DAVID Y. IGE
GOVERNOR OF HAWAII

FILE COPY

KEITH YAMAMOTO
DIRECTOR OF HEALTH

Initials ___ 12/18/14
Mailed Out DEC 22 2014

STATE OF HAWAII
DEPARTMENT OF HEALTH
P.O. Box 3378
HONOLULU, HAWAII 96801-3378

In reply, please refer to:
File:

14-948E CAB
File No. 0008-02

December 22, 2014

Mr. Cliff Townsend
Plant Manager
Puna Geothermal Venture
P.O. Box 30
Pahoa, Hawaii 96778

Dear Mr. Townsend:

**Subject: Notification of Commencement to Drill Kapoho State 16 (KS-16)
Noncovered Source Permit No. 0008-02-N
Attachment IIB, Special Condition No. E.1**

The Department of Health, Clean Air Branch (CAB), acknowledges receipt of your drilling program for production well KS-16 dated December 4, 2014, and additional information received on December 17, 2014.

The CAB has reviewed the drilling program and has no objections. The drilling program is hereby approved. Please note that Puna Geothermal Venture is still required to comply with all conditions of Noncovered Source Permit No. 0008-02-N during the drilling of production well KS-16.

If you have any questions, please call Mr. Darin Lum of my staff at (808) 586-4200.

Sincerely,

NOLAN S. HIRAI, P.E.
Manager, Clean Air Branch

DL:dh

c: Ed Yamamoto, EHS – Hilo
CAB Monitoring Section

PUNA GEOTHERMAL VENTURE

HAWAI'I

CL

DEC - 8 2014

DK POSTMARK

FL DEC 04 2014

December 4, 2014

Darin Lum
Clean Air Branch
Environmental Management Division
Hawaii Department of Health
P.O. Box 3378
Honolulu, HI 96801

**SUBJECT: NOTIFICATION OF COMMENCEMENT TO DRILL KAPOHO STATE 16 (KS-16)**

Dear Mr. Nagamine:

In accordance with the Noncovered Source Permit (NSP) No. 0008-02-N, Attachment IIB, Section E.1, Puna Geothermal Venture (PGV) hereby submits its written plan in accordance with said provision. PGV intends to drill production well KS-16 January 3, 2015 or shortly thereafter.

PGV requests approval from the Hawaii Department of Health (HDOH) for the plan outlined above.

Should you have any questions or need additional information, please do not hesitate to contact me at (808) 965-2838.

Sincerely,

Keoki Wells, EH&S coordinator for Cliff Townsend, Plant Manager

Enclosures: KS-16 Drilling Plan

Post Office Box 30 • 14-3860 Kapoho-Pāhoa Road
Pāhoa, Hawai'i 96778
Tel (808) 965-6233 • Fax (808) 965-7254
PunaGeothermalVenture.com
an ORMAT company

MD 28469

DEC - 8 2014

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DEC 04 2014

# PUNA GEOTHERMAL VENTURE

**PUNA GEOTHERMAL VENTURE**
**14-3860 Kapoho Pahoa Rd.**
**Pahoa, Hawaii HI 96778**

# DRILLING PROGRAM
# PUNA WELL KS-16
# NOVEMBER 2014

MD 28469

# ORMAT NEVADA INC.
# DRILLING PROGRAM PROJECT DESCRIPTION
CONCEPTUAL PRODUCTION WELL KS-16
Puna Field, Hawaii

## I. PROJECT DESCRIPTION

### A. Introduction and Location

Puna Geothermal Venture (Ormat) proposes to conduct a production well drilling program, on lands leased in the Puna field, Hawaii. The proposed drill site is located in an active geothermal project that generates electricity. The purpose of this proposed drilling program is to locate, drill, complete, test, and produce geothermal resources at this site.

Ormat proposes to do the following: (1) directionally drill new production well to a total depth of approximately ±6120 feet (ft); (2) measure the well's temperature profiles; and (3) utilize the well to produce geothermal fluids.

If the well is unsuccessful, it will be redrilled. Ormat anticipates drilling to commence as soon as the rig is available to move onto the location.

The general location of the well is shown on Figure 1. The actual location will be surveyed. Figure 2 depicts the proposed design for the new production well.

### B. Proposed Well Sites and Access Roads

The proposed well site is located on fee land leased by Ormat in the Puna geothermal field. The actual location will be surveyed after the 30-in. conductor is cemented. The well site and access road have been selected to minimize surface disturbance, reduce environmental issues, and make the best use of the existing site access with in the limitation of testing a known geothermal target. The proposed well site is believed located such that optimum quality resource can be obtained with a minimum amount of surface disturbance.

1. Clearing: At the selected site, the existing pad will be extended approximately 100 ft eastward. This extension area will be cleared of organic material, brush, and top soil. All of this material will be stockpiled separately for reclamation of a portion of the pad at conclusion of drilling, testing, and utilization activities.

2. Earthwork: Cut and fill slopes have been minimized in the site location process.

3. Drainage: The site will be graded to direct runoff from the pad into the cellar which will be pumped to the containment basin. Therefore, incidental or accidental uncontrolled spills of oil, fuel, and drilling fluids will be prevented from leaving the site.

4. Containment Basin: Exists on the pad. Contaminated mud and cuttings will be temporarily stored in this basin.

5. Well Sites Access: The access road to the well site will be improved as necessary.

6. Water: Water will be used for site construction, dust control and drilling. Water will be obtained from the on site water well.

C. Drilling Process

The hole will be drilled with a normal rotary drilling rig such as those previously used in the Puna field, Hawaii. The rig will be equipped with diesel engines, storage tanks, mud pumps, and other typical auxiliary equipment. During drilling, the top of the derrick will be approximately 175 ft above ground level.

The drilling program involves rigging up a rotary drilling rig with associated equipment to drill a 36-in. hole to approximately ±105 ft and to cement a 30-in. conductor in place. A 26-in. hole will be drilled to approximately ±1025 ft KB. Casing (20-in.) will be cemented in place and blowout prevention equipment (BOPE) installed. After testing the BOPE, a 17-1/2-in. hole will be drilled to approximately ±2525 ft KB and 13-3/8-in. casing containing a swell packer cemented in place. Following installation and testing of the BOPE, a 12-14-in. hole will be drilled to a total depth of approximately ±5000 ft KB. A 9-5/8-in.liner will be hung from ±2325 ft KB to approximately 5000 ft and cemented. An 8-1/2-in. hole will then be drilled to ±6120 ft KB (TD) and a 7-in. slotted liner hung from ±4900 ft KB to near bottom. A bridge plug will set at ±2400 ft, then a 9-5/8-in. Tie Back liner will ran from the surface to ±2325 ft KB and cemented. The bridge plug will be removed and the rig will be rigged down and released.

The hole will be drilled using a gel-based mud or gel and polymer drilling fluid to circulate the rock cuttings to the surface where they are removed. The mud will then be recirculated. The cuttings will be captured in the containment basin. See Appendix A for details of the proposed drilling program.

D. Blowout Prevention Equipment (BOPE)

A 21-1/4-in. 2M API annular preventer and 21-1/4-in. double gate will be used below ±1025 ft to ±2525 ft (Figure 3). A 13-5/8-in. 5M double gate with pipe and blind rams along with an annular preventer with rotating head will be used below ±2525 ft to total depth (Figure 4).

E. Personnel Requirements

Approximately 9 to 18 workers will be on location at any given time. The drilling crews will not be living on location.

F. Abandonment Program

The hole will be abandoned as directed by the regulatory agencies.

## II. PROTECTION OF THE ENVIRONMENT

All Ormat and drilling contractor personnel will be informed of Ormat's policy regarding undue degradation of the environment. These measures are intended to prevent all unacceptable impacts from occurring as a result of these drilling operations.

A. Fire Prevention

The well site and access road will be cleared of all vegetation. The cleared area will be maintained during drilling operations. Fire extinguishers will be available on the sites and around the drilling rig. Water that is used for drilling will also be available for fire fighting.

Personnel will be allowed to smoke only in designated areas. Any special permits required for welding and etc., will be applied for.

B. Prevention of Soil Erosion

Minimal soil erosion problems are anticipated from this project because cut and fill slopes have been minimized throughout the location of the hole and access road. In addition, runoff will be channeled to energy dissipaters to minimize erosion.

C. Surface and Ground Water Quality Protection

The locations of the operation have been selected to minimize the potential for surface water pollution from runoff during construction, drilling, and testing.

Surface water and ground water pollution from drilling and testing will be prevented by steel casing cemented to below these zones.

Only non-toxic, non-hazardous drilling mud constituents will be utilized during drilling operations. Waste drilling mud and drill cuttings will be stored in the lined containment basin. Any runoff from the sites will be discharged into the containment basin.

The well will be cased and cemented to prevent interzonal migrations of fluids and reduce the possibility of blowouts. Based on the water levels observed at the Puna production and injection wells, no over-pressured or gas-rich zones are expected to be above 2525 ft. Below 2525 ft, pressures encountered may be as high as 1600 psig.

D. Air Quality Protection

Fugitive dust generation during construction and use of access road and well site will be minimized by watering as necessary. Ormat will comply with any requirements concerning emissions of air pollutants from drilling equipment and non-condensable gases from the geothermal fluid during flow testing.

To limit $NO_x$ emissions to less than 250 pounds per day, the total diesel fuel consumption will not exceed an average of 1000 gallons per day. Discharge of hydrogen sulfide ($H_2S$) into the atmosphere will not exceed more than 2.5 kilograms per hour. If $H_2S$ emissions exceed this limit, abatement equipment and technology will be utilized.

E. Prevention of Noise

To abate noise pollution, mufflers will be utilized on engine-driven equipment.

F. Protection of Public Health and Safety

In addition to the emergency contingency plans (See Appendix B), public health and safety will be protected through instructions to work crews and contractors regarding compliance with regulations.

G. Protection of Fish, Wildlife, and Botanical Resources

Direct impacts to wildlife habitat and botanical resources will be limited because the well site exists. Fish habitats will be protected through prevention of erosion.

H. Protection of Cultural Resources

The drilling site will be monitored for cultural resources.

I. Waste Disposal

A containment basin is located on the drilling pad and all used mud and cuttings will be contained in this basin.

After drilling operations are complete, the mud and associated drilling liquids will be allowed to evaporate.

Solid waste materials (trash) will be deposited at an authorized landfill by a disposal contractor.

Portable chemical sanitary facilities will be used by all personnel. These facilities will be maintained by a local contractor.

J. Environmental Monitoring

Regular, routine visual inspections of the drill sites and access road will be conducted by the on-sites operational personnel to quickly detect and correct any operational problems that could lead to environmental problems. The drilling fluid and cuttings will be monitored by visual inspection and chemical analyses by the drilling personnel, the well-site geologist, and the contract mud engineer to detect any problems which may be occurring downhole.

The Puna Environmental Specialist will monitor and inspect the operations, if necessary, during the course of the project.

# APPENDIX A

## DRILLING PROGRAM

CONCEPTUAL NEW PRODUCTION WELL KS-16

Puna Field, Hawaii

ORMAT NEVADA INC.

NOVEMBER 2014

ORMAT NEVADA INC.

# CONCEPTUAL DRILLING PROGRAM

PRODUCTION WELL KS-16

Puna Field, Hawaii

(All depths referenced to KB unless specified)

Location: UTM Coordinates (NAD 83) E301618 N2154746

Ground Elevation: 620 ft MSL
KB: 25 ft above ground

Objective: Drill a new geothermal production well in the Puna field, Hawaii

Status: New Well

Regulatory Agency: State of Hawaii Dept. of Land and Natural Resources

1. Level the existing pad as needed. The area adjacent to the pad contains a containment basin. Extend the pad 100 ft eastward. The pad must be constructed to standard industry specifications that include soil compaction suitable to support the rig gross dead-weight plus 750,000 pounds of live loads, and capable of supporting heavy and frequent traffic. The pad must be contoured to drain into the cellar from the area around the rig. A fence will be installed around the basin on three sides away from rig.

2. Install a concrete cellar according to the rig specifications with an 6 ft depth.

3. Move in (MI) and rig up (RU) a rat hole drilling rig. Dig a 48-in. hole to 80 ft below ground. Run 80 ft of 30-in. 0.625-in. wall Grade B PEBFW linepipe for conductor (Figure 2). Center conductor. Cement conductor in tension with 10 cu yd of ready-mix. Two percent calcium chloride ($CaCl_2$) may be utilized depending on air and ground temperature. If used, $CaCl_2$ must be added at sites to prevent solidification during transport. The next day, determine top of cement. If required, dump additional cement until it is within 5 ft of the surface.

4. Rig down (RD) and move out rat hole drilling equipment.

5. Move in rotary drilling rig and associated drilling equipment. Rig up all equipment.

6. Post well sign, all applicable permits and emergency telephone numbers at the rig. All drill pipe, drill collars, and cross-overs must have passed an IADC-API Class II inspection since last used.

7. Move in and RU mud logging unit that includes a two-sensor hydrogen sulfide alarm system. Hydrogen sulfide sensors will be placed on rig floor and at the mud return pit.

8. Install direct communications between rig floor, tool pusher, mud loggers, mud engineer, and company man.

9. Hold safety meeting regarding equipment, procedures for well control, hydrogen sulfide, general safety, and environmental protection. At meeting, discuss drilling program, geological prognosis, directional program, chain of command, emergency procedures including telephone numbers, and other issues related to previous wells drilling performance. Drilling Supervisor and Pusher must complete rig safety inspection form (Appendix F). **The rig will not be allowed to spud until both the Drilling Supervisor and Pusher have signed the Safety Inspection** form.

10. Line up water supply line to the mud pits and water storage. Mix spud mud in the pits. Drill rat and mouse hole to drilling rig specifications. .

11. Weld the 30-in.flow nipple with flow line and connect to the shakers. Weld 2-in. fill up line. Weld 3-in. valve 1 ft. above floor of cellar for drainage. Ensure that all mud cleaning equipment is in good running condition.

12. Make up (MU) 26-in. drilling assembly. Run jars in all assemblies. Run into hole (RIH) and drill 26-in. hole with gel-based mud (see Mud Program) to ±1025 ft. Collect, wash, and bag three sets of rock cuttings every 10 ft. if circulation permits. Take directional surveys every 90 ft and keep well deviation within 2° total deviation and dog leg to less than 0.5°/100 ft over the 26-in. hole interval. Final casing point will be determined by well sites geologist. If significant lost circulation occurs, cure with lost circulation material (LCM). Continuously monitor well for flow and gases

13. At 26-in. total depth (TD) condition mud and hole for casing. Circulate hole clean and wipe the hole. Circulate the hole clean and POH for casing.

14. RU casing crew. Drift test and visually inspect casing and threads. Run ±1025 ft of 20-in. 94# K-55 BTC casing with stab-in float collar, 40 ft. shoe joint, and float shoe. Have casing measured to reach 3 to 5 ft. off bottom. Tack weld bottom three joints of casing. Centralize casing at 5 ft. above shoe and 5 ft. above float and every third joint to 30-in. shoe. <u>DO NOT RUN CENTRALIZERS INSIDE 30-IN. CASING.</u> Do not exceed running speed of one joint per 30 seconds to prevent surge. Fill casing with mud while

running to overcome buoyancy. Have the 20-in. circulating swedge on the rig floor. Reciprocate casing while circulating and conditioning mud prior to cement job. Rig down (RD) casing crew.

15. RU cementing unit. Centralize and set the casing in the slips and trip in the hole with centralizers on the. drill pipe (DP). Rabbit the drill pipe as it is picked up prior to running in the hole. Stop 2 ft. from float collar, circulate 2 barrels (bbls) per minute for 2 minutes, shut off pump, and stab into float collar with stab-in stringer. Circulate the hole clean and cool down the well. **ENSURE THAT CASING IS PROPERLY CENTERED BEFORE PUMPING CEMENT. SECURE CASING AS NEEDED TO PREVENT FLOATING DURING CEMENT JOB.** Pump 40 bbls of water. Pump 20 bbls of mud clean. Pump 30 bbls of 10.5 ppg sepiolite spacer. Pump 5 bbls of water. Pump 13 bbls of Flow Check. Pump 5 bbls of water. Pump 1500 cu ft of 13.0 ppg Premium Cement with 30% silica flour SSA-1, 10% Micro-silica 10 #/sk Spherelite, 3% calcium chloride, and normal chemicals mixed with fresh water,. Pump 231 cu ft. of 15.0 ppg Premium cement with 30% silica flour, SSA-1, 10% Micro-silica mixed with fresh water, and normal chemicals. Monitor returns throughout the job. If lead cement returned to surface then switch to tail cement. If no returns to surface then pump 150% excess cement and then switch to tail. Pump displacement. Check if floats are holding while stabbed in. POH with stab in tool. **The estimated static temperature at 1025 ft is 90°F.** Record start of pumping time and time of cement returns. Keep water out of 20-in. x 30-in. annulus. RD cementing unit.

***Note***Slurry Design is for 125°F bottom hole static temperature (BHST), $CaCl_2$ or retarder may be required if BHST changes***

16. Wait on cement (WOC) until cement samples at surface have hardened or 12 hours after initial cement job. Tag top of cement in annulus after six hours with 1-1/2-in. tremie pipe. If cement has fallen, perform top cement job utilizing tail cement with 30% silica flour, 10% Micro-silica mixed with fresh water, 3% CaCl2 and 0.5% Halad-344, if necessary. Wait six hours and repeat top job if necessary.

17. Cut off 30-in. conductor pipe to 6-in. above cellar floor (Check with Gary Dahl to confirm cut off depths ). Cut off 20-in. casing 49-in. above the ground level for space for proper positioning of the BOPE stack. Weld on 21-1/4-in. 2M by 20-in. casinghead with two 3-1/8-in. 5M flanged side outlets on the 20-in. casing utilizing API 5CT welding specifications for grade K-55 casing. Nipple up BOPE per Figure 4.

18. Test annular and rams, side outlet valves, and choke manifold to pressure specified by HI Dept .of Land and Natural Resources. Log tests on tour sheets.

19. MU 17-1/2-in. slick drilling assembly. Cleanout top of float collar and pressure to pressure specified by HI Dept. of Land and Natural Resources. Drill out the float collar half way down the shoe track and pressure test to pressure specified by HI Dept.of Land

and Natural Resources.

20. Drill out cement to 1 ft. below shoe. If "bad" cement is encountered at shoe, conduct leak-off test to a 0.65 psi/ft. gradient at shoe. If test fails, squeeze cement using tail cement mixture and rerun leak-off test until successful. Drill a 17-1/2-in. hole to ±90 ft. below shoe. POH.

21. MU 17-1/2-in. stabilized drilling assembly with float and drill to approximately ±2525 ft. Use flex subs below the drilling jars, and make sure to have shock tools, and drilling jars on all bottom hole assemblies (BHA)'s. If significant lost circulation occurs, attempt to cure with PREMA SEAL if LCM does not work drill until a cement plug is required, use the 20-in. tail mixture.

22. Turn mud cooler on before flow line temperature exceeds 110°F. Be prepared to set casing if there are any signs of encountering a high temperature reservoir. Catch 10 ft. samples of drill cuttings and monitor for changes in mineralogy indicative of high temperature geothermal reservoir. Continuously monitor well for flow and gases.

23. Run all solids control equipment as needed. Use coarse shale shaker screens if necessary to handle 750 – 850 gpm circulation rates.

24. Function Test BOPE every time a trip is made.

25. Condition hole for casing.

26. Wash and ream hole to bottom. Monitor well and make sure well takes proper amount of fluid. Casing point is to be decided by well site geologist,

27. RU casing crew. Drift test casing and visually inspect threads. Run ±2525 ft of 13-3/8-in. 72 lb./ft. L-80 DWC TC casing with swell packer, stab-in float collar and float shoe. Swell packer must be located inside the 20-in. casing. Centralize casing at 5 ft above shoe and 5 ft above float and every third joint up to 20-in. shoe. DO NOT RUN CENTRALIZERS INSIDE 20-IN. CASING. Tack weld bottom three joints. Do not exceed running speed of one joint per 30 seconds to prevent surge. Fill casing with mud while running to overcome buoyancy. Center the casing in the rotary table. Rig down (RD) casing crew.

28. RU cementing unit. RIH with 5-in. drill pipe with stab-in stringer and pump 2 bbls to clear the stab in string prior to stabbing in. Stab into float collar and circulate until the well is cool enough to cement. Pump 20 bbls of water. Pump 30 bbls of foamed water. Pump 13 bbls of Flow Check. Pump 5 bbls of water. Pump 722 cu ft of 10 ppg foamed premium cement with 30% silica flour SSA-1, 10% Micro-silica mixed with fresh water, 1.5 gal Latex per sk, and normal chemicals. Pump 2627 cu ft of 11 ppg foamed premium

cement with 30% silica flour SSA-1, 10% Micro-silica mixed with fresh water, 1.5 gal Latex per sk, and normal chemicals. Pump 228 cu ft of 15 ppg premium cement with 30% silica flour SSA-1, 10% Micro-silica mixed with fresh water, and normal chemicals Pump 321 cu ft of 13.5 ppg premium cement with 30% silica flour SSA-1, 10% Micro-silica mixed with fresh water, 1.5 gal Latex per sk, and normal chemicals The estimated static temperature at 2525 ft is 300°F, however circulating temperature will be much lower.

**Obtain bottom hole temperature from directional tools and compare to mud logging surface temperature prior to mixing cement.**

Monitor returns throughout the job. Record time start of pumping and of cement returns. RD cementing unit.

29. Displace cement with mud. Check if float is holding while stabbed in. Pull out of hole with stab in tool. Keep water away from 13-3/8-in. x 20-in. annulus.

30. Wait on cement (WOC) until cement samples have hardened or for at least 8 hours. Tag top of cement in annulus with 1-1/2-in. tremie pipe after six hours. perform top cement job utilizing premium cement with 30% silica flour SSA-1, 10% Micro-silica mixed with fresh water, and necessary chemicals, if necessary. Wait six hours and repeat top job if necessary. (Note: At the discretion of the drilling engineer and supervisor, the top job, if required, may be done by means of a top squeeze.)

31. Lift 21-1/4-in. 2M BOP and make an initial cut on 13-3/8-in. casing. Lay down cut off casing and nipple down BOP. Cut off the 20-in. casing 6-in. above the 30-in. casing (Confirm with Gary Dahl all cut off heights). Cut off 13-3/8-in. casing. Using a qualified welder and proper pre and post weld heat treatment, weld on 13-5/8-in. 5M by 13-3/8-in. SOW casing head with two 3-1/8-in. 5M flanged side outlets utilizing SMAW Welding of API 5CT Type L-80 Steels welding specifications. Test casing head to 1000 psi with nitrogen. Nipple up BOPE per Figure 5. Pressure test BOPE and casing to pressures specified by HI Dept.of Land and Natural Resources. Report all tests on tour sheet and have mud loggers prepare pressure plots.

32. MU 12-1/4-in. drilling assembly. RIH to the top of cement. Pressure test pipe rams to pressure specified by HI Dept.of Land and Natural Resources. Log the test result on the tour sheet and morning report. Clean out to the top of the float collar and pressure test the casing to pressure specified by HI Dept.of Land and Natural Resources. Drill out the float collar and half way down the shoe track and pressure test casing to pressure specified by HI Dept.of Land and Natural Resources. Drill to the top of the casing shoe and pressure test to 0.65 psi/ft. Drill out the cement, perform the shoe test at one ft below shoe. Drill 12-1/4-

in. hole ±70 ft below shoe. POH.

33. Make up 12-1/4-in. stabilized drilling assemble. RIH and drill to ±3200 ft. Take directional surveys every 250 ft. Keep well within 50 ft of directional drilling program. POH.

34. MU 12-1/4-in. directional drilling assemble. RIH and directionally drill a 12-1/4-in. hole to ±5000 ft. Use drilling jars, and make sure shock tools and drilling jars are on all BHA's. Take directional surveys as required by directional drilling program and keep well path within 50 ft. of program design. Catch 10 ft. grab samples of drill cuttings. Monitor well for flow changes and for any gas flows. Keep close watch on samples for changes in mineralogy indicative of high temperature geothermal reservoir. Run liner earlier if there are any signs of high temperature reservoir. Rotate through all slide sections prior to making connections.

35. Function test BOPE on every trip. In case of total losses or after the direction and angle has been established, pull out of hole with directional BHA and continue drilling ahead to TD with conventional rotary locked BHA

36. Circulate and condition hole for casing. POH.

37. RU casing crew. Drift test liner and visually inspect threads. Run ±2675 ft of 9-5/8-in. 53.5 lb./ft. T95 V&M CDC TC liner, tie back hanger, float shoe, and stab-in float collar Keep water running into hole. Hang liner ±2325 ft. Make up the liner hanger adapter and run liner in the hole on drill pipe. Release the liner hanger and pull out of hole. Do not exceed running speed of one joint per 30 seconds. RD casing crew.

38. RU cementing unit. RIH with 5-in. drill pipe with stab-in stringer and pump 2 bbls to clear the stab in string prior to stabbing in. Stab into float collar and circulate until the well is cool enough to cement. Pump 50 bbls of water. Pump 20 bbls of 8.5 ppg mud cleaner. Pump 30 bbls of 10.5 ppg sepiolite mud cleaner. Pump 5 bbls of water. Pump 13 bbls of Flow Check. Pump 5 bbls of water. Pump 1226 cu ft of 13.5 ppg premium cement with 30% silica flour SSA-1, 10% Micro-silica mixed with fresh water, with retarder, free water polymer, and normal chemicals. Pump 228 cu ft of 15.0 ppg premium cement with 30% silica flour SSA-1, 10% Micro-silica mixed with fresh water, retarder, free water polymer, and normal chemicals. The estimated static temperature at 5000 ft is 500°F, however circulating temperature will be much lower.

**Obtain bottom hole temperature from directional tools and compare to mud logging surface temperature prior to mixing cement.**

Monitor returns throughout the job. Record time start of pumping and of cement returns. RD cementing unit.

39. Displace cement with mud. Check if float is holding while stabbed in. Pull out of hole with stab in tool.

40. Wait on cement (WOC) until cement samples have hardened or for at least 8 hours.

41. MU 12-1/4-in. stabilized drilling assemble. RIH and clean out cement to top of liner hanger Pressure test liner lap to 500 psig. If test fail, squeeze cement. POH.

42. MU 8-1/2-in. stabilized drilling assemble. RIH and clean out cement to 100 ft below liner top Pressure test liner lap to 500 psig. If test fail, squeeze cement. RIH and clean out cement to 1 ft below shoe. Pressure test shoe to 0.65 psi/ft. Drill 8-1/2-in. hole to ±5070 ft. POH.

43. MU 8-1/2-in. directional drilling assemble. RIH and directionally drill a 8-1/2-in. hole to ±6120 ft. Circulate hole and prepare mud for liner. TD will be decided by well site geologist. Keep hole within 50 ft of directional program. POH.

44. RU casing crew. Drift test liner and visually inspect threads. Run ±1000 ft of 7-in. 26 lb./ft. L-80 CBCD TC with liner hanger and guide shoe. Keep water running into hole. Make up the liner hanger adapter and run liner in the hole on drill pipe. Hang liner ±4900 ft. Release the liner hanger and pull out of hole. Do not exceed running speed of one joint per 30 seconds. POH.

45. MU 9-5/8-in. cast iron bridge plug. RIH and set bridge plug at ±2425 ft. POH.

46. RIH with open ended drillpipe to ±2425 ft. Pump 8 cu ft of sand. Tag sand at ±2440 ft. POH to ±2430 ft. Pump 20 bbls of tail cement. POH to 2000 ft. Wait for 6 hrs and RIH and tag cement. POH.

47. Drift test liner and visually inspect threads. Run ±2325 ft of 9-5/8-in. 53.5 lb./ft. T95 V&M DWC Tie Back liner with hanger and stab-in adapter. Keep water running into hole. Stab into tie back receptacle on top of liner hanger. Hang liner from wellhead. Release the liner hanger and pull out of hole. Do not exceed running speed of one joint per 30 seconds.

48. Rig up cementing unit. RIH to bottom of 9-5/8-in. Tie Back liner. Pump 50 bbls of water. Pump 963 cu ft of Premium cement with 30% silica flour, 10% Mirco-lite, retarder, free water polymer, and normal chemicals. Displace cement with mud. POH.

49. Wait on cement for 12 hours. RIH and clean out cement and sand. Drill up bridge plug and push to bottom. **NOTE High Pressure Steam and Gas may exist below the Bridge Plug.**

50. POH and lay down drill pipe. Keep water running into hole.

51. Close master valve. Nipple down BOPE.

52. RD mud logging unit. RD and release drilling equipment.

53. Chain and lock wellhead valve.

54. Measure temperature profiles at times specified by reservoir engineer.

# MUD PROGRAM

NEW PRODUCTION WELL KS-16
Puna Field, Hawaii

Use low solids non-dispersed mud with additives as necessary for system control. The following parameters should be maintained:

## 0-±5900 ft

Mud Weight: <9.0 pounds per gallon unless it is necessary to weight up to control artesian flow.

| | |
|---|---|
| Viscosity: | 36 to 40 |
| API FL: | 8 to 10 |
| PV: | 9 to 12 |
| YP: | 7 to 15 |
| Initial Gel: | 3 to 6 |
| pH: | 10 |

Mud Cleaning Equipment: Mud Cleaner. Continuously use mud cleaning equipment to remove solids.

Maintain sufficient barite on location to control well at all times. Monitor well for flow, $CO_2$, and $H_2S$ at all times and increase mud weight to control. Maintain $H_2S$ control chemicals on site.

# APPENDIX B

## EMERGENCY PLANS
NEW PRODUCTION WELL KS-16
Puna Field, Hawaii

ORMAT NEVADA INC.
NOVEMBER 2014

ORMAT NEVADA INC.

# EMERGENCY PLANS

A. Injury Contingency Plan

1. In the event injuries occur in connection with an Ormat Nevada (Ormat) operation, specific and immediate attention will be given to proper transportation to a medical facility.

Ambulance
911

Paramedics
911

Hilo Hospital
(808) 974-4729

B. Blowout Contingency Plan (Also see Blowout Action Plan)

Blowout prevention equipment will be kept in operating condition and tested in compliance with Hawaii regulations and industry standards.

In addition, cold water and barite will be stored at the well site for use in killing the well in case of an emergency.

In the event of an emergency, such as a blowout, immediate efforts will be taken to shut surface valves and blowout preventer system.

If the means to shut-in or control the flow from the well is lost, the Drilling Supervisor is to:

1. Initiate appropriate control procedures.

    1. Arrange for any injured persons to be taken by the fastest transportation available to the nearest medical facility, as shown in the Injury Contingency Plan.

    2. Secure and maintain control of access roads to the area to eliminate entry of unauthorized personnel.

3. Contact the Project Manager and advise of the situation. The Drilling Supervisor will follow the same procedures stated in the Spill or Discharge Plan.

4. Initiate any further or supplemental steps that may be necessary or advisable, based on consultation with the Project Manager.

5. Be certain that all safety practices and procedures are being followed and that all members of the drilling crew are performing their assigned duties correctly.

6. Attempt to control the well at the rig site with rig personnel and supervisors.

7. If fluid flow is of an uncontained nature, attempt containment with required equipment by constructing sumps and/or dikes as rapidly as possible and as needed.

8. Attempt to construct and/or fabricate and install any wellhead facilities require to contain fluid flow at the well or casing head.

9. Maintain a continuing inspection of the pad area immediately around the well site subject to erosion that may cause failure to the drilling rig structure. Take necessary steps to avert areas of possible erosion by excavation and rebuilding of the area as necessary.

10. Following complete containment of the well, initiate steps to return the area to its normal state prior to the blowout or fluid flow, such as reseeding with similar and approved vegetation.

C. Fire Contingency Plan

1. Any small fires which occur around the well pad during drilling and/or testing operations should be able to be controlled by rig personnel utilizing on-site firefighting equipment.

2. A roster of emergency phone numbers will be available on-site so that the appropriate firefighting agency can be contacted in case of a fire.

D. Spill or Discharge Contingency Plan

1. Potential Sources of Accidental Spills or Discharges

a. Geothermal Fluid

Accidental geothermal fluid spills or discharges are very unlikely because the hole will be cased and blowout prevention equipment will be utilized. However, accidental discharges or spills could result from any of the following:

(1) Loss of well control (blowout)

2. Drilling Muds

Muds are a mixture of water, non-toxic chemicals and solid particles used in the drilling operations to lubricate and cool the bit in the hole, to carry cuttings out of the hole, to maintain the hole condition and to control formation pressure. Drilling muds are prepared and stored in metal tanks at the drilling site. Waste drilling mud and cuttings are discharged into the reserve pit, which is open and is adequately sized to hold the volume necessary for the operation. Accidental discharges of drilling mud are unlikely, but could occur by:

(1) Overflow of the reserve pit.

(2) Reserve pit wall seepage or wall failure.

(3) Discharge from equipment failure on location.

(4) Shallow lost circulation channeling to the surface.

3. Lubricating or Fuel Oils and Petroleum Products

A discharge of this type would probably be very small and be from equipment used in the field. Potential locations for accidental spills are:

(1) Drilling equipment and machinery at and around the drilling location.

(2) Other miscellaneous equipment and machinery at well site and roads.

4. Construction/Maintenance Debris

Typically a minor consideration, one which is usually able to be cleaned up on the job. Potential locations are the same as for lubricating or oils listed in Item 3, above.

2. Plan for Cleanup and Abatement

In the event of discharge of formation fluids, drilling muds, petroleum products or construction debris, the person responsible for the operation will make an immediate investigation, then contact the Drilling Supervisor and advise him of the spill. The

Drilling Supervisor will in turn call out equipment, regulate field operations, or do other work as applicable for control and clean-up of the spill, as follows:

1. Action - Small, Containable Spill

   If the spill is small (i.e., less than 250 gallons) and easily containable without endangering the watershed, the Drilling Supervisor will direct and supervise complete cleanup and return to normal operations.

2. Action - Large or Uncontainable Spill

   If the spill is larger than 250 gallons, or is not easily contained, or endangers, or has entered the watershed, the Drilling Supervisor will proceed to take necessary action to curtail, contain and clean up the spill, as above, and notify personnel as listed below.

3. Notification

   (1) The Drilling Supervisor will, as quickly as practicable:

   - Call out contractor(s), as required.
   - Notify the Ormat Project Manager.
   - Notify the local law enforcement agencies if the public safety is threatened.

   The Drilling Supervisor will also advise local population and affected property owners if spill affects residents or property.

4. Specific Procedures

   1. For geothermal fluid spills:

      Contain spillage with dikes if possible and haul to disposal site by vacuum or water trucks or dispose of in a manner acceptable to the Dept. of Land and Resources.

   2. For drilling mud:

      Repair sump or contain with dikes. Haul liquid to another sump, available tanks or approved disposal site.

   3. For petroleum products:

Contain spill with available manpower. Use absorbents and dispose of same in approved disposal area.

For (1) through (3) above, Ormat will have the source of spill repaired at the earliest practical time, and continue working crews and equipment on cleanup until all concerned agencies are satisfied.

5. Confirm telephone notification to agencies and regulatory bodies. Telephone notification shall be confirmed by the Ormat Project Manager in writing within two weeks of telephone notification.

   Written confirmation will contain:

   i. Reason for the discharge or spillage.

   ii. Duration and volume of discharge or spillage.

   iii. Steps taken to correct problem.

   iv. Steps taken to prevent recurrence of problem.

E. Hazardous Gas Contingency Plan

1. There is a very limited possibility of encountering hazardous non-condensable gases while drilling and testing. Although noxious or dangerous amounts of gases have not been associated with other geothermal wells drilled in the area, it is prudent to be prepared. The three main gases expected in this area are steam, hydrogen sulfide ($H_2S$), and carbon dioxide ($CO_2$).
2. The effectiveness of this plan is dependent upon the cooperation and effort of each person who enters the site during drilling or testing operations. Each person must know their responsibilities under stressful emergency operating conditions. All personnel must see that their safety equipment is stored and functional in addition to the location and operation of safety equipment.

3. All personnel will be trained in warning signs, signals, first aid, and responsibilities in case of hazard gases. The site will have two briefing areas so that one is upwind from the well and containment basin at all times. Before drilling or testing commences, all personnel will be advised of escape routes. **Weekly drills will be conducted.**

4. All vehicles will be parked with the front towards the exit road. A normal size first aid kit, stokes litter, wind direction apparatus, portable hand-held $H_2S$ and $CO_2$ detectors will be available on the location. There will also be $H_2S$ scavenger chemicals on the

location for treating the mud. Warning signs will be posted on the access road to the location.

5. Steam is hot water in the gas form. It causes burns to the skin. It is possible that steam temperatures may exceed 300°F during flow tests. All personnel must stay away and downwind from venting steam. Note water as hot as 220°F may be present in the testing tanks. If a person is burnt, remove them from the site and cool the burnt area. Transport to the hospital.

6. $H_2S$ is a colorless gas with a rotten egg odor in concentrations under 100 ppm. Above a concentration of 100 ppm, $H_2S$ will cause health problems including death (See Table 1). Above a $H_2S$ concentration of 1000 ppm, death is instantaneous. $H_2S$ is heavier than air and will accumulate in low spots. At high concentrations, $H_2S$ is combustible. Automatic $H_2S$ detectors are stationed around the rig. At a 5 ppm concentration, a red light will flash. At this concentration, workers can continue their jobs for 8 hours. At a concentration above 10 ppm, a red light will flash and a warning horn sound. All personnel will immediately assemble at the upwind briefing area except for the driller who will shut the well in. He will then travel to the briefing area. Remember at concentrations above 100 ppm, personnel cannot smell $H_2S$. Hand held detectors will be utilized to determine the $H_2S$ concentration. Depending on the measured concentration, the Company Drilling Supervisor will assign duties.

7. $CO_2$ is a colorless odorless gas. At concentrations above 50000 ppm personnel risk affliction. At concentrations above 5%, $CO_2$ is combustible. The same procedure should be utilized as the $H_2S$ procedure.

8. If a person becomes unconsciousness due to a hazardous gas, do not attempt to remove him without proper protective equipment. **You May Also Become A Victim.** Do not attempt a rescue without proper protective equipment. If you have the proper protective equipment, move the victim to a safe area. If the victim has been affected by $H_2S$ or $CO_2$, apply artificial respiration until the paramedics or onsite medic arrives. Even if the symptoms pass, transport the victim to a hospital and place him under the care of a doctor.

9. After a hazardous gas has been detected, operations will proceed as follows:

A. Condition – **POTENTIAL DANGER**

**$H_2S$ concentration <10 ppm**
**$CO_2$ concentration <5000 ppm**
**STEAM >150°F**

All personnel will be immediately notified of the potential danger. Routine checking of the drilling fluid and monitoring equipment will alert mud loggers of possible danger. The mud loggers will immediately notify the Project Manager, Company

Drilling Supervisor, Tool Pusher, Driller, Test Supervisor, and Mud Engineer. These personnel will immediately notify their crew members. All safety equipment, monitors, and alarms will be checked for correct operating conditions. A review of the emergency program and drills will be conducted before drilling continues.

B. Condition – **MODERATE DANGER**
**$H_2S$ concentration 10 ppm TO 20 ppm**
**$CO_2$ concentration 5000 ppm TO 50000 ppm**
**STEAM >190˚F**

All personnel will be immediately notified of the danger. The mud loggers will immediately notify the Project Manager, Company Drilling Supervisor, Tool Pusher, Driller, Test Supervisor, and Mud Engineer. These personnel will immediately notify their crew members. The Driller will shut in the well if $H_2S$ concentration exceeds 10 ppm. All personnel will meet at the briefing site. Selected personnel will take steps to locate the source of the hazardous gas. Drilling will not proceed until the gas is controlled. All nonessential personnel will be sent upwind and out of the potential danger zone. Gas concentrations around the well will be verified with hand held gas detectors. Access to the site will be limited to authorize personnel only. Warning signs will be posted.

C. Condition – **EXTREME DANGER**
**$H_2S$ concentration >20 ppm**
**$CO_2$ concentration >50000 ppm**
**STEAM >200˚F**

All personnel will be immediately notified of the extreme danger by a honking horn. All personnel will immediately put on their protective gear. The mud loggers will immediately notify the Project Manager, Company Drilling Supervisor, Tool Pusher, Driller, Test Supervisor, and Mud Engineer. These personnel will immediately notify their crew members. The Driller will shut in the well. All personnel will meet at the upwind briefing site for evacuation. The Drilling Supervisor will assess the situation, outline a control program, and assign duties to control the situation. The proper agencies will be notified. Drilling will not proceed until the gas is controlled. All nonessential personnel will be sent upwind and out of the potential danger zone. Access to the site will be limited to authorized personnel wearing protective equipment. Warning signs will be posted to limit access to the site. If the gas cannot be controlled, the Emergency Plan will be initialized.

# PHYSICAL EFFECTS OF HYDROGEN SULFIDE

| CONCENTRATION (ppm) | 0-2 MINUTES | 15-30 MINUTES | 30-60 MINUTES |
|---|---|---|---|
| 10-20 | Rotten egg smell | Detectable | Maximum 8-hour exposure with protective mask |
| 100 | Coughing Loss of smell | Eye pain and Sleepiness | Throat and eye irritation |
| 450 | Eye irritation | Respiration difficult | Serious respiratory disturbance |
| 1000 | Unconsciousness | Death | Death |

# Emergency Personnel and Telephone Numbers

**Fire**

| | | |
|---|---|---|
| Pahoa Fire | (808) 965-2708 | |

**Law Enforcement**

| | | |
|---|---|---|
| Pahoa Police | (808) 935-3311 | |
| | (808) 966-7432 | |

**Hospital**

| | | |
|---|---|---|
| Hilo | (808) 974-4729 | |

**Company Representative**

| | | |
|---|---|---|
| Ormat Nevada Inc. | (775)-356-9029 | (office) |

**Ormat Project Managers**

| | | |
|---|---|---|
| Skip Matlick | (775)-356-9029 | (office) |
| | (562)-693-3966 | (home) |
| | (562)-544-5141 | (cell) |
| James Tennison | (760)-550-3459 | (cell) |
| Brad Peters | (775)-225-2288 | (cell) |
| Cliff Townsend | (808)-965-6233 | (office) |
| | (808)-769-1631 | (cell) |
| Puna Control Room | (808)-965-2832 | |

**Department of Land and Resources**

| | | |
|---|---|---|
| Eric Tanaka | (808)-961-9588 | (office) |

Ormat Nevada
EMERGENCY PLANS

**BLOWOUT ACTION PLAN**

## PREVENTION OF A BLOWOUT

***To Be Posted In Doghouse***

1) Fill drill pipe before attaching a circulating head or Kelly and re-establishing circulation

2) Pull drill pipe from the well at a speed which does not induce swabbing of the fluid from the well or reduction of down hole pressures to less than static formation fluid pressures.

3) Fill well with liquid when pulling the drill string from the well

4) Cool the drilling fluid adequately prior to circulating down the drill string

5) Pump at an adequate rate to cool the well

6) Refrain from pumping a drilling fluid that contains air or gas

7) Use a drilling fluid with adequate density to give down hole pressures in the hole which are more that reservoir fluid pressures at the same depth (i.e. drilling in an over balanced condition).

8) Leave hole or part of the hole filled with fluid which has sufficient density and gel strength to avoid becoming gas cut over a period of time. (e.g. pilot hole during the period required to open the full length of the pilot hole to the desired diameter).

9) Reduce the rate of penetration to allow gas or heat to be circulated out when drilling through softer formations which may contain gas or high temperature fluids.

10) Pump water to the annulus outside the drill string when drilling without fluid returns.

11) Circulate drilling fluid in stages when running drill string into a hot well to remove heat from the well.

# INDICATIONS OF A BLOWOUT

***To Be Posted In Doghouse***

1) Change in the total volume of drilling fluid.

2) Signs of formation gas in the drilling returns.

3) Increase in the temperature of the drilling fluids.

4) Increase in the flow rate of the drilling fluid returns.

5) Rapid increase in penetration rate or a drilling break (where the hole is advanced rapidly with little or no weight being required on the bit).

6) Loss of circulation—Note: When drilling without returns, a deeper loss circulation may be indicated by a rapid loss of pumping pressure.

7) An apparent loss of drill string weight while drilling, which is inconsistent with the rate of feed of the drill string into the well—Note: An influx of hot fluids into the well will cause the drill string to expand resulting in an increase in the weight on the bit.

8) Contamination of the drilling fluids as indicated by reduction in density or increase in dissolved solids.

Ormat Nevada
EMERGENCY PLANS

**BLOWOUT ACTION PLAN**

## GEOTHERMAL KILL PROCEDURES

***To Be Posted In Doghouse***

While drilling a geothermal well the following procedures should be followed in the event that a kick is possible or is occurring.

1) If there is drill string on bottom, pull off bottom to avoid becoming stuck.

2) Ensure that the choke line is open and close an appropriate BOP (i.e. blind rams if there is no drill string in the well, pipe rams if opposite drill pipe, or annular preventer if neither apply).

3) Pump cold water or drilling fluid to fill and cool the well—Note: If the drill string is in the well, pumping down the drill string via the Kelly or a circulating head is more effective than pumping down the annulus.

4) Control the well head pressure by gradually opening or closing the choke line—Note: The wellhead pressure would be limited so as to not exceed the pressure rating of any wellhead component (including casing) nor a pressure which is likely to initiate the breakdown of the formation integrity below the shoe of the deepest cemented casing. Conversely, allowing the wellhead pressure to drop to a low value will allow further influx of gas and het and may induce hole collapse.

5) If pumping of cold water or drilling fluid does not cool and control the well flow, then proceed to follow the steps in the Wait and Weight and Drillers Methods.

***Note: Fluids in a geothermal well (including drilling fluids) will be heated to temperatures significantly above 212°F (100°C). When the pressure on such hot fluids reduces, the water in the fluid will start boiling to steam. The steam will reduce the density of the fluid column in the well causing further reduction in down hole pressures and resulting in boiling of further water. Such boiling can be self-sustaining and accelerate until boiling occurs over most of tor all of the well depth. This phenomenon is distinctly different from the rising, expanding gas bubble considered as the basis for the kick control in oil and gas drilling and BOP operating procedures.***

Ormat Nevada
EMERGENCY PLANS

**BLOWOUT ACTION PLAN**

# WAIT AND WEIGHT METHOD

***To Be Posted In Doghouse***

1. The hole is to be kept full of drilling or completion fluids at all times unless this becomes impossible due to lost circulation.

2. Before starting out of hole with drill pipe or tubing, circulate off bottom until mud is properly conditioned.

3. Close and open pipe rams once per day and log on tour sheet. Pressure test BOPE prior to drilling out of casing shoes and coincident with casing test. Log results on blowout preventer check list.

4. Close blind rams when out of hole and log on tour sheet.

5. Fill hole at five (5) stand intervals or less while pulling drill pipe out of hole. Count pump strokes or use chart attached to the pit volume indicator to determine the volume required to fill the hole.

6. Watch pit flow or pit level indicator when running in the hole to insure that the volume of mud displaced by the drill pipe is not exceeded.

7. The drill pipe will be run in the hole to the shoe of the casing and a TIW valve installed to perform any of the following operations:

    a) Slip or cut drilling line.
    b) Repair equipment (if possible).
    c) Any foreseen delay.

8. Record reduced circulating pressure at 30 strokes per minute (SPM) or other suitable kick control SPM daily and after each bit change.

9. An approved inside blowout preventer and full opening safety valve with wrench must be immediately available on the rig floor.

10. A blowout prevention drill will be conducted by the rig tool pusher under the supervision of the Drilling Supervisor for each drilling crew to ensure that each person is properly trained to carry out emergency procedures. Assign kick control

duties in advance: i.e. mud mixing assigned to floor man, operating pumps assigned to derrick man, etc.

11. At first indication of gain in pit level (or other sign of possible blowout), the driller will immediately do what is necessary to control the well. In most cases this action should be:

While Drilling:

a) Pull kelly up out of rotary table and stop pumps.
b) Open valve(s) on choke line.
c) Close the blowout preventer and gradually reclose choke line.
d) Record shut-in drill pipe ($P_{dp}$) and casing ($P_{cg}$) pressure. Maximum allowable casing pressure to be dependent on casing depth and burst rating. Allowable pressure for each string to be posted and noted in driller's instructions and on well control data sheet.

Inform the Drilling Supervisor and/or precede with appropriate kick control measures as follows in Step 12.

While Tripping:

a) Install full opening safety valve.
b) Open valve on choke(s) line.
c) Close safety valve.
d) Close blowout preventer and gradually reclose choke valve(s).
e) Record shut-in drill pipe and casing pressure.
Maximum allowable casing pressure to be dependent on casing depth, mud weight and burst rating.
f) Inform the Drilling Supervisor. Run drill string in hole as far as practical after first installing inside BOP and reopening safety valve, and/or proceed with appropriate kick control measures as follows in Step 12.

12. Calculate and mix mud of weight necessary to keep well under control using the well control worksheet and attached monograph.

Mud weight increase in lb./gallon =

$$\frac{P_{dp}}{\text{Drill string depth (ft.)} \times 0.052} + 0.4 \text{ lb./gallon}$$

Where $P_{dp}$ = shut-in drill pipe pressure in psig.

13. When sufficient volume of proper weight mud has been prepared, start pumping increased weight mud down drill pipe at constant kick control SPM which will reduce circulating pressure downward gradually from $P_i$ (initial drill pipe circulating pressure) as calculated on the well control worksheet to $P_f$ (final drill pipe circulating pressure) when drill pipe is filled with weighted mud. Therefore hold drill pipe pressure constant at $P_f$ by adjusting choke until proper weight mud returns to surface.

14. When proper weight mud returns to surface, stop pumps, release any remaining pressure on casing, and check for additional kick before returning to normal operations.

15. Drill new directional hole as a last resort to kill well.

Ormat Nevada
EMERGENCY PLANS

**BLOWOUT ACTION PLAN**

# DRILLERS METHOD

***To Be Posted In Doghouse***

1) The hole is to be kept full of drilling or completion fluids at all times unless this becomes impossible due to lost circulation.

2) Before starting out of hole with drill pipe or tubing, circulate off bottom until mud is properly conditioned.

3) Close and open pipe rams once per day and log on tour sheet. Pressure test BOPE prior to drilling out of casing shoes and coincident with casing test. Log results on tour sheet.

4) Close blind rams when out of hole and log on tour sheet.

5) Fill hole at five (5) stand intervals or less while pulling drill pipe out of hole. Count pump strokes or use chart attached to the pit volume indicator to determine the volume required to fill the hole.

6) Watch pit flow or pit level indicator when running in the hole to insure that the volume of mud displaced by the drill string is not exceeded.

7) The drill pipe will be run in the hole to the shoe of the casing and a full opening safety valve installed to perform any of the following operations:

   a) Slip or cut drilling line.

   b) Repair equipment (if possible).

   c) Any foreseen delay.

8) Record on the tour sheet the reduced circulating pressure at 30 strokes per minute (SPM) or other suitable kick control pump rate daily and after each bit change.

9) An approved inside blowout preventer and full opening safety valve with wrench must be immediately available on the rig floor.

10) A blowout prevention drill will be conducted by the rig tool pusher and observed by the Drilling Supervisor for each drilling crew to ensure that each person is properly trained to carry out emergency procedures. Assign kick control duties in advance: i.e. mud mixing assigned to floor man, operating pumps assigned to derrick man, etc.

11) At first indication of gain in pit level (or other sign of possible blowout), the driller will immediately do what is necessary to control the well. In most cases this action should be:

Shut-In Procedure While Drilling:

a) Pull kelly above the rotary table and stop pumps.

b) Check the well for flow.

c) Close the blowout preventer and shut the well in completely.

d) Record pit level, shut-in drill pipe ($P_{sidp}$) and shut-in casing pressure ($P_{sicg}$).

e) Inform the Drilling Supervisor and/or precede with appropriate kick control measures as follows.

Shut-in Procedure While Tripping:

a) Set slips with tool joint in rotary table.

b) Install full opening safety valve.

c) Close safety valve.

d) Close blowout preventer.

e) Install the kelly.

f) Record shut-in drill pipe and casing pressure.

g) Inform the Drilling Supervisor.

12) Run drill string in hole as far as practical after first installing inside BOP and reopening safety valve, and/or proceed with appropriate kick control measures as follows.

Kick Control Measures for Driller's Method

First Circulation

I. Select a pump speed for the kill operation. This will usually be the previously recorded slow pump rate. It is important to maintain a constant speed throughout the kill operation.

II. Start the pump and open the choke to maintain the casing pressure ($P_{cg}$) constant as the pump is brought up to the desired kill speed. Once the kill speed is reached, observe the new drill pipe pressure ($P_{dp}$). Record the drill pipe pressure.

III. Pump one full circulating volume at constant pump speed while operating the choke to maintain the drill pipe pressure constant.

IV. Stop the pump and shut the choke. At this point the new shut-in casing pressure and the shut-in drill pipe pressure should be equal. Record these pressures. If a drill pipe float is making it difficult to obtain drill pipe pressure readings, the new shut in casing pressure may be used in the calculation below.

Second Circulation

I. Calculate the kill-weight mud density.

$$\text{New Mud Weight} = \text{Current Mud Weight} + \frac{\text{Drill Pipe Pressure}}{0.052 * \text{TVD}}$$

A trip margin may be added if desired, but management approval is required for a trip margin in excess of
0.2 ppg.

II. Start the pump, bringing it up to the kill speed, and operate the choke as necessary to maintain the casing pressure constant. Continue operating the choke to keep the casing pressure constant until one drill string volume of kill weight mud has been pumped.

III. After pumping one drill string volume of the kill weight mud, maintain the pump speed constant and record the circulating drill pipe pressure.

IV. Maintain the pump speed constant and operate the choke so as to maintain the drill pipe pressure constant until kill weight mud returns are measured at the surface.

V. Stop the pump and check for flow.

# APPENDIX C

## ENGINERING DATA
NEW PRODUCTION WELL KS-16
Puna Field, Hawaii

Ormat Nevada
NOVEMBER 2014

# CASING SAFETY FACTORS

**CASING – 20-in. 94# K-55 BTC WITH SHOE @ 1025 FT**

## BURST AT 20-in. SHOE DURING CEMENTING

Assumes 16 lb/gal cement slurry inside & water outside.

Inside pressure = 16 ppg * .052 psi/ft * 1025 ft
= 853 psi

Outside pressure = 8.33 ppg * .052 psi/ft * 1025 ft
= 444 psi

Calculated burst pressure = 409 psi

Burst rating at specified minimum yield = 2110 psi

Safety Factor = 416%

## BURST AT 20-in. SHOE DURING CASING TEST

Assumes 8.6 lb/gal mud inside, water outside, and 500 psig test pressure.

Inside pressure = (8.6 ppg * .052 psi/ft * 1025 ft) + 500
= 958 psi

Outside pressure = 8.33 ppg * .052 psi/ft * 1025 ft
= 444 psi

Calculated burst pressure = 514 psi

Burst rating at specified minimum yield = 2110 psi

Safety Factor = 310%

## COLLAPSE AT 20-in. SHOE DURING CEMENTING

Assumes 8.33 lb/gal water inside and 16 lb/gal cement outside.

Inside pressure = 8.33 ppg * .052 psi/ft * 1025 ft
= 444 psi

Outside pressure = (16 ppg * .052 psi/ft * 1025 ft)
= 853 psi

Calculated collapse pressure = 409 psi

Collapse rating = 520 psi

Safety Factor = 0.79%

## 20-in. CASING TENSILE YIELD AS RUN

Assumes 1025 ft of casing hung in air.

Calculated tensile yield = 1025 ft * 94 lb/ft
= 96,3503 lb

Tensile rating at specified minimum yield = 1,480,000 lb

Safety Factor = 1436%

**CASING - 13-3/8-in. 72# L-80 DWC WITH SHOE @ 2525 FT MD**

## BURST AT 13-3/8-in. SHOE DURING CEMENTING

Assumes 16 lb/gal cement slurry inside & water outside with 500 psig pumping pressure.

Inside pressure = (16 ppg * .052 psi/ft * 2525 ft) + 500
= 2601 psi

Outside pressure = 8.33 ppg * .052 psi/ft * 2525 ft
= 1090 psi

Calculated burst pressure = 1511 psi

Burst rating at specified minimum yield = 5380 psi

Safety Factor = 256%

## COLLAPSE AT 13-3/8-in. SHOE DURING CEMENTING

Assumes 8.33 lb/gal water inside and 16 lb/gal cement outside.

Inside pressure = 8.33 ppg * .052 psi/ft * 2525 ft
= 1090 psi

Outside pressure = 16 ppg * .052 psi/ft * 2525 ft
= 2101 psi

Calculated collapse pressure = 1011 psi

Collapse rating = 2670 psi

Safety Factor = 164%

## 13-3/8-in. CASING TENSILE YIELD AS RUN

Assumes 2525 ft of casing hung in air.

Calculated tensile yield = 2525 ft * 72 lb/ft
= 181,800 lb

Tensile rating at specified minimum yield =
1,661,000 lb

Safety Factor = 814%

**LINER - 9-5/8-in. 53.5# T95 V&M CDC T&C**
**Hung from 2325-5000 ft**

## BURST AT 9-5/8-in. SHOE DURING CEMENTING

Assumes 16 lb/gal cement slurry inside & water outside with 800 psig pumping pressure.

Inside pressure = (16 ppg * .052 psi/ft * 5000-2325 ft) + (8.8*0.052*2325) + 800
=5153 psi

Outside pressure = 8.33 ppg * .052 psi/ft * 5000 ft
= 2158 psi

Calculated burst pressure = 2995 psi

Burst rating at specified minimum yield = 9410 psi

Safety Factor = 214%

## COLLAPSE AT 9-5/8-in. SHOE DURING CEMENTING

Assumes 8.33 lb/gal water inside and 16 lb/gal cement outside and 9.0 ppg mud above hanger with cement 100 ft above hanger.

Inside pressure = (8.33 ppg * .052 psi/ft * (5000-2225 ft)) + (9.0 ppg * 0.052 psi/ft * 2225 ft)
= 2243 psi

Outside pressure = (16 ppg * .052 psi/ft * (5000-2225 ft)) + (9.6 ppg * 0.052 psi/ft * 2225 ft)
= 3420 psi

Calculated collapse pressure = 1177 psi

Collapse rating = 7340 psi

Safety Factor = 524%

## 9-5/8-in. LINER TENSILE YIELD AS RUN

Assumes 2675 of casing hung in air.

Calculated tensile yield = 2675 * 53.5 lb/ft
= 143,113 lb

Tensile rating at specified minimum yield = 1,477,000 lb

Safety Factor = 932%

## 7-in. LINER TENSILE YIELD AS RUN

Assumes 1000 of casing hung in air.

Calculated tensile yield = 1000 * 44 lb/ft
= 44,000 lb

Tensile rating at specified minimum yield = 604,000 lb

Safety Factor = 1273%

# APPENDIX D

**CEMENTING PROGRAM**
NEW PRODUCTION WELL KS-16
PUNA FIELD, HAWAII

Ormat Nevada
NOVEMBER 2014

## CEMENTING PROGRAM

NEW PRODUCTION WELL KS-16
PUNA FIELD, HAWAII

**CASING** – 20-in. 94# K-55 BT&C
**DEPTH** - 0-1025 ft.
**HOLE SIZE** – 26-in.
**EXISTING CASING** – 30-in. Conductor 0-80 ft.
**CALCULATED VOLUME** – 1727 $ft^3$
**PROPOSED CEMENT VOLUME** – 1727 $ft^3$ (0% Excess on Open Hole Volume)
**ESTIMATED BHST = 90 F**

**CEMENT PARAMETERS**

LEAD CEMENT (1500 cu ft.)

| | |
|---|---|
| Premium Cement | Slurry Weight – 13.0 lb./gal |
| 30% SSA-1 | Slurry Yield - 2.50 $ft^3$/sk |
| 10% Micro-silica | Water Requirement – 11.20 gal/sk |
| Mixed With Fresh Water | Total Mixing Water – 1160 bbls |
| 10% Spherelite | Slurry Volume – 267.2 bbls |
| Normal Chemicals | Cement Required – 600 sks |

TAIL CEMENT (175 cu ft.)

| | |
|---|---|
| Premium Cement | Slurry Weight – 15.0 lb./gal |
| 30% SSA-1 | Slurry Yield - 1.78 $ft^3$/sk |
| 10% Micro-silica | Water Requirement – 7.78 gal/sk |
| Mixed With Fresh Water | Total Mixing Water – 24.1 bbls |
| Normal Chemicals | Slurry Volume – 41.2 bbls |
| | Cement Required – 130 sks |

**CASING** – 13-3/8-in. 72# L-80 DWC TC
**DEPTH** - 0-2525 ft.
**HOLE SIZE** – 17-1/2-in.
**EXISTING CASING** – 20-in. 0-1025 ft.
**CALCULATED HOLE VOLUME** – 2120 $ft^3$
**PROPOSED CEMENT VOLUME** – 3580 $ft^3$ (70% Excess on Open Hole Volume)
**ESTIMATED BHST WILL BE 300 F: MONITOR & CONFIRM PRIOR TO PUMPING**

## FOAM LEAD CEMENT (738.9 cu ft.)

| | |
|---|---|
| Premium Cement | Slurry Weight – 10 lb./gal |
| 30% SSA-1 | Slurry Yield - 2.19 $ft^3$/sk |
| 10% Micro-silica | Water Requirement – 7.46 gal/sk |
| Mixed With Fresh Water | Total Mixing Water – 44.4 bbls |
| Foam | Slurry Volume – 131.6 bbls |
| Normal Chemicals | Cement Required – 250 sks |

## LATEX FOAMED LEAD CEMENT (2687.9 cu ft.)

| | |
|---|---|
| Premium Cement | Slurry Weight – 11 lb./gal |
| 30% SSA-1 | Slurry Yield - 2.19 $ft^3$/sk |
| 10% Micro-silica | Water Requirement – 7.46 gal/sk |
| Mixed With Fresh Water | Total Mixing Water – 177.6 bbls |
| Foam | Slurry Volume – 478.7 bbls |
| Normal Chemicals | Cement Required – 1000 sks |

## TAIL CEMENT (262.5 cu ft.)

| | |
|---|---|
| Premium Cement | Slurry Weight – 15.0 lb./gal |
| 30% SSA-1 | Slurry Yield - 1.79 $ft^3$/sk |
| 10% Micro-silica | Water Requirement – 6.21 gal/sk |
| Mixed With Fresh Water | Total Mixing Water – 19.2 bbls |
| Normal Chemicals | Slurry Volume – 41.4 bbls |
| 0.175% SCR-100 | Cement Required – 130 sks |

# APPENDIX F

## DIRECTIONAL DRILLING PROGRAM

NEW PRODUCTION WELL KS-16

PUNA FIELD, HAWAII

Ormat Nevada

NOVEMBER 2014

| MD [ft] | Inclination [°] | Azimuth [°] | TVD [ft] | TVD from Fld Ref [ft] | North [ft] | East [ft] | Grid East [US ft] | Grid North [US ft] | Latitude | Longitude | DLS [°/100ft] | Toolface [°] | Build Rate [°/100ft] | Turn Rate [°/100ft] | Vert. Sect [ft] | Major Semi [ft] | Minor Semi [ft] | Vert Semi [ft] | Minor Azim [°] | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 141.00 | 0.00 | -620.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 100.00 | 0.00 | 141.00 | 100.00 | -520.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.33 | 1.33 | 3.40 | 90.00 | |
| 200.00 | 0.00 | 141.00 | 200.00 | -420.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.67 | 2.67 | 3.40 | 90.00 | |
| 300.00 | 0.00 | 141.00 | 300.00 | -320.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.00 | 4.00 | 3.40 | 135.00 | |
| 400.00 | 0.00 | 141.00 | 400.00 | -220.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.34 | 5.34 | 3.47 | 0.00 | |
| 500.00 | 0.00 | 141.00 | 500.00 | -120.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.67 | 6.67 | 3.56 | 135.00 | |
| 600.00 | 0.00 | 141.00 | 600.00 | -20.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.01 | 8.01 | 3.62 | 0.00 | |
| 700.00 | 0.00 | 141.00 | 700.00 | 80.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.34 | 9.34 | 3.64 | 135.00 | |
| 800.00 | 0.00 | 141.00 | 800.00 | 180.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.68 | 10.68 | 3.70 | 0.00 | |
| 900.00 | 0.00 | 141.00 | 900.00 | 280.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.01 | 12.01 | 3.77 | 135.00 | |
| 1000.00 | 0.00 | 141.00 | 1000.00 | 380.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.35 | 13.35 | 3.84 | 0.00 | |
| 1100.00 | 0.00 | 141.00 | 1100.00 | 480.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.68 | 14.68 | 3.92 | 0.00 | |
| 1200.00 | 0.00 | 141.00 | 1200.00 | 580.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.02 | 16.02 | 4.00 | 135.00 | |
| 1300.00 | 0.00 | 141.00 | 1300.00 | 680.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 17.35 | 17.35 | 4.10 | 0.00 | |
| 1400.00 | 0.00 | 141.00 | 1400.00 | 780.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.69 | 18.69 | 4.20 | 0.00 | |
| 1500.00 | 0.00 | 141.00 | 1500.00 | 880.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.02 | 20.02 | 4.31 | 0.00 | |
| 1600.00 | 0.00 | 141.00 | 1600.00 | 980.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21.36 | 21.36 | 4.41 | 90.00 | |
| 1700.00 | 0.00 | 141.00 | 1700.00 | 1080.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 22.69 | 22.69 | 4.52 | 90.00 | |
| 1800.00 | 0.00 | 141.00 | 1800.00 | 1180.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.03 | 24.03 | 4.64 | 90.00 | |
| 1900.00 | 0.00 | 141.00 | 1900.00 | 1280.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.36 | 25.36 | 4.77 | 0.00 | |
| 2000.00 | 0.00 | 141.00 | 2000.00 | 1380.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 26.70 | 26.70 | 4.90 | 90.00 | |
| 2100.00 | 0.00 | 141.00 | 2100.00 | 1480.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 28.03 | 28.03 | 5.03 | 0.00 | |
| 2200.00 | 0.00 | 141.00 | 2200.00 | 1580.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 29.37 | 29.37 | 5.17 | 0.00 | |
| 2300.00 | 0.00 | 141.00 | 2300.00 | 1680.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 30.70 | 30.70 | 5.32 | 90.00 | |
| 2400.00 | 0.00 | 141.00 | 2400.00 | 1780.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 32.04 | 32.04 | 5.46 | 0.00 | |
| 2500.00 | 0.00 | 141.00 | 2500.00 | 1880.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.37 | 33.37 | 5.62 | 90.00 | |
| 2600.00 | 0.00 | 141.00 | 2600.00 | 1980.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 34.04 | 34.04 | 5.77 | 78.90 | |
| 2700.00 | 0.00 | 141.00 | 2700.00 | 2080.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 34.04 | 34.24 | 5.93 | 170.23 | |
| 2800.00 | 0.00 | 141.00 | 2800.00 | 2180.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 34.02 | 34.22 | 6.10 | 225.00 | |
| 2900.00 | 0.00 | 141.00 | 2900.00 | 2280.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 34.05 | 34.28 | 6.27 | 135.00 | |
| 3000.00 | 0.00 | 141.00 | 3000.00 | 2380.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 34.08 | 34.28 | 6.44 | 135.00 | |
| 3100.00 | 0.00 | 141.00 | 3100.00 | 2480.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 34.10 | 34.05 | 6.62 | 90.00 | |
| 3200.00 | 0.00 | 141.00 | 3200.00 | 2580.00 | 0.00 | 0.00 | 662215.25 | 221167.54 | 19°28'29.782"N | 154°58'15.663"W | 0.00 | 141.00 | 0.00 | 0.00 | 0.00 | 34.12 | 34.12 | 6.80 | 225.00 | |
| 3300.00 | 1.00 | 141.00 | 3299.99 | 2679.99 | -0.68 | 0.55 | 662215.80 | 221166.86 | 19°28'29.776"N | 154°58'15.657"W | 1.00 | 0.00 | 1.00 | 0.00 | 0.87 | 34.15 | 34.15 | 6.98 | 223.87 | |
| 3400.00 | 2.00 | 141.00 | 3399.95 | 2779.95 | -2.71 | 2.20 | 662217.45 | 221164.83 | 19°28'29.756"N | 154°58'15.600"W | 1.00 | 0.00 | 1.00 | 0.00 | 3.49 | 34.19 | 34.15 | 7.17 | 220.72 | |
| 3500.00 | 3.00 | 141.00 | 3499.86 | 2879.86 | -6.10 | 4.94 | 662220.21 | 221161.06 | 19°28'29.722"N | 154°58'15.631"W | 1.00 | 0.00 | 1.00 | 0.00 | 7.85 | 34.24 | 34.21 | 7.37 | 224.84 | |
| 3600.00 | 4.00 | 141.00 | 3599.68 | 2979.68 | -10.85 | 8.78 | 662224.07 | 221156.32 | 19°28'29.675"N | 154°58'15.591"W | 1.00 | 0.00 | 1.00 | 0.00 | 13.96 | 34.29 | 34.25 | 7.58 | 220.41 | |
| 3700.00 | 5.00 | 141.00 | 3699.37 | 3079.37 | -16.94 | 13.72 | 662229.00 | 221150.24 | 19°28'29.624"N | 154°58'15.640"W | 1.00 | 0.00 | 1.00 | 0.00 | 21.81 | 34.34 | 34.30 | 7.79 | 220.20 | |
| 3800.00 | 6.00 | 141.00 | 3798.90 | 3178.90 | -24.39 | 19.75 | 662235.06 | 221142.81 | 19°28'29.551"N | 154°58'15.777"W | 1.00 | 0.00 | 1.00 | 0.00 | 31.39 | 34.40 | 34.35 | 7.96 | 223.61 | |
| 3900.00 | 7.00 | 141.00 | 3898.26 | 3278.26 | -33.19 | 26.88 | 662242.23 | 221134.00 | 19°28'29.452"N | 154°58'15.702"W | 1.00 | 0.00 | 1.00 | 0.00 | 42.71 | 34.48 | 34.42 | 8.17 | 229.50 | |
| 4000.00 | 8.00 | 141.00 | 3997.40 | 3377.40 | -43.35 | 35.06 | 662250.47 | 221123.91 | 19°28'29.360"N | 154°58'15.618"W | 1.00 | 0.00 | 1.00 | 0.00 | 55.74 | 34.52 | 34.47 | 8.34 | 224.87 | |
| 4100.00 | 9.00 | 141.00 | 4096.30 | 3476.30 | -54.86 | 44.32 | 662259.81 | 221112.40 | 19°28'29.246"N | 154°58'15.516"W | 1.00 | 0.00 | 1.00 | 0.00 | 70.54 | 34.59 | 34.55 | 8.59 | 227.77 | |
| 4200.00 | 10.00 | 141.00 | 4194.93 | 3574.93 | -67.69 | 54.75 | 662270.24 | 221099.59 | 19°28'29.127"N | 154°58'15.411"W | 1.00 | 0.00 | 1.00 | 0.00 | 87.05 | 34.67 | 34.63 | 8.81 | 225.24 | |
| 4300.00 | 11.00 | 141.00 | 4293.26 | 3673.22 | -81.93 | 66.25 | 662281.73 | 221085.55 | 19°28'28.981"N | 154°58'15.201"W | 1.00 | 0.00 | 1.00 | 0.00 | 105.27 | 34.75 | 34.73 | 9.03 | 210.27 | |
| 4400.00 | 12.00 | 141.00 | 4391.29 | 3771.29 | -97.30 | 78.73 | 662294.34 | 221070.00 | 19°28'28.825"N | 154°58'15.160"W | 1.00 | 0.00 | 1.00 | 0.00 | 125.21 | 34.89 | 34.85 | 9.28 | 158.97 | |
| 4500.00 | 13.00 | 141.00 | 4488.87 | 3868.87 | -114.17 | 92.41 | 662308.10 | 221053.30 | 19°28'28.660"N | 154°58'15.017"W | 1.00 | 0.00 | 1.00 | 0.00 | 146.85 | 34.98 | 34.82 | 9.44 | 147.50 | |
| 4600.00 | 14.00 | 141.00 | 4585.11 | 3965.11 | -132.28 | 107.11 | 662322.76 | 221035.20 | 19°28'28.481"N | 154°58'14.854"W | 1.00 | 0.00 | 1.00 | 0.00 | 172.19 | 35.12 | 35.01 | 9.71 | 145.06 | |
| 4700.00 | 15.00 | 141.00 | 4682.12 | 4062.12 | -151.72 | 122.89 | 662338.56 | 221015.81 | 19°28'28.289"N | 154°58'14.680"W | 1.00 | 0.00 | 1.00 | 0.00 | 196.23 | 35.30 | 35.11 | 9.94 | 144.02 | |
| 4800.00 | 16.00 | 141.00 | 4778.29 | 4158.29 | -172.49 | 139.66 | 662355.46 | 220995.00 | 19°28'28.082"N | 154°58'14.522"W | 1.00 | 0.00 | 1.00 | 0.00 | 221.06 | 35.49 | 35.22 | 10.16 | 143.42 | |
| 4900.00 | 17.00 | 141.00 | 4873.17 | 4253.17 | -194.58 | 157.56 | 662373.40 | 220973.08 | 19°28'27.864"N | 154°58'14.337"W | 1.00 | 0.00 | 1.00 | 0.00 | 250.36 | 35.70 | 35.33 | 10.43 | 143.04 | |
| 5000.00 | 18.00 | 141.00 | 4970.64 | 4350.54 | -217.81 | 176.42 | 662392.40 | 220949.76 | 19°28'27.633"N | 154°58'14.138"W | 1.00 | 0.00 | 1.00 | 0.00 | 280.43 | 35.93 | 35.44 | 10.66 | 142.77 | |
| 5100.00 | 19.00 | 141.00 | 5065.37 | 4445.37 | -242.59 | 196.45 | 662412.44 | 220925.05 | 19°28'27.387"N | 154°58'13.920"W | 1.00 | 0.00 | 1.00 | 0.00 | 312.16 | 36.17 | 35.51 | 10.92 | 142.46 | |
| 5200.00 | 20.00 | 141.00 | 5159.83 | 4539.83 | -268.53 | 217.49 | 662433.53 | 220899.28 | 19°28'27.135"N | 154°58'13.711"W | 1.00 | 0.00 | 1.00 | 0.00 | 345.54 | 36.17 | 35.55 | 11.16 | 142.15 | |
| 5246.00 | 20.46 | 141.00 | 5202.78 | 4582.79 | -281.84 | 227.46 | 662444.26 | 220886.65 | 19°28'27.008"N | 154°58'13.606"W | 1.00 | 0.00 | 1.00 | 0.00 | 361.44 | 36.53 | 35.62 | 11.29 | 141.99 | 5246 ft Fracture |
| 5300.00 | 21.00 | 141.00 | 5253.35 | 4633.30 | -296.75 | 239.40 | 662455.68 | 220872.13 | 19°28'26.861"N | 154°58'13.481"W | 1.00 | 0.00 | 1.00 | 0.00 | 380.58 | 36.83 | 35.65 | 11.40 | 141.84 | |
| 5400.00 | 22.00 | 141.00 | 5346.34 | 4726.34 | -326.21 | 262.56 | 662478.80 | 220843.72 | 19°28'26.573"N | 154°58'13.240"W | 1.00 | 0.00 | 1.00 | 0.00 | 417.21 | 36.47 | 35.84 | 11.66 | 141.78 | |
| 5500.00 | 23.00 | 141.00 | 5438.72 | 4818.72 | -355.67 | 286.64 | 662502.00 | 220814.05 | 19°28'26.282"N | 154°58'12.988"W | 1.00 | 0.00 | 1.00 | 0.00 | 455.47 | 37.10 | 35.83 | 11.90 | 141.66 | |
| 5546.00 | 23.50 | 141.00 | 5481.68 | 4861.68 | -369.37 | 299.09 | 662515.44 | 220800.76 | 19°28'26.131"N | 154°58'12.866"W | 1.00 | 0.00 | 1.00 | 0.00 | 475.23 | 37.45 | 35.87 | 12.08 | 141.60 | 5546 ft Fracture |
| 5600.00 | 24.00 | 141.00 | 5530.43 | 4910.43 | -384.98 | 311.73 | 662528.16 | 220785.54 | 19°28'25.979"N | 154°58'12.736"W | 1.00 | 0.00 | 1.00 | 0.00 | 495.25 | 37.54 | 35.88 | 12.16 | 141.56 | |
| 5700.00 | 25.00 | 141.00 | 5621.42 | 5001.42 | -417.92 | 338.63 | 662554.36 | 220750.99 | 19°28'25.657"N | 154°58'12.455"W | 1.00 | 0.00 | 1.00 | 0.00 | 535.62 | 37.94 | 35.74 | 12.43 | 141.51 | |
| 5800.00 | 25.00 | 141.00 | 5712.06 | 5092.30 | -450.53 | 364.43 | 662581.06 | 220718.23 | 19°28'25.331"N | 154°58'12.176"W | 0.00 | 0.00 | 0.00 | 0.00 | 578.06 | 38.38 | 35.93 | 12.70 | 141.46 | |
| 5900.00 | 25.00 | 141.00 | 5802.60 | 5182.80 | -482.57 | 391.02 | 662607.76 | 220685.47 | 19°28'25.006"N | 154°58'11.897"W | 0.00 | 0.00 | 0.00 | 0.00 | 621.24 | 38.60 | 35.87 | 12.96 | 141.42 | |
| 5996.00 | 25.00 | 141.00 | 5887.77 | 5267.77 | -514.35 | 415.35 | 662632.[illegible] | 220655.[illegible] | 19°28'24.[illegible]"N | 154°58'11.[illegible]"W | 0.00 | 0.00 | 0.00 | 0.00 | 661.45 | 38.88 | 35.97 | 13.08 | 141.41 | 5996 ft Fracture |

# APPENDIX G

**WELDING PROCEEDURE**
NEW PRODUCTION WELL KS-16
PUNA FIELD, HAWAII

Ormat Nevada
NOVEMBER 2014

## WELDING PROCEDURE FOR 13-3/8-in. CASING HEAD

This welding procedure uses the API recommendations for field welding a SOW casing head.

1. Cut off existing casing at depth specified by Drilling Supervisor.

2. Grind and clean the area to be welded in the casing and in the interior of the SOW portion of the casing head.

3. Open the test ports on the new casing head. Position and level up casing head on top of casing.

4. Allow 1.5 mm of space between the slip-on portion of the casing head and the top of the casing, to allow for expansion.

5. Pre-heat casing and casing head to 350°F. Use a pre-heating torch from a distance of approximately 5 to 7.5 cm on either side of the weld location. Use heat-sensitive crayons to test the temperature both inside and outside of the casing and casing head. Special attention must be given to the pre-heating operation of the thick body of the casing head., to ensure proper heating and expansion with respect to the thinner casing.

6. Use a 3 mm (1/8-in.) E-6010, 5P or 7010G electrode for the root pass. Weld approximately 10 cm long bread, and then go diametrically to the opposite side and repeat. Move 90° and weld another portion and again move diametrically opposite. Repeat until the entire first pass has been completed.

7. Clean out the weld slag before welding the second pass.

8. The second pass and the succeeding passes should be made with a 3 mm (1/8-in.) minimum, 4 mm (5/32-in.) maximum 7018B2l electrode. The pass shall be continuous, leaving stringer beads with good penetration. Low hydrogen electrodes must not be exposed to the atmosphere until ready to be used. If accidentally exposed, they must be dried for 1 to 2 hours at 480 to 575°F before use. Open cans must be stored inside a rod oven.

9. During welding, check casing and casing head temperatures. Re-heat and maintain temperature to specified range of 248 to 302°F. Do not allow temperature to rise above 572°F during inter-pass welding. Use heat-sensitive crayons to check temperature of the metal elements.

10. Balance welding groove with several (at least three) continuous passes (without back-stepping or lacing), using a low-hydrogen electrode not thicker than 5 mm (3/16-in.). All new passes must be cleaned out of slag before applying the next pass. Inter-pass temperature must be kept below 572°F.

11. Cure must be taken that the welding cable is properly grounded to the casing or casing head. The ground wire must be firmly clamped to the casing or casing head. Avoid sparking from bad contact. This could result in hard spots, beneath which incipient cracks could later develop.

12. Re-heat the casing and casing head to 445°F.

13. Repeat the procedure, steps 4 to 7 for welding of the inside portion. Balance the welding groove with one pass of continuously welding, using a thick 5 mm (3/16-in.) low-hydrogen electrode.

14. Wrap elements in an insulating blanket. Stress-relieve casing head following a controlled post-weld heat treatment:

15. Heat casing head and the attached casing to 1112°F to 1202°F.

16. Hold up this temperature for a minimum of one hour per-in. of thickness (casing head slip-on portion plus casing) if total thickness is up to 5 cm. For thickness above 5 cm (2-in.), hold temperature for a minimum of 2 hours plus 15 minutes for each additional 25 mm-in. in excess of 5 cms.

17. The cool-down period shall not exceed the rate of 572°F per hour, divided by ½ of the maximum thickness, without exceeding the maximum rate of 572°F per hour.

18. Remove insulting blankets only when the temperature has reached 347°F.

19. Pressure test through the casing head testing ports with nitrogen.

20. Test at 1000 psig for 15 minutes.

21. Any defects coming from cracks or holes must be removed to sound white metal by grinding. A new weld bead must be deposited and if allowed, a new pass made above it.

22. Clean up gasket grooves and rings with solvent and install on casing head. Do not grease groove or rings. Nipple BOPE.

# APPENDIX H

## RIG SAFETY INSPECTION FORM

NEW PRODUCTION WELL KS-16

PUNA FIELD, HAWAII

Ormat Nevada

NOVEMBER 2014

Company: ____________ Rig Number: ____________ Inspection Date: ____________

Toolpusher: ____________ Driller: ____________ Inspection Made by: ____________

**( ) If OK**
**( - ) If not applicable**
**( X ) If correction is needed.**
**Refer to the back for details.**

**I. DRILL SITE**

- a. AUTHORIZED PERSONNEL signs posted
- b. HARD HAT/SAFETY GLASSES signs posted
- c. NO SMOKING / SMOKING areas designated
- d. NO PARKING near rig
- e. H2S controls if applicable
- f. Over head lines flagged 8' above ground
- g. Toilet Facilities provided
- h. Hard hats/safety glasses available for visitors
- i. Toolpusher's trailer (bunk house) grounded
- j. Toolpusher's trailer tied down
- k. Regulatory Safety, etc Posters posted as required
- l. Employee training records available as needed
- m. Containers properly marked to contents
- n. Company policies posted
- o. Forklift / misc. hoisting & lifting equipment
- p. Bench grinders properly guarded, tool rest adjusted, PPE available, Safety signs posted.

**II. DOG HOUSE(S)**

- a. Adequate exits, doors installed properly, operate freely
- b. Approved heaters used
- c. Hazard communication/M.S.D.S. on site
- d. First aid kit and facilities
- e. Crew trained in first aid
- f. Emergency phone numbers posted
- g. Outside communications provided
- h. Safety equipment available
- i. Crew wearing hard hats and safety glasses
- j. Crew wearing hard-toed shoes (boots)
- k. Proper clothing worn by crew
- l. No hazardous jewelry worn
- m. NO SMOKING rules observed
- n. Accidents posted on OSHA or other incident log
- o. Ton miles logged ____________
- p. Gas detector fully charged and sensors working
- q. B.O.P. drills, test logged ____________
- r. Safety meetings logged ____________
- s. Driller or competent person at or near controls
- t. Toolpusher/Rig Manager at rig location
- u. Approved and adequate lighting
- v. General Housekeeping

**III. DRILLING FLOOR AREA**

- a. Rotary table area
- b. Kelly bushing guard used
- c. Kelly Safety Controls adequate if no guard used
- d. Rotary chain drive guarded
- e. All unused floor holes covered
- f. Lighting
- g. Pipe / collar slips, dies, handles, pins, keepers
- h. Racking floor area
- i. Vee door gate provided - in place
- j. Makeup and breakout tongs
- k. Tong snubbing lines, clamps
- l. Tong counter weights (sheave assemblies)
- m. Tong body and jaws condition
- n. Tong safety handle pin secured
- o. Tong dies sharp, keeper used
- p. Air hoist line, guide, guarded
- q. Catheads surface smooth, anti-rope fouling device
- r. Catline(s)
- s. Kelly cock, wrench accessible
- t. Jerk and Spinning chain, headache post
- u. Breakout tong pull back cable, guide rollers
- v. Crown-O-Matic device, operating
- w. Drilling line
- x. Drawworks and overrunning clutch
- y. Driller's controls
- z. Hand tools
- aa. Drawworks Drum Drill Line Anchor secure
- bb. Drawworks Brake Linkage
- cc. Drawwords Guards
- dd. Proper electrical wiring provided as required
- ee. Fire extinguishers properly marked, inspected
- ff. Safety signs posted as needed.
- gg. General housekeeping

**IV. STAIRS, WALKWAYS, HANDRAILS, GUARDRAILS**

- a. Adequate stairs provided off rig
- b. Stairs level, secure, no obstructions
- c. Adequate handrails provided (stairs)
- d. Stair treads uniform, of non-skid type
- e. Guardrails, mid-rails, toe boards
- f. Handrails used

**V. SUBSTRUCTURE**

- a. Safety Signs Posted as needed
- b. Approved and adequate lighting
- c. Substructure's beams and braces
- d. All assembly pins in place, secure
- e. Dead line properly anchored

**VI. BLOWOUT PREVENTERS**

- a. B.O.P. properly installed, tested
- b. Wheels and stems in place
- c. BOP Stack properly stabilized
- d. All hydraulic lines connected, no leaks/damage, & protected
- e. All unused lines capped
- f. Accumulator & Remote Control unit(s) properly located – Unobstructed
- g. Gauges properly located – in good condition
- h. Choke manifold and line, secured
- i. Blooey line used, pilot light used
- j. Approved wiring and lighting in use and adequate lighting
- k. Signage
- l. Scaffolding boards secured and in good condition
- m. Fall protection properly attached under rig floor protected clean
- n. BOP Remote control properly labeled and operating
- o. Fire extinguisher located near BOP Controls area
- p. Housekeeping, drainage

**VII. PIPE RACK AREA**

- a. Ends of pipe racks chocked
- b. Layers of pipe chocked. spacers used
- c. Pipe racks level, stable
- d. Pipe rack catwalk
- e. Stairs with hand rails provided
- f. Vee door slide, pipe stops used
- g. Pipe tubs and bridles
- h. Derrick stand and ladder
- i. Employees not on top of pipe
- j. Drilling line from anchor to spool elevated off the ground
- k. General housekeeping, lighting

**VIII. DERRICK, DERRICK BOARD AREA & CROWN AREA**

- a. Derrick ladder – good condition
- b. Derrick climber installed properly – good condition and used
- c. Climbing/Derrick board Safety Harness, safety catch
- d. Safety lines or lanyards used
- e. Derrick emergency escape line
- f. Derrick escape cart on line or escape assembly installed
- g. Pipe fingers and tools secured (finger safety line(s) attached)
- h. Standpipe(s) (mud, air, hydraulic, gas vent) secured
- i. Mud hose snubbed on both ends
- j. Derrick board & Stabbing board fall protection installed
- k. Derrick Board / Stabbing Board – good condition
- l. Derrick properly guyed if applicable
- m. Boom(s) and boom lines
- n. Sheaves & Shackles properly attached to the derrick (safety line(s) / clips attached)
- o. Approved and adequate lighting
- p. Derrick Crown Light operating and in good condition, secure
- q. Crown Saver blocks are in good condition & wrapped with expanded metal
- r. Handrails at crown in good condition
- s. Derrick, A-frame – pins in place, secured with keepers
- t. Elevators, bails
- u. Traveling Blocks, Top Drive, Swivel
- v. No loose ropes or other items in the derrick.
- w. General housekeeping

**IX. MUD PUMP AREA**

- a. Rotating Equipment, Drive Belts, Pony Rods guarded
- b. Head and valve covers fully bolted
- c. Shear pin pop-off valve covered/tested
- d. Ends of relief lines secured
- e. Ends of high pressure vibrator hose(s) snubbed
- f. Approved and adequate lighting
- g. Drip pans installed and cleaned as needed.
- h. Tools & supplies stored in proper place.
- i. General housekeeping

**X. MUD MIXING AREA**

- a. Bagged material properly stacked
- b. Caustic or acids properly stored separate from other materials
- c. Chemical mixing barrel
- d. Adequate personal protective equipment
- e. Signs posted & MSDS in mixing area(s)
- f. Adequate eyewash (shower) available
- g. Adequate ventilation in area
- h. Elevated loading door opening protected
- i. Approved and adequate lighting
- j. General Housekeeping

**XI. MUD TANKS AND PITS**

- a. Adequate stairs with handrails
- b. Walkways & guardrails in good condition
- c. Walkways free from obstruction/tripping hazards
- d. Gates seal, no leaks in tanks
- e. Adequate ventilation in area
- f. Guardrails provided on crossovers
- g. Approved adequate lighting
- h. Eye protection required warning signs
- i. Shale shaker belt & pulley drive guarded
- j. Desander, desilter, degasser units
- k. Explosive-proof equipment at shale shaker area
- l. Agitator shafts and couplings guarded
- m. Mud guns and jetting hoses secured
- n. General housekeeping

**XII. GENERATOR AREA & ENGINE AREA**

- a. Generators properly located
- b. All generator moving parts guarded
- c. Generators properly grounded
- d. Cover panels on electrical control boxes
- e. Electrical controls marked - lockout/tagout
- f. HIGH VOLTAGE warning signs used
- g. Insulating mats at electrical panels
- h. All electrical tools grounded
- i. Condition of electrical wiring
- j. Electrical wires properly strung
- k. Unused electrical outlets covered
- l. Air compressors properly guarded
- m. Air storage tanks equipped with pop-off
- n. Hearing Protection Signs Posted
- o. Hearing protection available & utilized
- p. S.C.R. house if available
- q. Lighting
- r. Engine drip pans installed in good condition
- s. General housekeeping

**XIII. FUEL STORAGE TANKS**

- a. Fuel storage tanks properly located
- b. All storage valves marked as to contents
- c. Discharge nozzles, hoses, valves
- d. Liquefied petroleum gas storage tanks
- e. Piping and fuel lines
- f. Stationary ladders on storage tanks
- g. NO SMOKING signs posted
- h. Tanks labeled as per hazard & contents
- i. Off road use only sign posted as needed
- j. Drip pans installed in good condition
- k. General housekeeping, lighting

**XIV. FIRE PROTECTION**

- a. Adequate fire extinguishers distributed around the rig and location, not obstructed
- b. Fire extinguishers fully charged, in good condition, current inspection
- c. NO SMOKING Signs posted as needed
- d. No open pit burning
- e. Flammables in U.L. safety cans
- f. Flare area clear of combustibles
- g. Boiler (air heater) and its safety controls
- h. Welding performed safely
- i. Fire Watch Posted
- j. Spark and heat arrester on engines

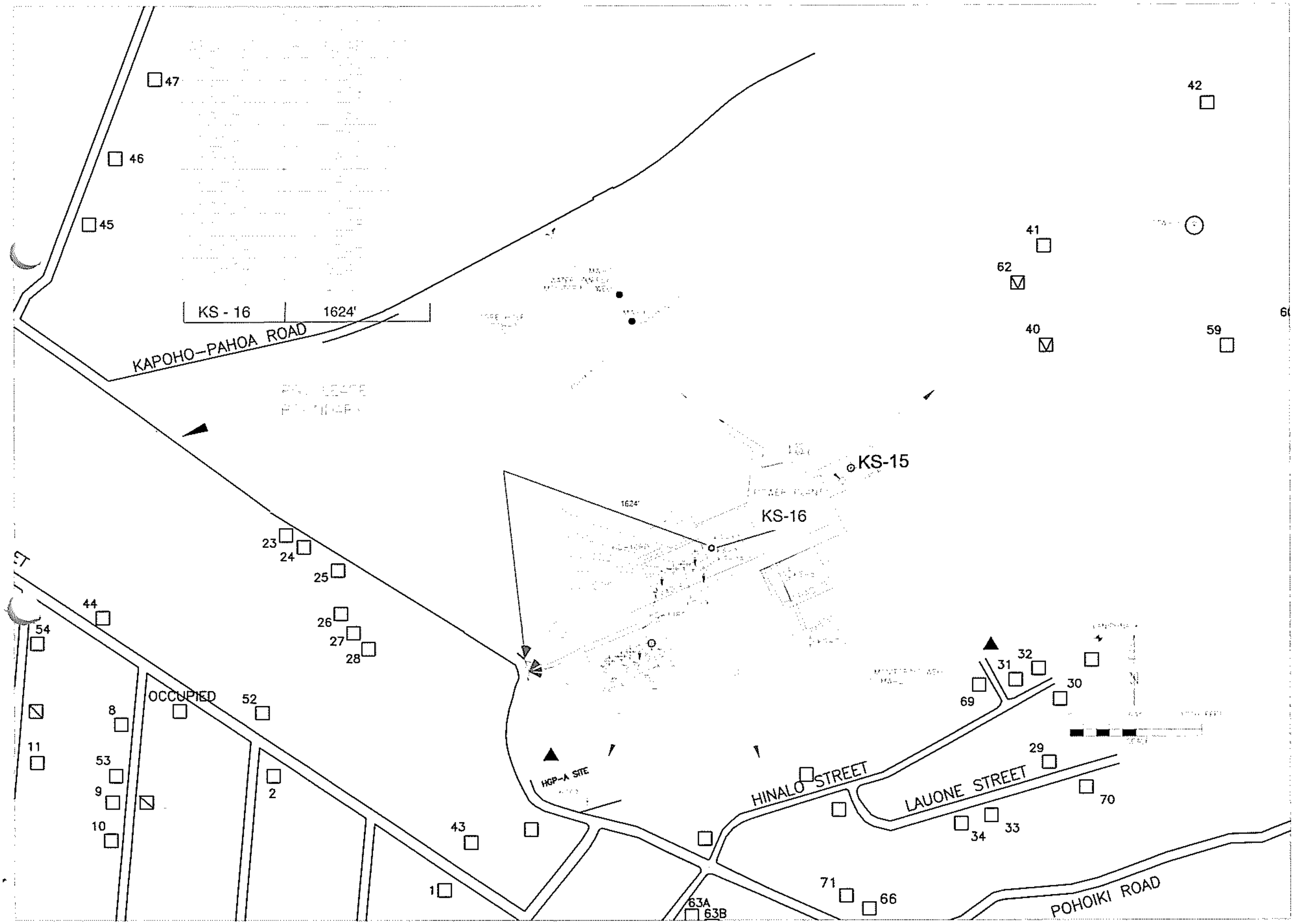
**XV. SLEEPING QUARTERS/BUNK HOUSE**

- a. Quarters / Bunk house clean & Orderly
- b. Restroom clean & sanitary, needed supplies available
- c. Smoke/Fire alarms available and working
- d. Food preparation area clean, food and dishes put away
- e. Fire Extinguishers available
- f. Two exits – unobstructed

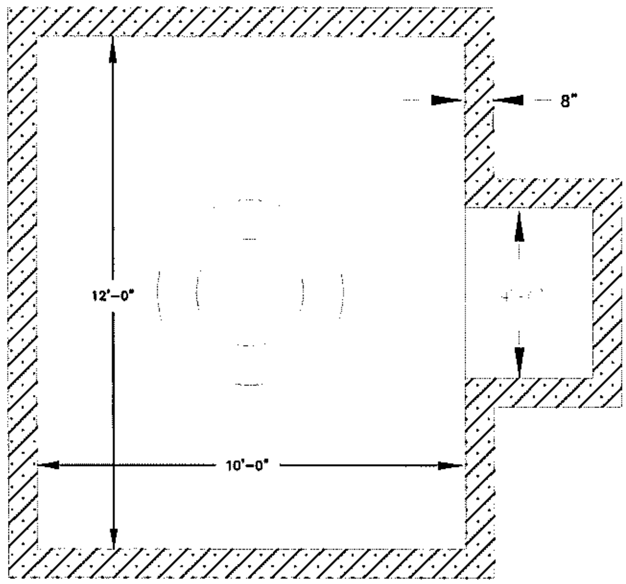
Unsatisfactory mark requires clarifying comment

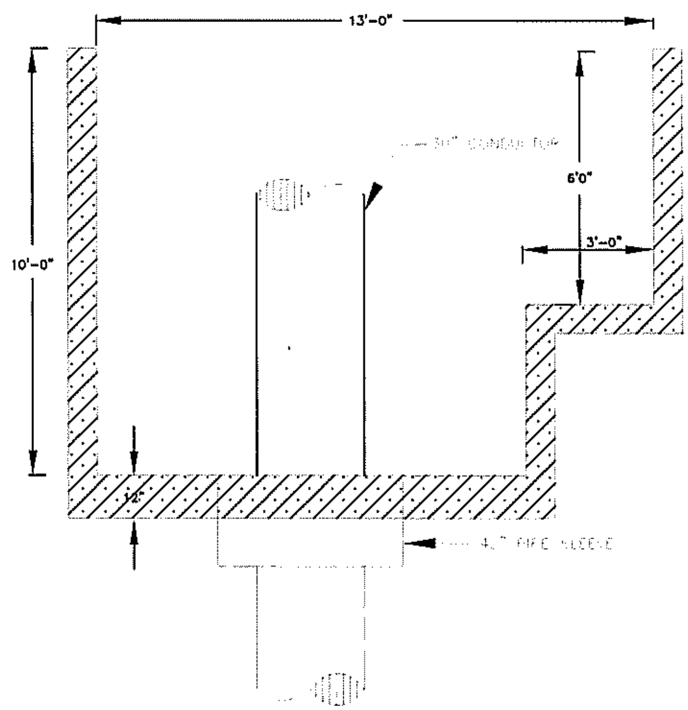
**Figure 1: Well Location Map**

**Figure 2: Proposed well schematic.**




PUNA GEOTHERMAL VENTURE

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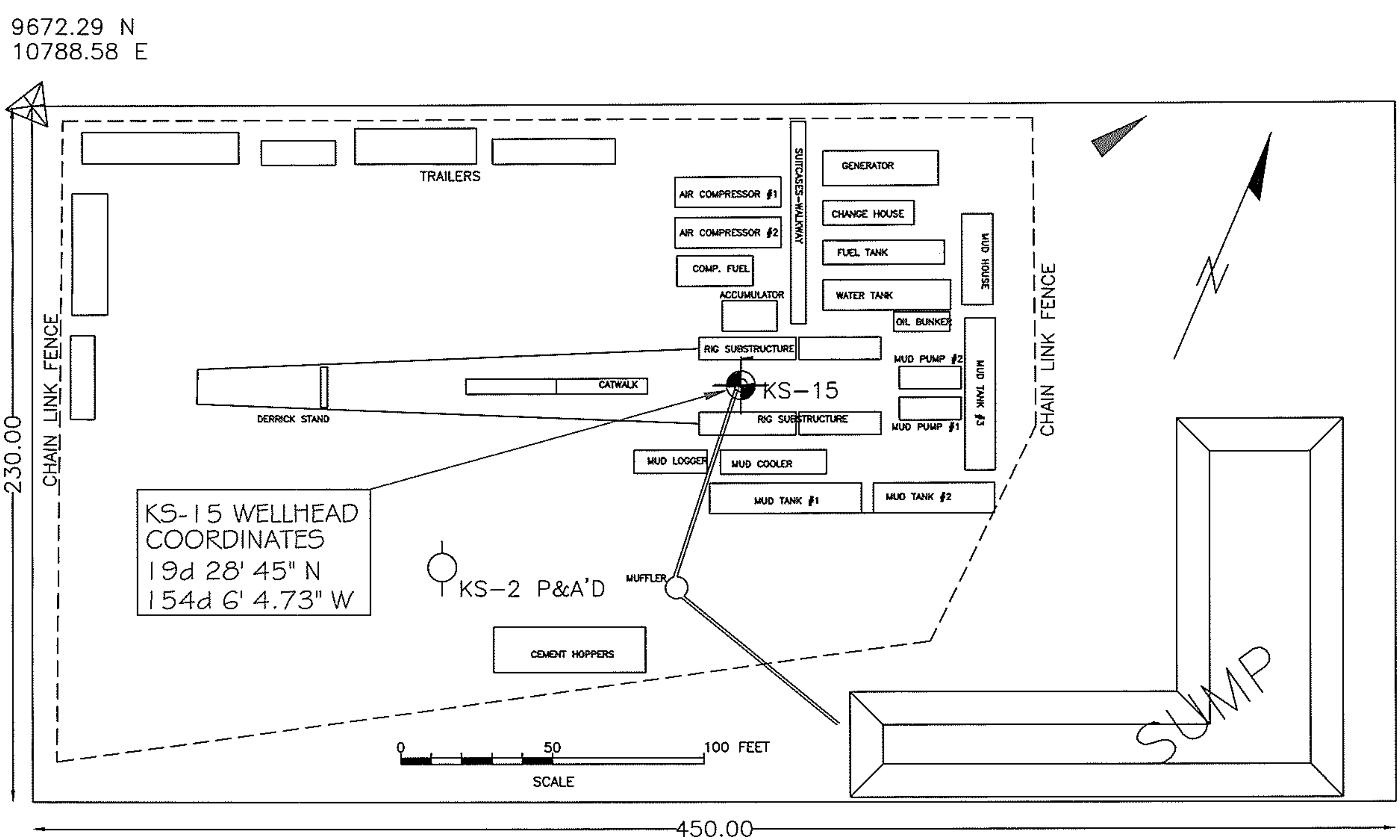


| PUNA GEOTHERMAL VENTURE | GEOTHERMAL WELL KS–15<br>RIG LAYOUT | DATE: 5/10/2011 | BY: WM. TEPLOW<br>FIGURE 3–2 |
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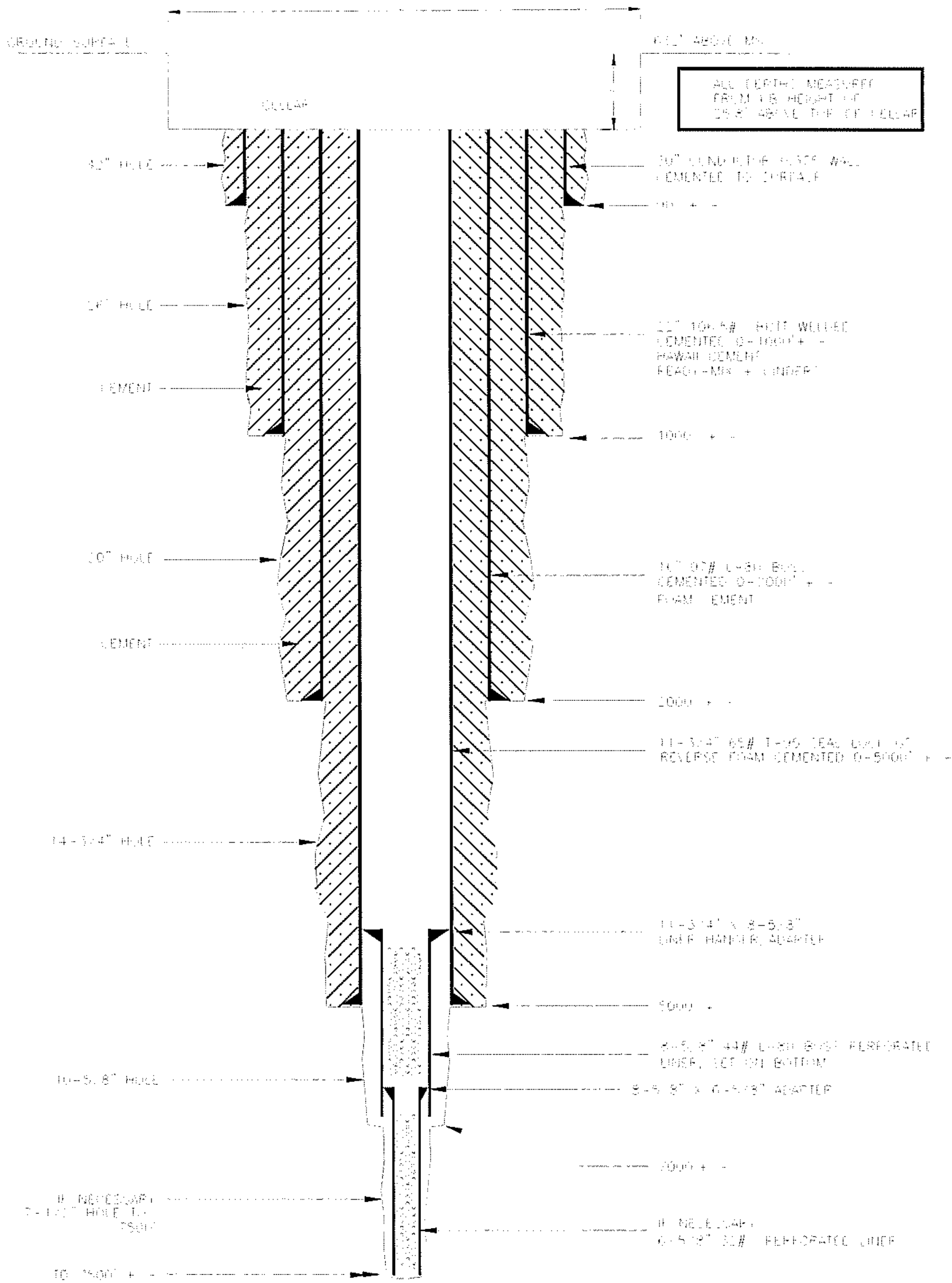


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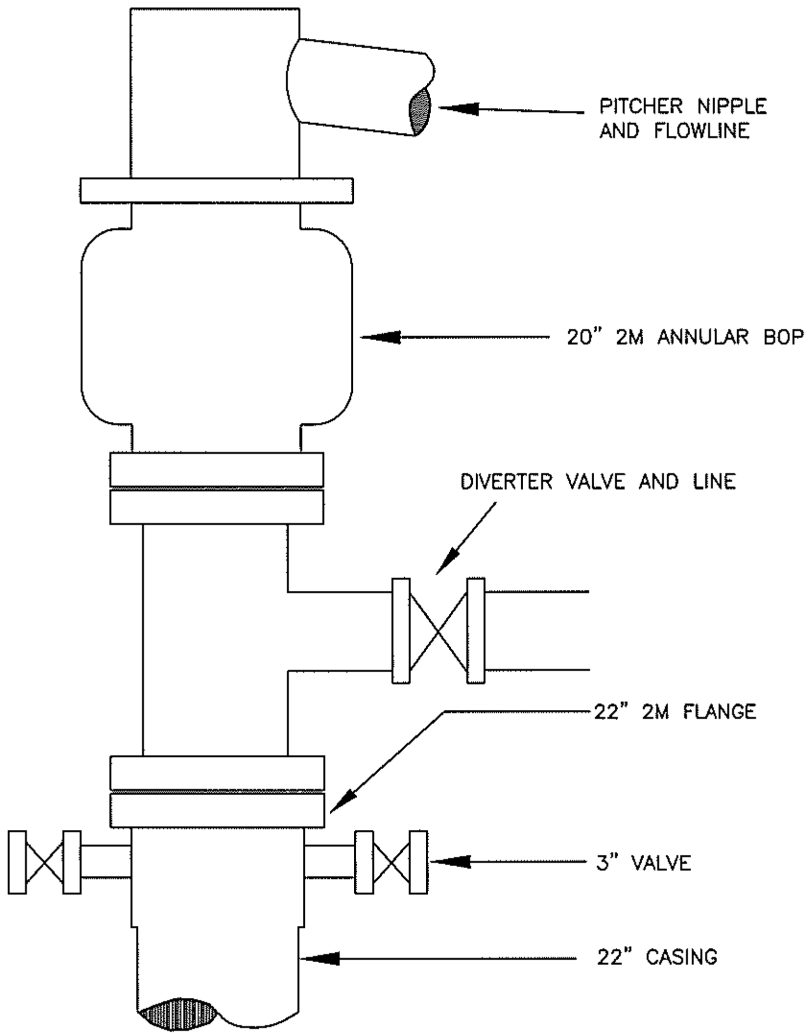
|---|---|---|---|
| | | DATE 11/13/2014 | FIGURE |

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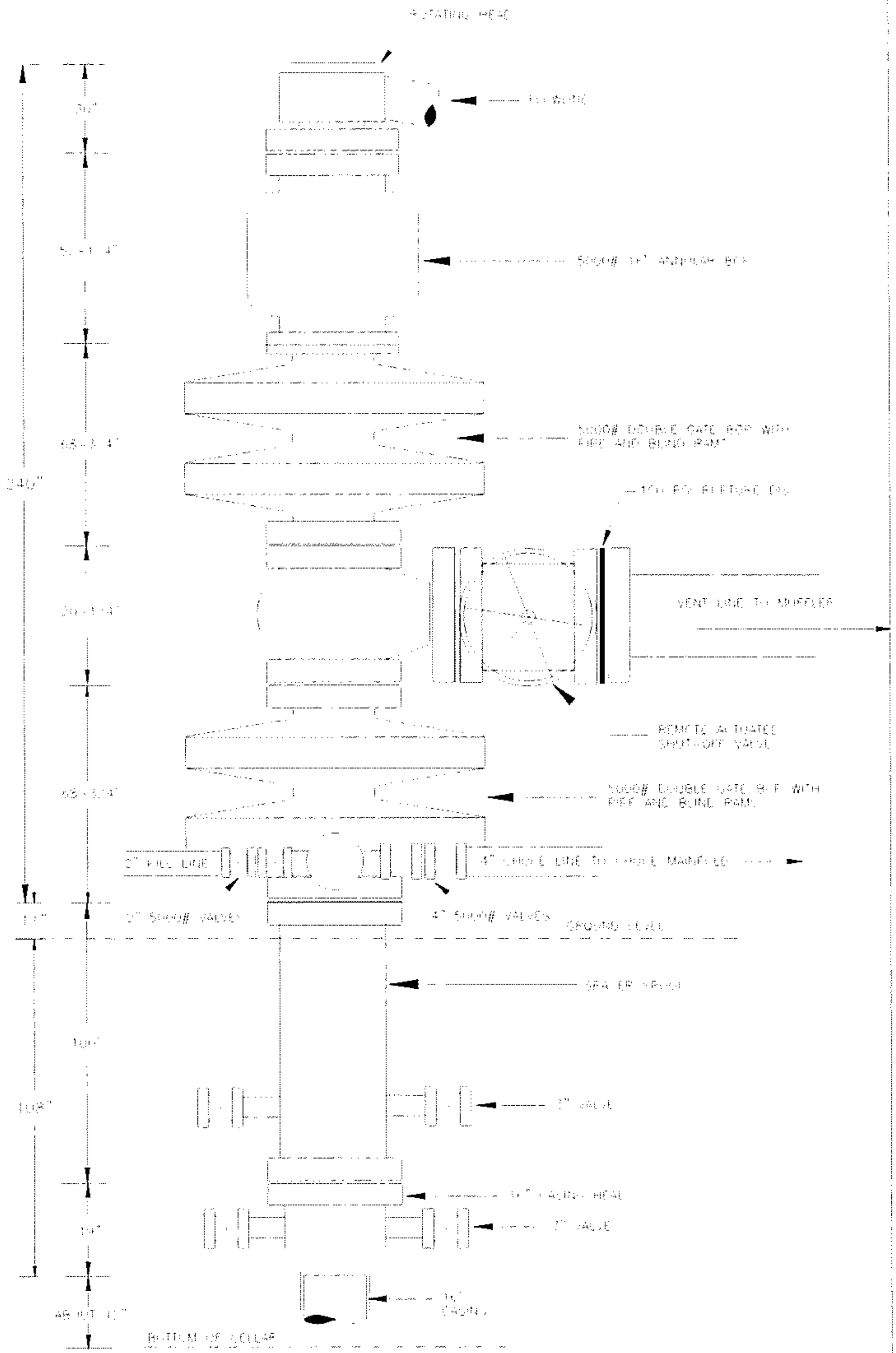


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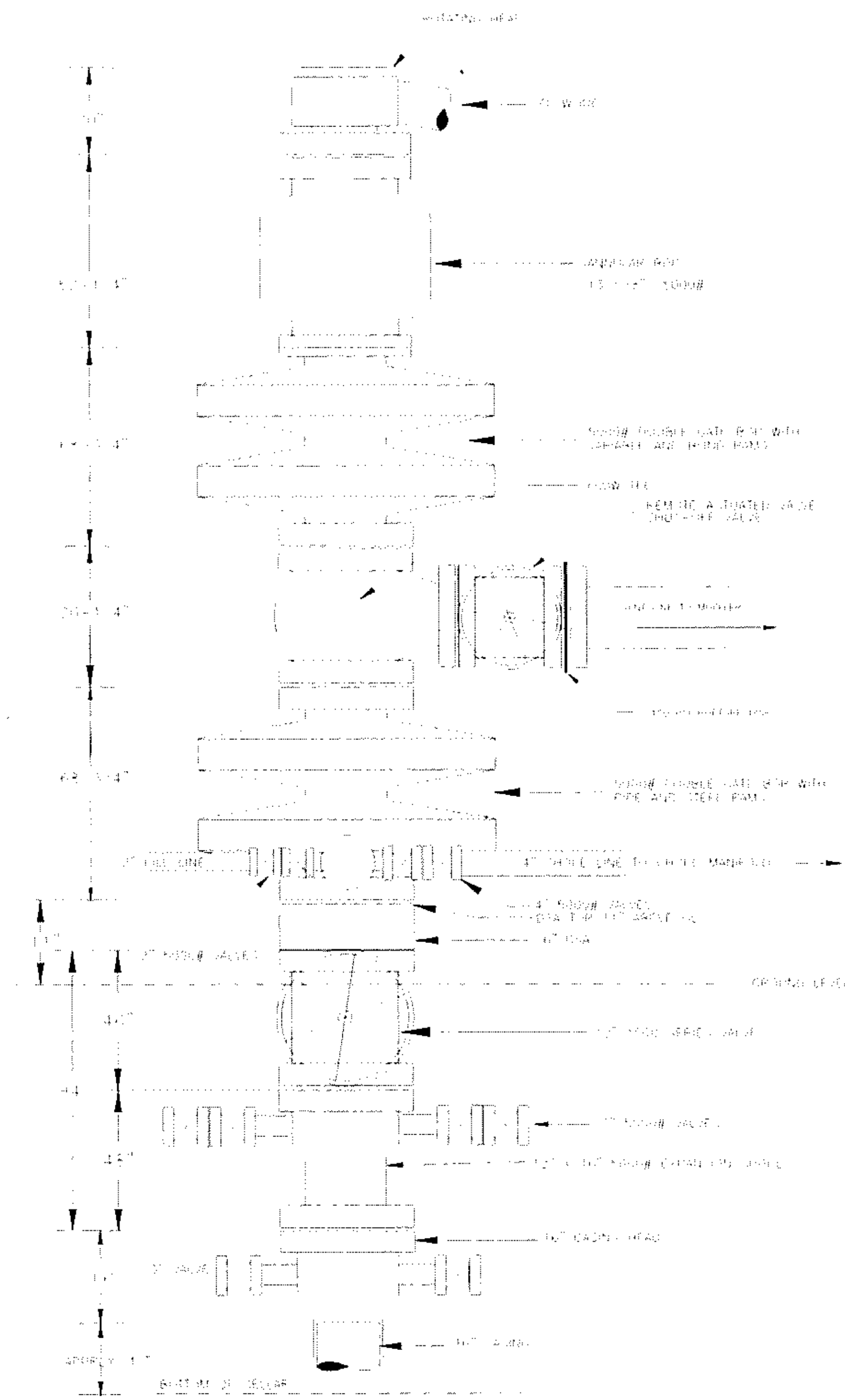

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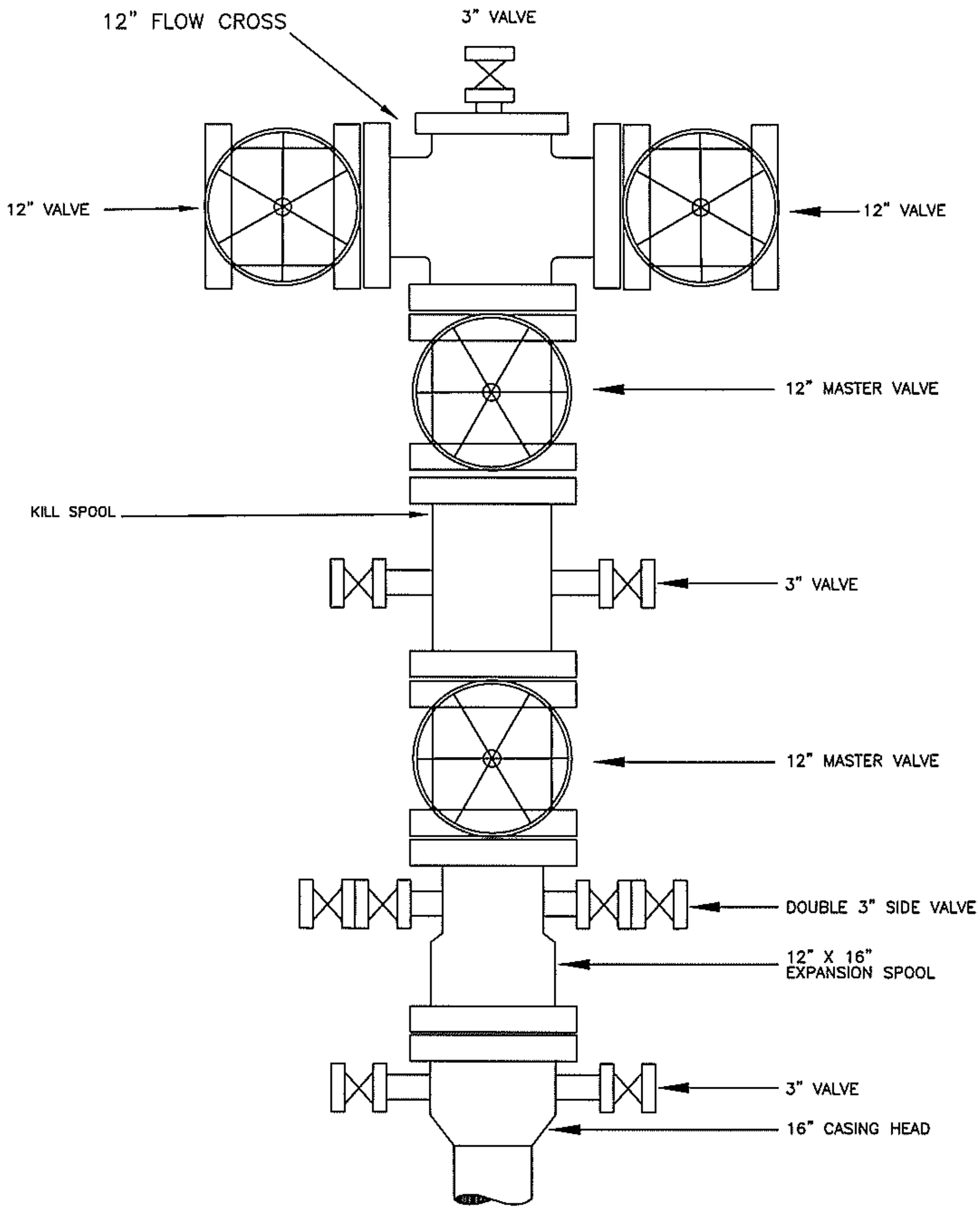
| | | DATE 11/13/2014 | | FIGURE ... |

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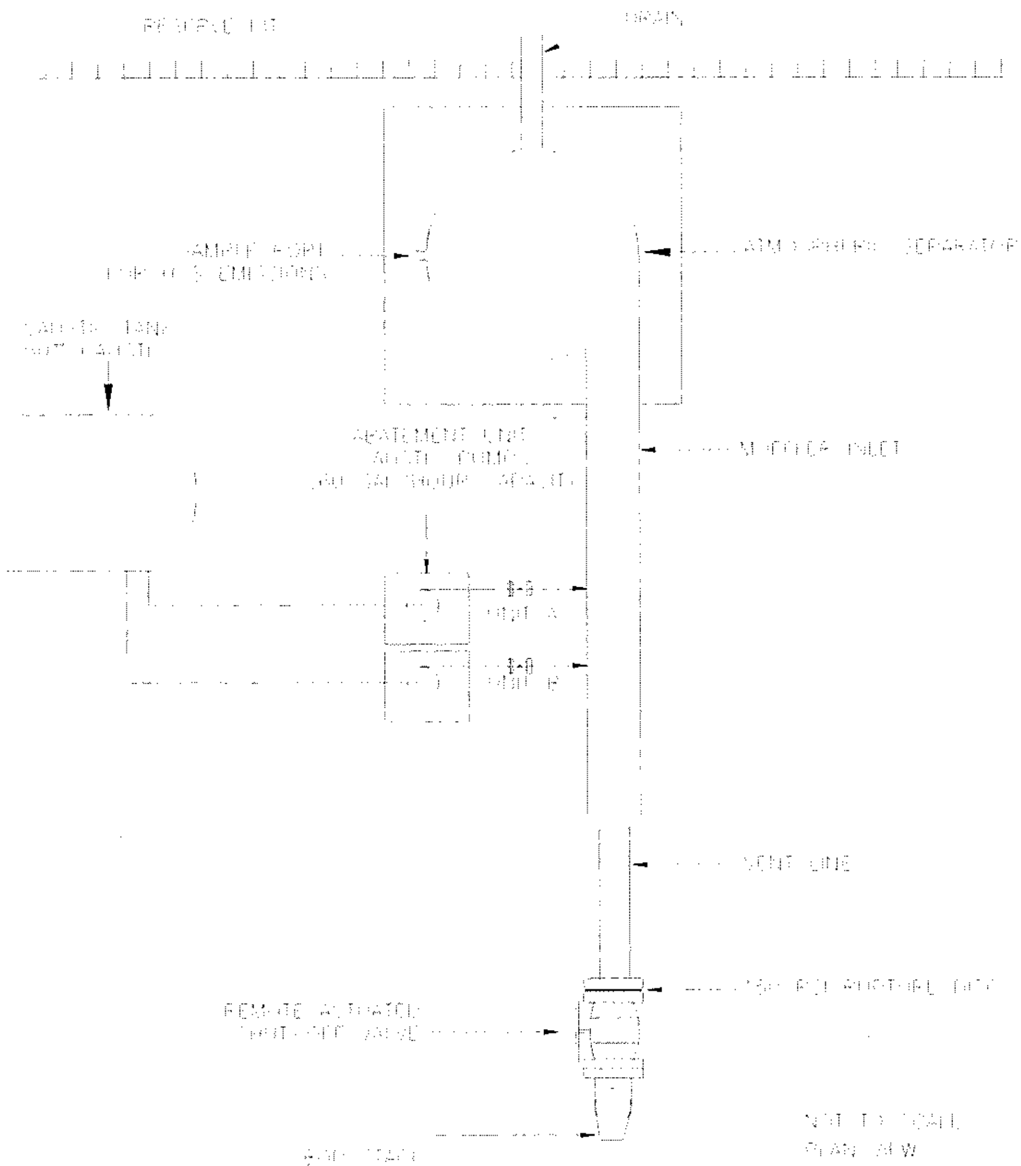

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|---|---|---|---|
| PUNA GEOTHERMAL VENTURE | GEOTHERMAL WELL ..-16 MUFFLER AND ABATEMENT SYSTEM DURING DRILLING | DATE 11/13/2014 | FIGURE 3-8 |