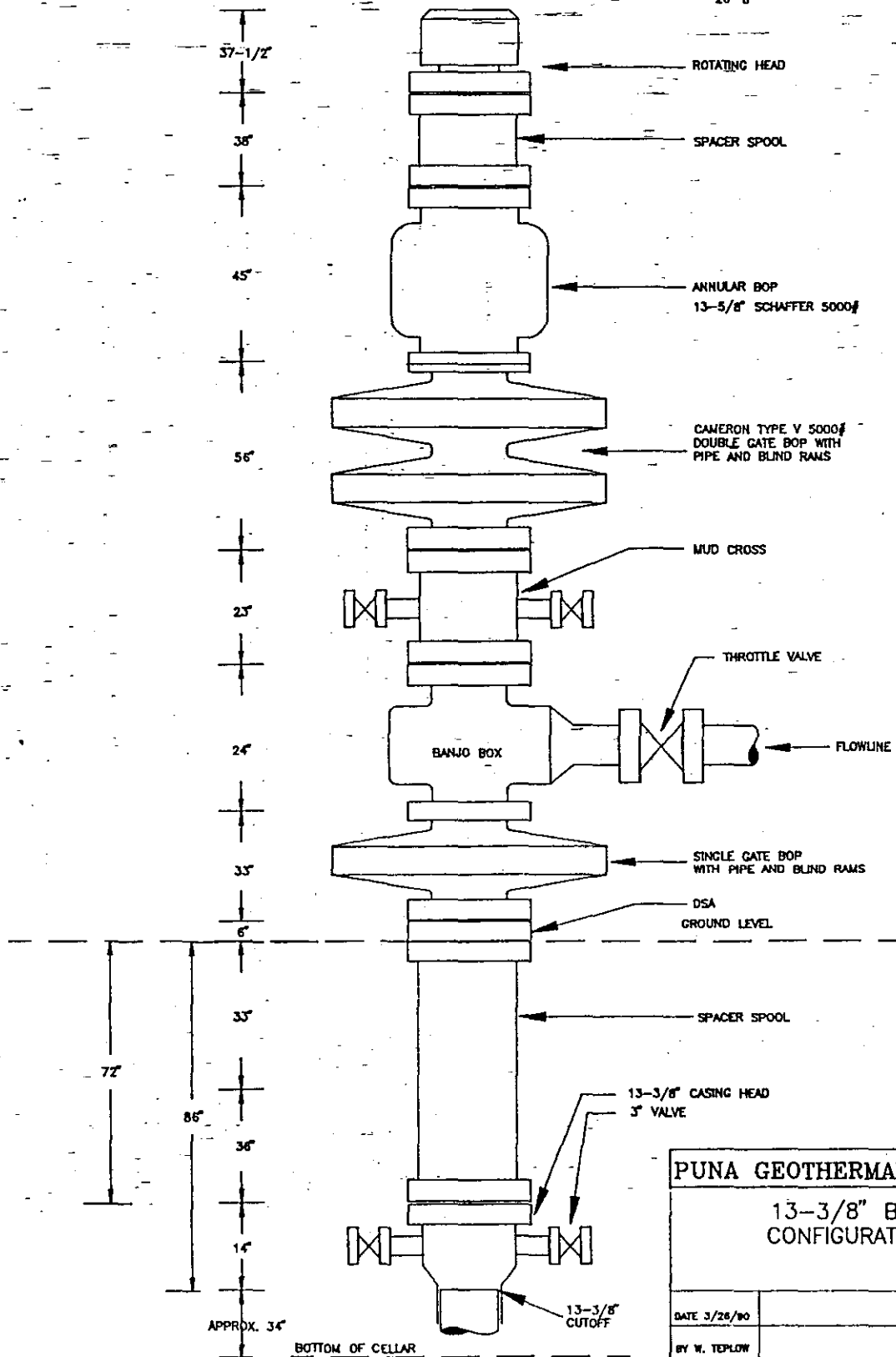
DATE 3/28/90

REV. 1

BY W. TEFLOW

FIGURE NO. 5

BOTTOM OF ROTARY BEAM
20' 0"



PUNA GEOTHERMAL VENTURE

13-3/8" BOP CONFIGURATION

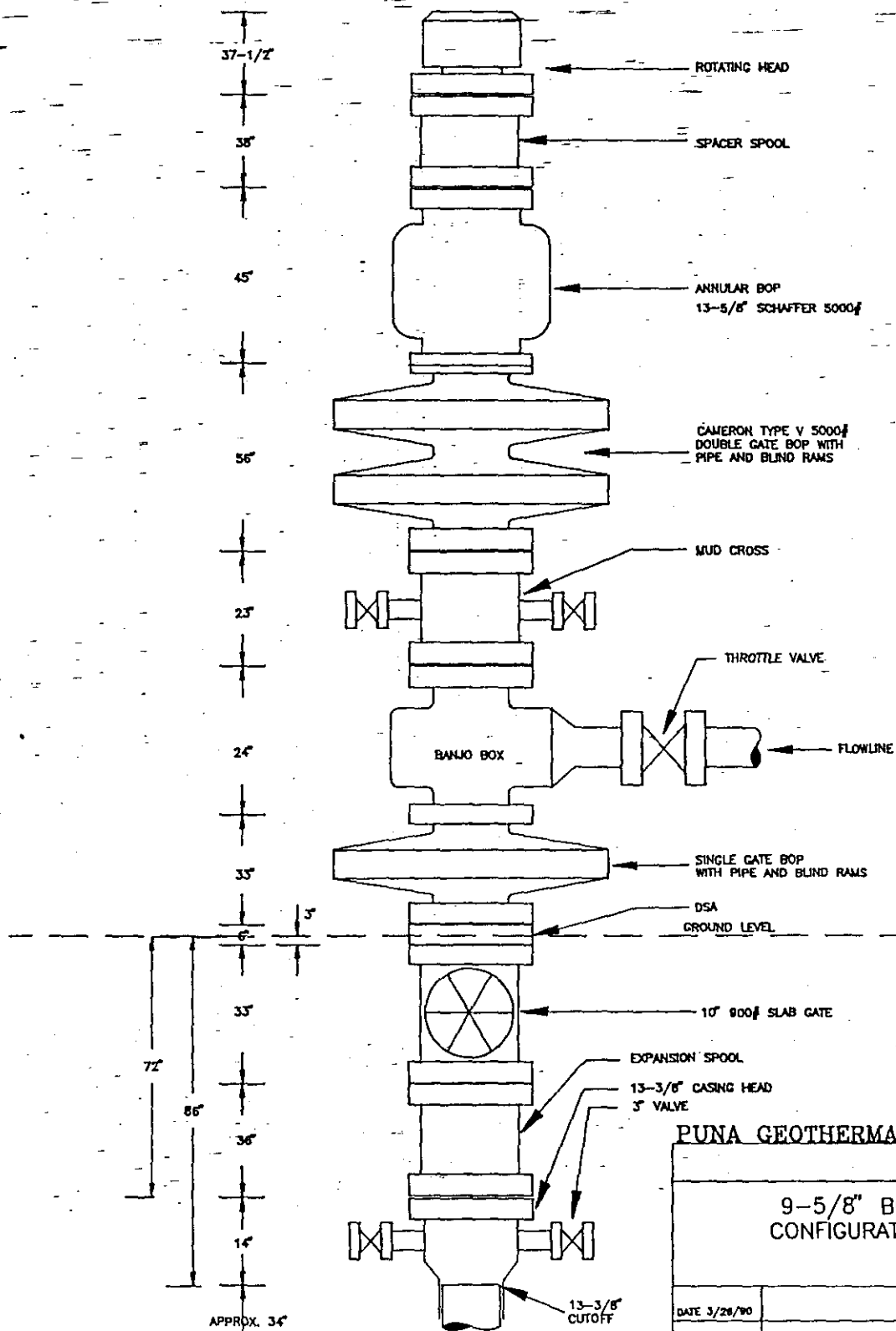
DATE 3/28/80

REV. 1

BY W. TELOW

FIGURE NO. 6

BOTTOM OF ROTARY BEAM
20' 8"



PUNA GEOTHERMAL VENTURE

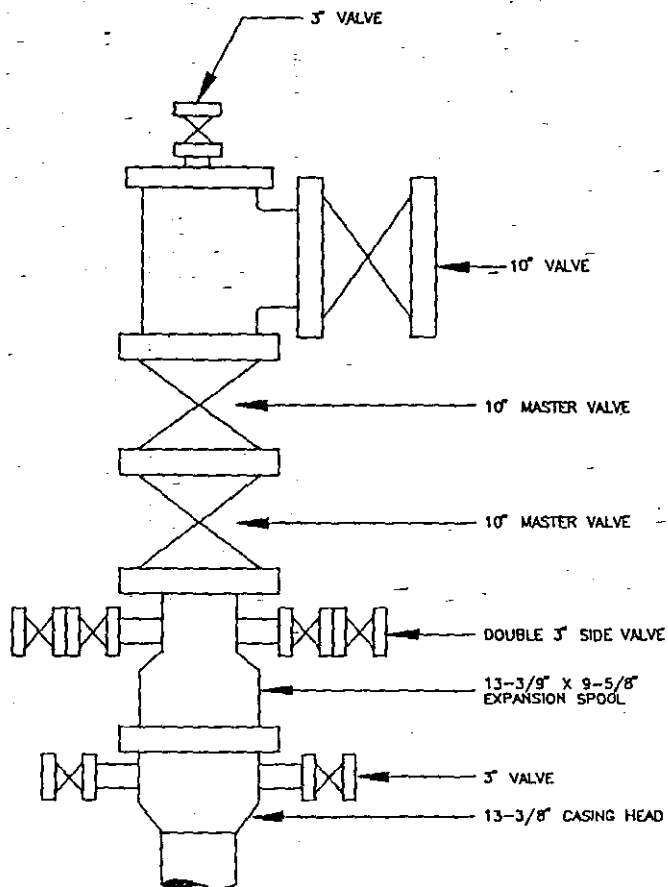
9-5/8" BOP
CONFIGURATION

DATE 3/28/90

REV. 1

BY W. TEPLON

FIGURE NO. 7



PUNA GEOTHERMAL VENTURE

PRODUCTION WELLHEAD CONFIGURATION

DATE 3/26/90

REV. 1

BY W. TEPLER

FIGURE NO. 8



DEPUTIES

KEITH W. AHUE
MANABU TAGOMORI
RUSSELL N. FUKUMOTO

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

P. O. BOX 621
HONOLULU, HAWAII 96809

AQUACULTURE DEVELOPMENT
PROGRAM
AQUATIC RESOURCES
CONSERVATION AND
ENVIRONMENTAL AFFAIRS
CONSERVATION AND
RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

REF:WL-MH

GEOHERMAL WELL DRILLING PERMIT

Kapoho State 6

TO: Puna Geothermal Venture
101 Aupuni Street, Ste. 1014-B
Hilo, HI 96720

Your application, dated April 6, 1990, for a permit to drill a geothermal well as follows, on lands located within the Kapoho Section of the Kilauea Lower East Rift Geothermal Resource Subzone and included in State of Hawaii, Department of Land and Natural Resources Mining Lease No. R-2 is approved:

Well Designation: Kapoho State 6
Location: TMK 1-4-01:02, Kapoho, Puna, Hawaii
Leased to: Kapoho Land Partnership
Subleased to: Puna Geothermal Venture
Operator: AMOR VIII Corporation
Ground Elevation: 620 ft.±
Total Depth: 7,000 feet (maximum)

You are hereby granted permission to drill the geothermal well described above and in your application in accordance with the Department's Administrative Rules, Chapter 13-183, and the following conditions:

- (1) All work shall be performed in accordance with the permission and terms of the occupier of the land, the Drilling and Completion Procedures submitted with you application, the Department's Administrative Rules (Chapters 13-183 and 13-184), and all other applicable Federal, State, and County laws, ordinances, rules and regulations;
- (2) The applicant, its successors and assigns, shall indemnify and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the applicant, assigns, officers, employees, contractors and agents under this permit or relating to or connected with the granting of this permit;

GEOHERMAL WELL DRILLING PERMIT

Kapoho State 6

Page 2

- (3) The applicant shall observe and comply with all valid requirements of County, State, and Federal authorities, and regulations pertaining to the lands and permittee's operations including, but not limited to, all water and air pollution control laws, and those relating to the environment;
- (4) The applicant shall secure the approval and issuance of a County Geothermal Resource Permit (GRP) from the Planning Commission prior to commencement of drilling activities;
- (5) If there are any contemplated changes in the proposed drilling program, the applicant shall obtain the Chairperson's approval prior to the execution of any such contemplated changes of work;
- (6) The applicant shall file with the Chairperson prior to the start of the permitted activity, a signed and completed certificate of liability insurance as required under the Department's Administrative Rules, Section 13-180-35;
3
- (7) The well shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling unless modified by the Chairperson upon request;
- (8) When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified with reasonable time allowed for travel to the site, to witness the sampling of a representative groundwater sample and the measurement of the static water level. Applicant shall have the sample analyzed by an independent laboratory and the results submitted to the Department ^{upon} completion of the analysis;
- (9) All Blowout-Prevention Equipment (BOPE) and cemented casing strings, shall be pressure tested before commencing any other operations on the well. Test pressures shall not be less than 600 pounds per square inch nor greater than 1,500 pounds per square inch, and shall be applied for a period of thirty minutes.
- (10) Prior to the start of drilling, applicant shall submit to the Chairperson the location of the bottomhole target and direction of the proposed deviation;
- (11) The drilling permit shall be valid for a period of one year from the date of issuance;

GEOHERMAL WELL DRILLING PERMIT
Kapoho State 6
Page 3

- (12) The applicant shall submit to the Chairperson, the results of the exploration, all drilling and testing records, date of completion, down-hole directional survey of the well, and a survey of the well location and elevation above mean sea level by a Hawaii licensed surveyor within six months after completion of the well;
- (13) The applicant shall notify the Division of Water and Land Development, in writing, of the date of the start of work;
- (14) During use of the well for testing, monitoring, and/or production purposes, the well and site shall be properly maintained until the well is plugged and abandoned in accordance with our Department's Administrative Rules, Chapter 13-183;
- (15) The site shall be restored as near as possible to their original condition after operations are completed.



WILLIAM W. PATY, Chairperson
Board of Land and Natural Resources

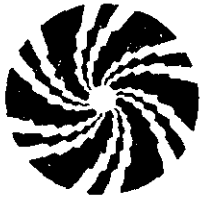
JUN 13 1990

Date of Permit

cc: Land Board Members
Hawaii County Planning Dept.
DBED
Department of Health
OEQC

ORMAT®

RECEIVED



April 6, 1990
Reference No. 90131.011

90 APR 12 4 31 58

DEPT. OF LAND
& NATURAL RESOURCES
STATE OF HAWAII

Mr. William Paty
Chairman
Board of Land and Natural Resources
Kalanimoku Building, Room 130
1151 Punchbowl Street
Honolulu, Hawaii 96813

Subject: Application for Permit to Drill Geothermal Well Kapoho
State 6 - State Geothermal Mining Lease R-2

Dear Mr. Paty:

In accordance with the Department of Land and Natural Resources Administrative Rules, Title 13, Chapter 183-65, Puna Geothermal Venture (PGV) hereby submits the enclosed application for a permit to drill geothermal well Kapoho State 6. Also enclosed is our check number 177 in the amount of \$100.00 for the filing fees for this application. Kapoho State 6 will be drilled from the proposed wellpad E of the PGV Project, as approved in the Plan of Operation on March 10, 1989 by the Board of Land and Natural Resources.

Your timely consideration and approval of this application would be greatly appreciated. Please do not hesitate to contact this office if you have any questions or desire any additional information regarding this application.

Sincerely,


Maurice A. Richard
Regional Development Manager

Enclosures

PUNA GEOTHERMAL VENTURE

- | | | | | |
|---|---|--------------------------|---|--------------------------|
| <input type="checkbox"/> 101 Aupuni Street Suite 1014-B, Hilo, Hawaii 96720 | • | Telephone (808) 961-2184 | • | Facsimile (808) 961-3531 |
| <input type="checkbox"/> 610 East Glendale Ave., Sparks, Nevada 89431-5811 | • | Telephone (702) 356-9111 | • | Facsimile (702) 356-9125 |

APPLICATION FOR PERMIT TO DRILL PROPOSED GEOTHERMAL WELL
KAPOHO STATE 6 ON RESERVED LANDS, KAPOHO, PUNA, HAWAII

Complying with Department of Land and Natural Resources (DLNR) Administrative Rule, Title 13, Chapter 183, Subchapter 65, Puna Geothermal Venture (PGV) herewith makes application for Permit to Drill for approval by the Hawaii Board of Land and Natural Resources.

1. Applicant:

Puna Geothermal Venture
101 Aupuni Street
Suite 1014-B
Hilo, Hawaii 96720
(808)961-2184

PUNA GEOTHERMAL VENTURE

By: 

Maurice A. Richard
Hawaii Regional Development Manager
Puna Geothermal Venture

Owner of Mining Rights:

Kapoho Land Partnership

Land Owner:

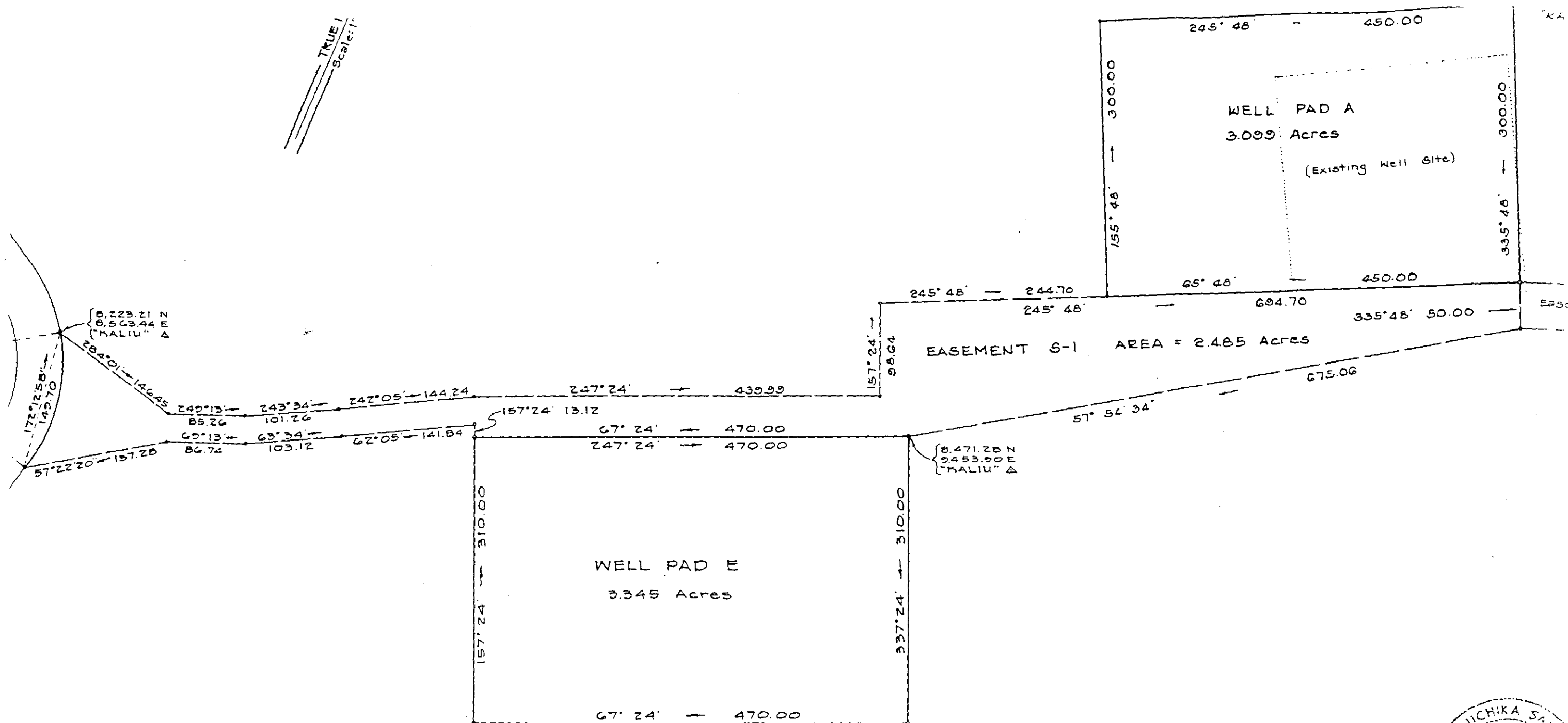
Kapoho Land and Development Company, Limited

2. Proposed well designation: Kapoho State 6 (KS-6) off Wellpad E.

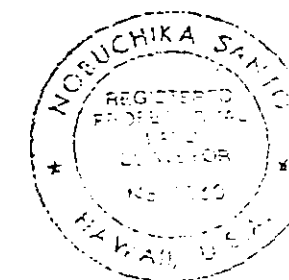
3. The enclosed tax key map, Attachment I, designates the approximate location of the drillsite for KS-6 off Wellpad E located on State Geothermal Mining Lease R-2. The elevation at Wellpad E is approximately 620 feet above mean sea level. A survey of the wellpad for the PGV project is enclosed as Attachment II.
4. The proposed PGV Project geothermal well KS-6 has been designed to maximize the possibility of intersecting, below approximately 4,000 feet, near-vertical fractures which are generally aligned along the axis of the Lower East Rift Zone (LERZ) and which carry geothermal fluids for the purpose of providing geothermal resources to power the PGV Project power plant, previously approved in the Plan of Operation approved March 10, 1989, by the Board of Land and Natural Resources.
5. A detailed Well Drilling and Completion Program, a Drillsite Plan, and a Vertical Section of the Well for the KS-6 well are contained in Attachment III.
6. A multi-well drilling bond (\$25,000) has previously been filed with the State of Hawaii.

Application for Permit to Drill
Kapoho State 6
April 6, 1990

7. Puna Geothermal Venture agrees to perform such drilling as outlined in this application and agrees to maintain the well in accordance with Title 13, Chapter 183, State of Hawaii, and all Federal and County geothermal regulations.



PLAN SHOWING
EASEMENT S-1 AND WELL PAD E
PUNA GEOTHERMAL VENTURE PROJECT
BEING PORTIONS OF L.P. 8177 AND R.P. 4497,
L.C. AW. 8559, APANA 5 TO C. KANAINA
KAPOHO, PUNA, HAWAII



Noruchika Saki

Plan by:
Island Survey, Inc.
P.O. Box 337
Hilo, Hawaii
February 12, 1999

24 James H. Thompson &
Augustine Thompson - T/C

25 James H. Thompson

37 Augustine Thompson T. 1st 1/2 of
2nd 1/2

35 Augustine Thompson

26 Paradise 1st Street 4 of
Leaves 20 - 1/2

48 Sharon A. Caldwell

49 Sharon Caldwell & Paul Caldwell A. - P's

50 Sharon A. Caldwell

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35 Менделеев Дмитрий Иванович

26 February 1944 Page 4 of
Lettering 44 - 1/4

50 Colony & Reaction

52 Monday 2 November

State of Hawaii
Dept. of Land & Natural Resources
Forestry & Wildlife Division
Hon. Hqs. and Dep. 1666
Honolulu, Hawaii 96813
Tel. 535-5171
Fax 535-5171

12 State of Hawaii
Dept. of Land & Natural Resources - Div. of State Parks
Geology Research & Mapping Branch Page One of Two

42 C. L. CHAMBERS
JAMES CHAMBERS - NY
S. ADD. ASB.
43 WILLIAM T. CHAMBERS
C. M. CHAMBERS - NY
S. 100 ASB.
44 WILLIAM CHAMBERS
C. M. CHAMBERS - C. T. 10
S. 100 ASB.
45 JOHN J. CHAMBERS
CHAMBERS - NY
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62 CHAMBERS - CHAMBERS
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21 John L. Murphy and Suzanne
R. T.C. '72
Merle & Casey L. Thomas P
T.C. '72
54 James & Shimeyane and Frances
L.H. T.C. '72
William W. H. and Alice T.C. '72

22-511-6

WELL PAD E
PRODUCTION WELLS KS-3, 4, 5, 6

NOTE: NUMBER OF THE CASE IS 68-107 AND
DATE OF THE CASE IS 1968-10-10.
CASE NAME IS JOHN WILLIAM CASE
A LATTER CASE FILED IN
IN THE COURT OF THE DISTRICT

NOTE: THERE'S A COPY OF THE CASE IN THE
DISTRICT COURT (NAME) OF THE DISTRICT COURT.

DEPARTMENT OF TAXATION
TAXATION MAPS BUREAU
STATE OF HAWAII
TAX MAP
THIRD TAXATION DIVISION
DATE 4 01

FOR REAL PROPERTY TAXATION PURPOSES
SUBJECT TO CHANGE

POR PUUA-KAPOHO, PUUA, HAWAII

PUNA GEOTHERMAL VENTURE
DRILLING PROGRAM
PRODUCTION WELL KS-6

WELL DATA:

Location: Wellpad E (See Figure 1)
Datum: Approximately 650' above MSL
Projected Depth: 7,000 feet TVD
Well Type: Development 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	1300' - TD	Dense basalt with alternating layers and volcanic ash. Lost circulation below 4300'.

CONDUCTOR PIPE AND CELLAR:

Thirty inch (30") A53 Schedule 40 (.375" wall) Grade A or B 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 30" conductor pipe. Order out 10 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 - 26" HOLE:

Rig up Parker #231 as shown in Figure 3. Following rig up of Parker #231, weld on 30" pitcher nipple or William 30" rotating head. Spud in with 26" 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 26" hole on water, aerated mud, or foam. Drill to a depth of 1000' - casing point for 20" 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 20" 94# 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 20" casing through drill pipe with 1900 sacks (3010 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 20" 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 - 17 1/2" HOLE (Figure 5):

Cut off casing and weld on 20" - 2M slip on RTJ flange. Weld on two opposing 2" - 2M or 3" - 2M weld neck flanges for side outlet below flange. Valve the outlets with a 2" x 6" standard nipple and a 2" x 2M ball valve or 3" - 2M RTJ gate valve.

Blowout prevention equipment to drill a 17 1/2" hole should consist of one 21-1/4" - 2M MSP Hydril Type Annular Preventer. Nipple up annular preventer to 20" - 2M flange (see Figure 2). Run 2" or 3" diverter line from wing valve outlets on casing to choke manifold and then to reserve pit. Stake and hobble line.

Annular BOP to be tested prior to drilling out the 20" shoe to a pressure of 600 psi. Hold test for 30 minutes. Notify appropriate state regulatory agencies 24 hours prior to testing.

Should the well at anytime begin to flow, the 2"/3" divert line should be opened prior to closing in the annular preventer. The well should be allowed to flow to the pit until enough weighted mud can be mixed to kill the flow.

The annular preventer should be function tested daily. Test should be noted in the IADC tour report as well as in the morning report.

DRILLING 17 1/2" HOLE:

Drill out from underneath the 20" surface casing on pre-treated mud with a 17 1/2" mill tooth bit and slick bottomhole assembly. Dull bit and trip for insert type bit and recommended bottomhole assembly.

Should lost circulation persist. Loss interval(s) should be cemented. Mud sweeps with 40-50% (50 lb/bbl) of LCM may be attempted but should not be continued if returns are not regained after two sweeps.

The 17 1/2" hole is to be drilled to a depth of 2200' where 13 3/8" casing is to run. At casing point, circulate bottoms up and short trip to the collars. Trip back to bottom and check for fill. Note torque and drag. Circulate bottoms up and trip out to run pipe.

INTERMEDIATE CASING:

Approximately 2200' of 13 3/8" 61# K55 NEW VAM casing is to be run and cemented in place in a single stage. The float equipment should consist of a cement guide shoe, a single shoe joint followed by a load carrying screw-in sleeve float collar. Weld and strap the float equipment and the bottom three joints. Centralize the casing with three centralizers - one midway up the shoe joint, a second on the third collar and a third centralizer on the fifth collar. Fill casing on every second joint.

Land casing one to three feet off bottom. Set casing in slips and make up screw-in stinger on drill pipe. Run inner string drill pipe and screw into float collar. Circulate casing as required for hole conditioning. Full returns should be obtained before commencing the cement job. Pressure test cement lines to 2000 psi prior to cementing. Maximum cementing pressure 2000 psi.

Cement with 100 bbls of water followed by (1) 10 bbls of CaCl₂ water, (2) 40 bbls of super Flush and (3) 10 bbls of water. Mix

and pump 1955 sacks (3090 ft³) of type II cement + 40% silica flour + .65% CFR-3. If losses are encountered below the 20" casing shoe, it may be advisable to cement the 13 3/8" string with a light weight spherlite cement slurry tailed by 200 sacks of type II slurry. Pump 60% excess. Cut cement short if cement returns are obtained at the surface. Reciprocate casing 30' throughout job. Displace cement slurry with water. Bump drill pipe plug before releasing from float collar. Cement slurry should be mixed and pumped at a rate of 5 - 6 bpm. Trip out with inner string drill pipe. Hookup elevators to top of casing. Pull 80% of string weight and hold. Wait on cement for 12 hours. Release weight on casing.

BLOWOUT PREVENTION EQUIPMENT - 12 1/4" 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. (See Figure 3). 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 (as per regs) psi. 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 3900'. Should any losses be encountered while drilling, heal the loss zones as described in the 17 1/2" section of hole before drilling deeper. Previous wells drilled through this section have not reported any mud loss.

PRODUCTION CASING:

Approximately 3900' of 9 5/8" 47# C90 NEW VAM 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 2200 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 CAC12, (2) 40 bbls of Super Flush and (3) 10 bbls of water spacer. Cement casing with 540 sacks (2020 ft³) of type II cement + 40% silica flour + 50 lb/sk of spherulite + 4% gel + 1.25% CFR-3 + 1.5% HALAD 22A. Excess is calculated at 60%. Do not over displace. Reciprocate casing 10' - 15' throughout job if annular preventer is not closed. 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.

In the event that loss of circulation is encountered while drilling the 12 1/4" hole or the formation leakoff pressure is below 1250 psi (see leak-off test above) the 9 5/8" casing will be run as a liner and tie back according to the following procedure.

Pick-up 1950' 9 5/8" 47# C-90, NEW VAM with float shoe, single shoe joint and float collar.

Thread lock float equipment and bottom three joints. Pick-up Hyflo 9 5/8" x 13 3/8" L-80 liner hanger with Brown type 6' extension, 9 5/8" setting sleeve and landing collar.

Pick-up 1980' of 5" drill pipe. Trip in hole and circulate liner with mud. Set liner hanger. Sting out of liner and sting back in circulate preflush as above. Cement with 790 ft³ type II cement + 40% silica flow & 50 lb/sk Spherulite + 4% gel + 1-25% CFR-3 + 1.5% HALAD-22. Excess is calculated at 30%.

Sting out of liner hanger. Pull 1 stand up and reverse circulate excess cement out of hole. Wait on cement 8 hours.

Run in hole with 8 7/8" mill and drill collars. Clean-out to top of liner hanger. Pressure test to 1000 psi.

Displace hole with air and foam. Pick-up 1970' 9 5/8", 47#, C-90, new VAM with float collar 1 joint from bottom. Sting into

top of liner hanger and open ports. Cement to surface with 790 ft³ type II cement + 40% silica flour + 50#/sk Sperulite + 4% gel + 1.25% CFR-3 + 1.5% HALAD-22. Excess is calculated at 30%.

Displace with water. 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 12 hours. After WOC, cut off 9 5/8" casing. Dress casing above casing head with 27 1/2 deg.

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 7):

Blowout prevention equipment to drill the 8 1/2" section of hole should consist of a 10" - 3M WKM gate valve, 10" - 3M x 12" - 5M DSA or cross-over spool, 12" - 5M SG ram preventer, 12" - 5M diverter spool (banjo box), 12" - 5M DG ram preventers, 12" - 5M annular preventer, 12" - 5M x 30" - 300 ANSI crossover spool followed by a 30" Williams rotating head (see Figure 4).

Blank off 8" outlet on banjo box with 8" - 5M blind flange. 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 IAOC tour report as well as in the daily morning report.

DRILLING 8 1/2" HOLE:

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 4100' 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 865' at a 7000' 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 7000' TDV circulate out mud with fresh water. Trip -out of hole and rig up injection test. If test is successful, run production liner.

PRODUCTION LINER:

Trip in hole with slick BHA and check for fill. If hole is opened, run approximately 3220' of 7" 29# L80 BT&C casing slotted with 1/2" x 2" slots on an 18 per row pattern. Run liner with cement guide shoe on bottom. Make up casing on 7" x 9 5/8" single slip cone type liner hanger. No float equipment or centralizers are to be run. Hang liner at 3780'. Top three joints should be blank (no slots). Release from hanger and trip out laying down.

If mud is in the hole, pick up 3 1/2" drill pipe and run to bottom. Displace hole with water. Trip out of hole laying down 3 1/2" pipe. Trip in with remainder of 5" drill pipe. Trip out laying down.

Nipple down BOP and install final wellhead (Figure 8).

MUD PROGRAM:

26" Hole

Mud System: Water

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 viscofier 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' - 3000'	250'	3	1 /100'
3000' - 4000'	250'	4	1 /100'
4000' - 7000'	100' - 200'	As required by target	4 /100'

KOP will be two hundred feet below the 13 3/8" 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:

26" Hole

Holding Assembly:

26" Bit
Rubber Sleeves Stabilizer
10" Monel Drill Collar
Rubber Sleeves Stabilizer
2 - 10" Drill Collars
10 - 8" Drill Collars

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
6 1/2" Monel Drill Collar upon angle and course
direction}
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 " Monel Drill Collar
8 " 3-point Roller Reamer
1 - 6 " Drill Collar
8 " Integral Blade Stabilizer
16 - 6 " 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 30" 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 26" 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 20" 94# K55 BT&C casing. Cement with 1900 sacks (3010 ft³ of Type II Hawaii cement + 40% silica flour + 2% CaCl₂ + .65% CFR-3. Cement calculated at 100% excess. WOC.
5. Cut off casing and weld on casing head flange. Nipple up 21 " annular hydril. Test BOP to 500 psi.
6. Drill out from underneath the 20" casing with a 17 1/2" bit. Drill to a depth of 2200'. Some mud losses may occur from 1000' to 1300'. Combat losses with LCM products.
7. At 2200' run 13 3/8" 61# K55 NEW VAM casing. Cement casing with 1955 sacks (3090 ft³/sk) of Type II portland + 40% silica flour + .65% CFR-3. WOC
8. 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.
9. Drill out from underneath the 13 3/8" casing to a depth of 3900'. Maintain hole as straight as possible. At 3900' prepare to run 9 5/8" casing.
10. Run 3900' of 9 5/8" 47# C90 NEW VAM casing. Cement with 540 sacks (2020 ft³/sk of Type II portland + 40% silica flour + 50 lb/sk of spherlite + 4% gel + 1.25% CFR-3 + HALAD 22A. WOC.
11. 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.

12. Drill ahead in the 8 " hole with mud a depth of 4100'. At 4100', 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 7000' TVD. Drill to a total depth of 7000' 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.
13. At 7000' displace mud with water and run injection test.
14. Run 3220' of 7" 29# L80 BT&C slotted casing liner. Hang liner off at 3780'. Last three joints are to be left blank.
15. Pick up 3850' of 3 " drilling pipe + 3150' of 5 " drilling pipe. Run in hole, clean out to BTM, circulate hole with clean water, and come out laying down drill pipe.
16. Lay down 5" drill pipe. If mud is in the hole pick up 3 " drill pipe. Trip to bottom. Displace any mud that is in the hole.
17. Tear out and move rig., Nipple up wellhead assembly.

CASING AND CEMENT SUMMARY

20" 94# K55 BT&C:

Surface - 1000'

3010 ft3 (1900 sacks) of Type II
portland cement + 40% silica flour
+ 40% silica flour + 2% CaCl₂ +
.65% CFR-3

Calculated Excess: 100%
Slurry Weight - 15.7 ppg
Slurry Yield - 1.58 ft3/sk

13 3/8" 61# K55 NEW VAM:

Surface - 2200'

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" 47# C90 NEW VAM:

Surface - 3900'

2020 ft3 (540 sacks) of Type II
portland cement + 50 lb/sk of
spherlite + 4% gel + 1.25% CFR-3 +
1.5% HALAD - 22A

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

7" 29# L80 BT&C Casing Liner
slotted with 1/2" x 2" slots on
18 Row Pattern

3780' - 7000' TD

PUNA GEOTHERMAL VENTURE

SITE PLAN MAP FOR TEMPORARY STRUCTURE LOCATION WELL PAD E AND STAGING AREA

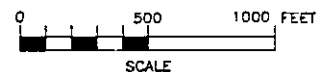
DATE 3/12/90

SCALE 1"=500'

REV. NO. 1

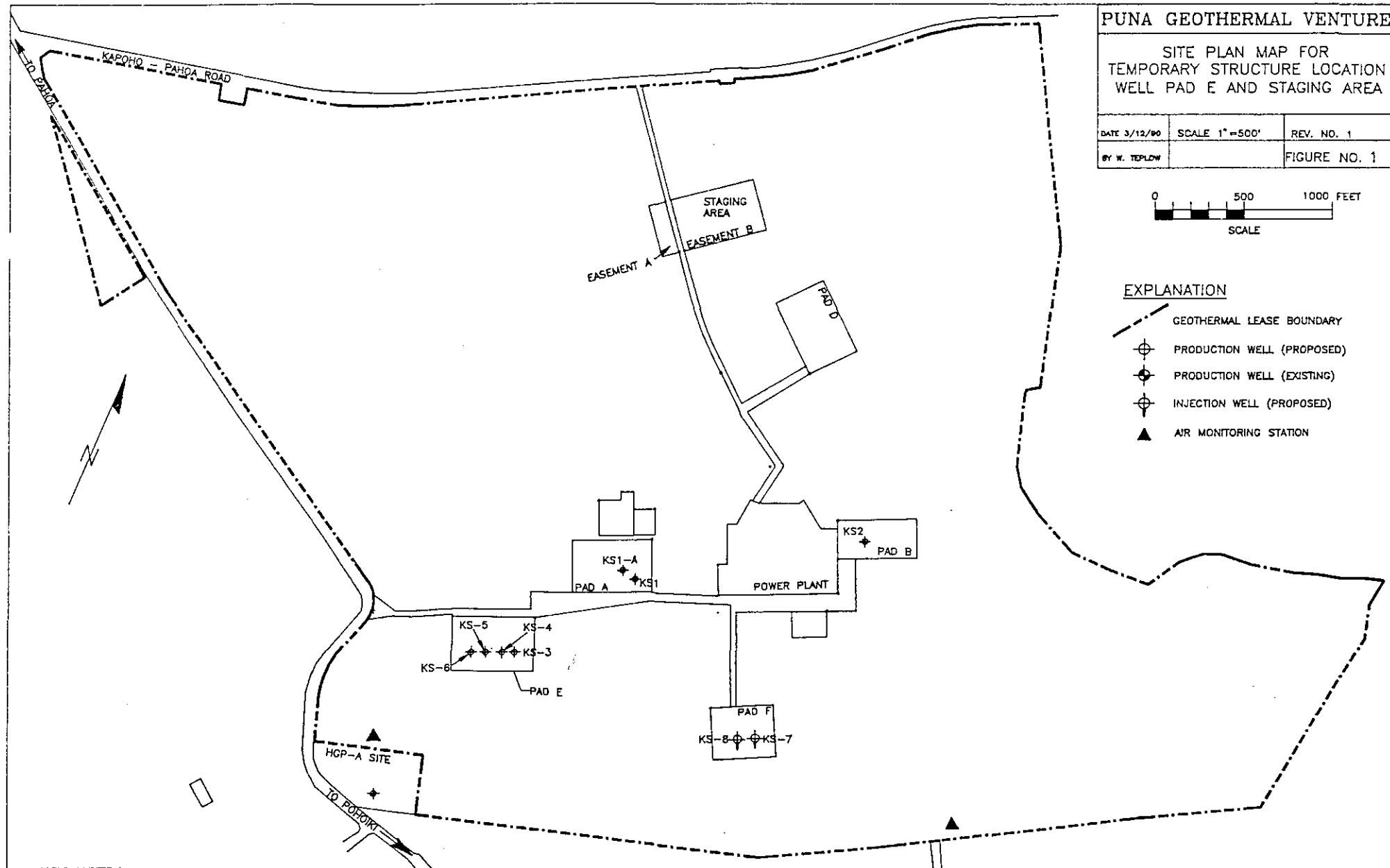
BY W. TEPLDOW

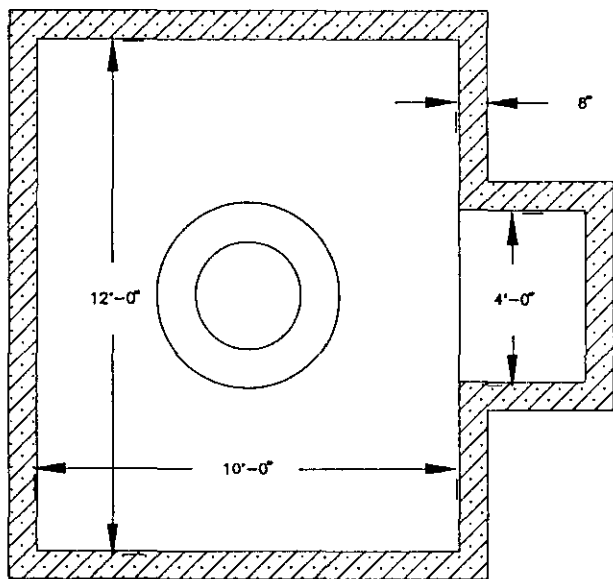
FIGURE NO. 1



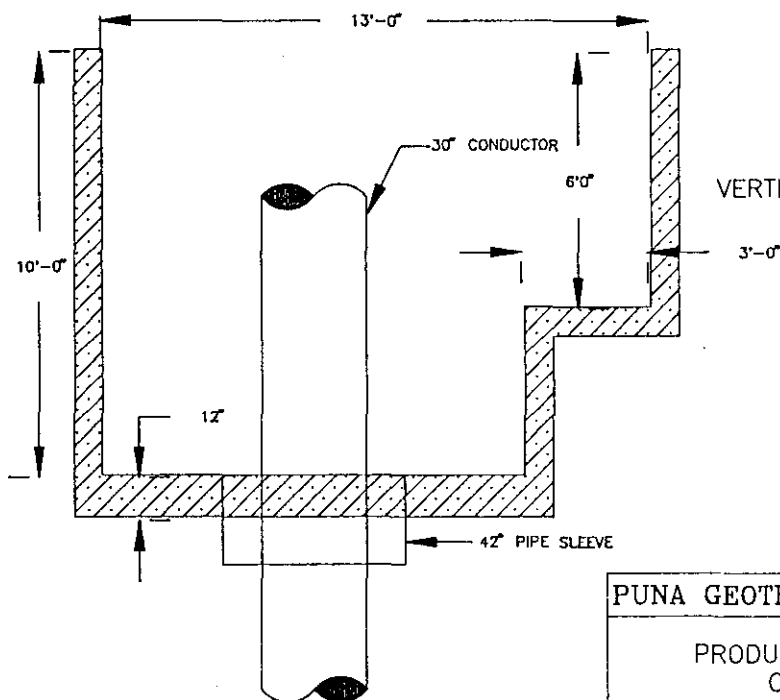
EXPLANATION

- GEOTHERMAL LEASE BOUNDARY
- PRODUCTION WELL (PROPOSED)
- PRODUCTION WELL (EXISTING)
- INJECTION WELL (PROPOSED)
- AIR MONITORING STATION





PLAN



VERTICAL SECTION

PUNA GEOTHERMAL VENTURE

PRODUCTION WELL
CELLAR

DATE 3/12/90

SCALE 1" = 4'

BY W. TEPLON

FIGURE NO. 2

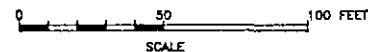
EASEMENT S-1

ACCESS ROAD

"KALI" Δ
8471.28 N
9453.90 E

EQUIPMENT LIST

ITEM	HEIGHT (FT)
1. GEOLOGIST TRAILER.....	14.0
2. DIRECTIONAL SERVICES.....	12.0
3. AIR SERVICES.....	12.0
4. TOOL PUSHER.....	12.0
5. DRILLING SUPERINTENDENT.....	14.0
6. MUD SERVICES.....	12.0
7. MUD LOGGER.....	12.0
8. DRILL RIG.....	168.0
9. WATER TANK/FUEL TANK.....	20.0
10. SCR HOUSE.....	10.5
11. GENERATOR #1.....	10.7
12. GENERATOR #2.....	10.7
13. MUD HOUSE.....	9.4
14. MUD PUMP #1.....	10.5
15. MUD PUMP #2.....	10.5
16. MUD TANK #1.....	4.4
17. MUD TANK #2.....	4.4
18. RESERVE PIT.....	10.0
19. PIPE RACKS (2).....	6.7
20. CATWALK.....	4.4
21. AIR COMPRESSOR.....	20.0
22. FRAC TANKS (4).....	14.0
23. MUD COOLER.....	24.1
24. CAUSTIC TANK.....	14.0
25. DEGASSER.....	20.0



PUNA GEOTHERMAL VENTURE

PAD E - WELL KS-6
DRILLING EQUIPMENT
AND
TRAILER LAYOUT

DATE 3/26/90	SCALE 1" = 50'
BY W. TEPLow	FIGURE NO. 3

WELL PAD E

TRAILERS

FRAC TANKS

COMPRESSOR

PIPE RACKS

MUD LOGGER

DRILL RIG

KS-6

KS-5

CAUSTIC TANK

MUD COOLER

PIT 1

PIT 2

RESERVE MUD PIT

18

470'

10'

110

75

KS-4

KS-3

75

15

GEN 1

GEN 2

FUEL TANK

WATER TANK

13

MUD HOUSE

14

PUMP

PUMP

15

23

25

24

21

22

20

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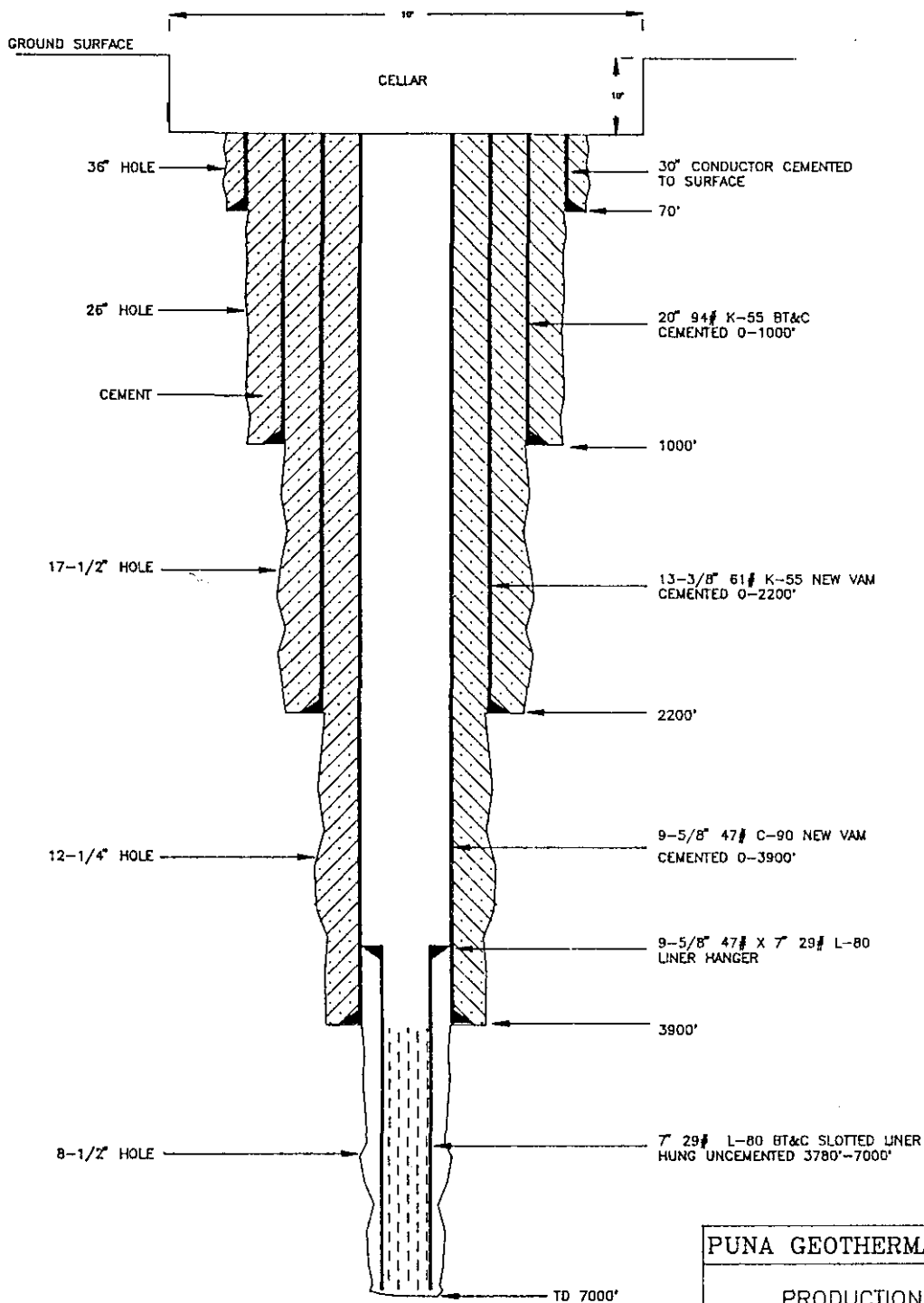
2

1

0

300

610' TO NEAREST
PROPERTY BOUNDARY



PUNA GEOTHERMAL VENTURE

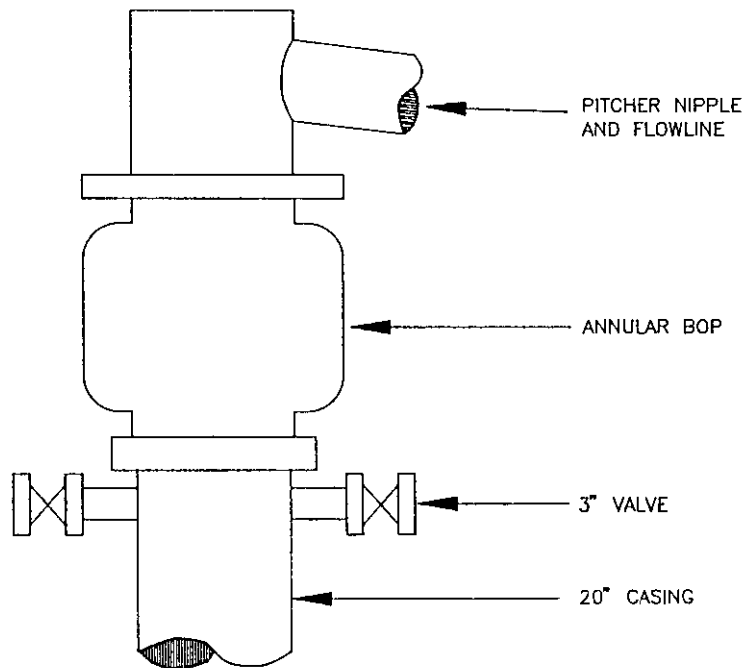
PRODUCTION WELL CASING DESIGN

DATE 3/28/90

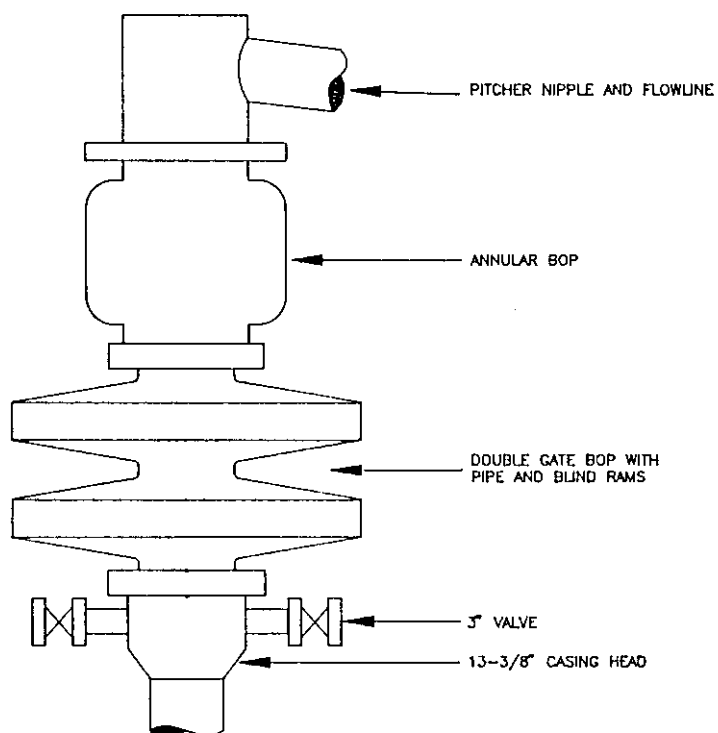
REV. 1

BY W. TOPLOW

FIGURE NO. 4



PUNA GEOTHERMAL VENTURE		
20" BOP CONFIGURATION		
DATE 3/26/00		REV. 1
BY W. TEPLow		FIGURE NO. 5



PUNA GEOTHERMAL VENTURE

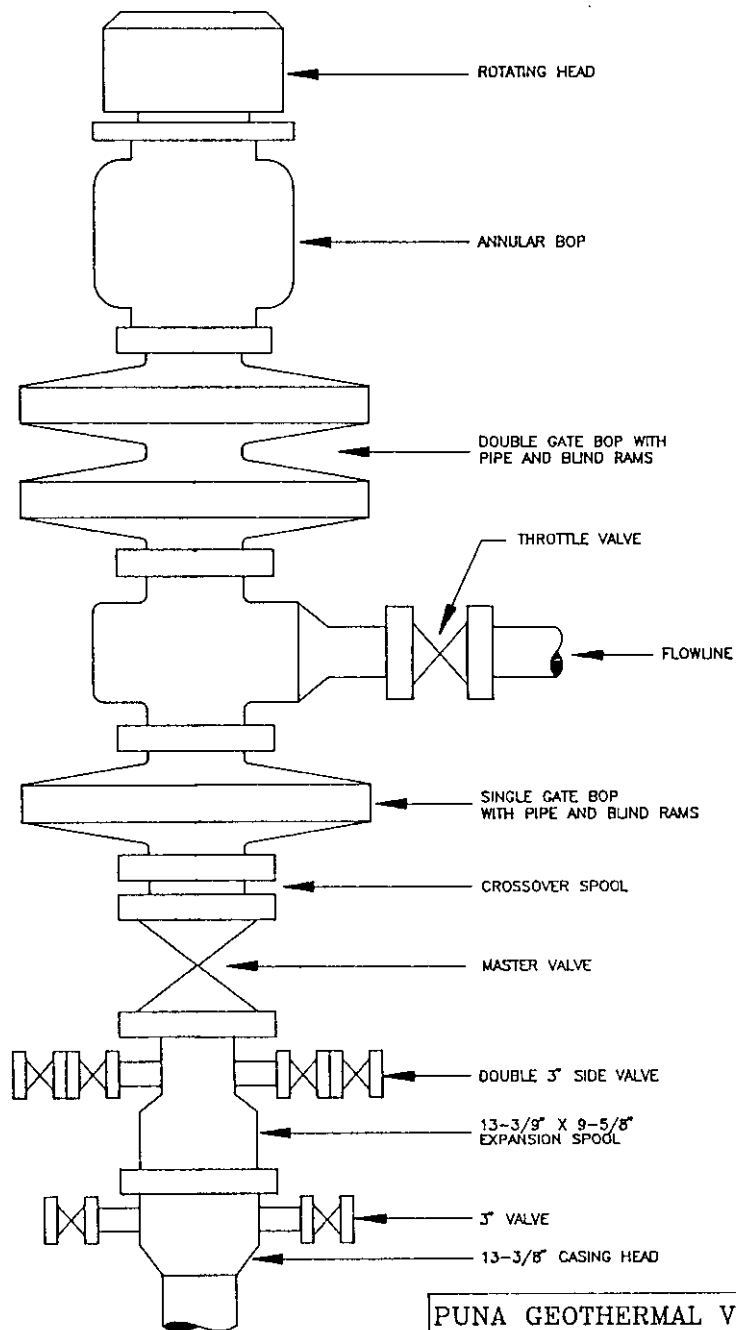
13-3/8" BOP CONFIGURATION

DATE 3/26/90

REV. 1

BY W. TELOW

FIGURE NO. 6



PUNA GEOTHERMAL VENTURE

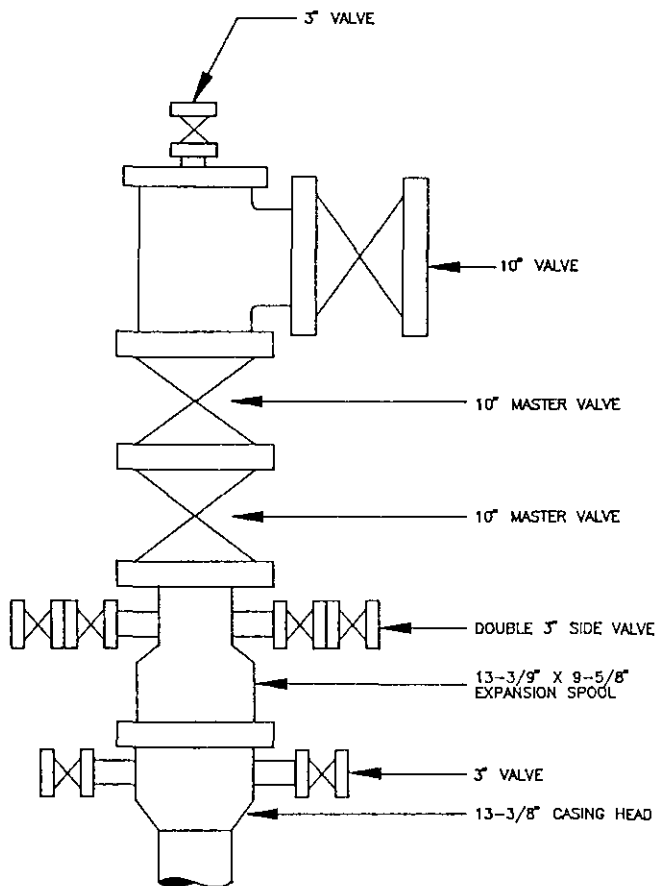
9-5/8" BOP CONFIGURATION

DATE 3/26/90

REV. 1

BY W. TELOW

FIGURE NO. 7



PUNA GEOTHERMAL VENTURE

PRODUCTION WELLHEAD CONFIGURATION

DATE 3/28/90

REV. 1

BY W. TEPLOW

FIGURE NO. 8