DRAFT

SPECIFICATIONS FOR DRILLING CONSTRUCTION AND DEVELOPMENT OF THE THORIUM SEEPAGE COLLECTION WELLS

for

UNC Mining and Milling
Gallup, New Mexico

by

Billings & Associates, Inc.
Kimberling City, MO

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40%
90%

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Introduction:

This report was prepared in order to be consistent with the technical intent of the Environmental Improvement Division's (EID) order of 23 May 1983. Billings & Associates, Inc. and S. S. Papadopulos & Associates, Inc. do not necessarily agree with all of the specifications resulting from said consistency with the EID order. The purpose of this report is to present the techniques and specifications for the drilling, construction and development of Thorium Seepage Collection Wells to be constructed in Zone 3 and 1 of the Upper Gallup Formation at the United Nuclear Corporation (UNC) Churchrock tailings facility (Plate 1). Wells 610 (124 reamed), 608, 609 and 613 (Gallup 3 reamed) will be completed in Zone 3, and wells 611 (450 A reamed), 606 and 612 will be completed in Zone 1 using the techniques and specifications contained herein. Note that wells 610, 613 and 611 are existing wells that will have to be recompleted to meet these specifications.

Billings & Associates, Inc. and S. S. Papadopulos & Associates, Inc. have investigated the possibility of using open borehole techniques as a methodology of enhancing well yields. Our results indicate that the wells should be constructed using a modified open borehole technique which is described in more detail later in this report. In addition, discussions with other consultants, government agencies and private firms (see Appendix A and References Used) confirm this. The use of open boreholes in this type of rock in general, could prove effective. However, based on our previous experience at the UNC site (BAI; January, 1982) and with discussions of other geohydrologists (John Shoemaker, Joe Renier; see Appendix A) a formation stabilizer should be used to prevent collapse of the well. A stabilizer is needed for several reasons:

will stabilizer decrease yield more than a screen?

1) Zones 1 and 3 at the site are near an outcrop area and are thus more susceptible to weathering resulting in a weaker matrix;
2) acid-leaching could have occurred thereby weakening the matrix;
3) ? the potential of sluffing is increased because of potential fracture(s) in the area;
4) previous drilling at the site has produced only small amounts of chips returned in the drilling fluid indicating a loosely cemented rock; and
5) previous drilling at the site has indicated sluffing occurs in open boreholes (BAI; January, 1982).

A formation stabilizer is installed in a well by lowering the screen into the target formation and surrounding it with a formation stabilizer that is of a larger diameter than the formation (UOP, Inc.; 1975). By doing this, the possibility of losing the hole is greatly decreased compared to a well left completely open. The wells should have a screen slot size capable of retaining all of the stabilizer material. The stabilizer material should be of a grain size several times larger than a selected grain size of the formation in order to minimize the effects of the stabilizer on efficiency.

how selected?

field determination

Drilling Techniques:

Rotary drilling has been used successfully in the past (BAI; January, 1982 and BAI; September, 1982) at the UNC site. It is recommended its use be employed again. The diameter of the borehole to be drilled will be 11.25 inches except as otherwise noted. The diameter of the casing to be used is 6 inches. This will allow a stabilizer of at least 2 inches thick to be installed. This thickness complies with recommendations by Johnson (UOP, Inc; 1975) which indicates a stabilizer thickness of 2 inches is acceptable for stabilized wells. Specifications and requirements related to the drilling of the wells are presented in Appendix B .

The mud used in the drilling fluid necessary to remove the cuttings from the hole will be Revert. Revert has been used successfully in past drilling at the site (BAI; January, 1983 and BAI; Septen r, 1982). The advantage of this mud is that it decomposes in a few days thereby reducing the possibility of borehole damage due to drilling fluid.

The final depth of drilling will be determined in the field based on geologic cuttings indicating a break in formations. This technique has been used successfully at the UNC site in the past (BAI; September, 1982) as evidenced by geophysical logging. Based on previous experience at the UNC site the shale break between the Mancos Shale and Zone 1 is easier to identify than the break between Zone 3 and Zone 2. The Zone 1 wells will be drilled first in order to obtain a better estimate of the depth of the Zone 3 wells to be drilled later.

Fractures may be encountered during the drilling of the wells. Any such fractures will be maximally developed to enhance well yield. In order to identify any fractures, a driller's log will be compiled and reported according to Section 45.001-000-000 of the EPA manual (EPA-57019-75-001) (see Appendix B). In addition, a penetration rate log (EPA-57019-75-001) will be compiled and reported. Should any indication of loss or gain of fluid and/or a rapid increase in the penetration rate be noted, the possibility of fractures will be noted at that depth. The possibility of

Should Ken Schmidt see this? SRIC?

fractures will be further investigated by the use of a Caliper geophysical log (see Geophysical Logging). Should either of these methods identify the presence of a fracture(s), the fracture area will be maximally developed before the casing is placed. The techniques to be used are discussed later in this report in the Well Development section.

Geophysical Logging:

When the drilling is complete, the wells will be geophysically logged. The types of logs to be used will be:

- Gamma
- Spontaneous Potential
- Resistance
- Neutron-Neutron
- Caliper

Gamma, Spontaneous Potential, Resistance and Neutron-Neutron logging techniques have been used successfully at the site in the past (BAI; January, 1982 and BAI; September, 1982). The Caliper log is recommended in an attempt to better identify the presence and depth of any fracture(s). Specifications and requirements related to geophysical logging are presented in Appendix C.

Well Design and Construction:

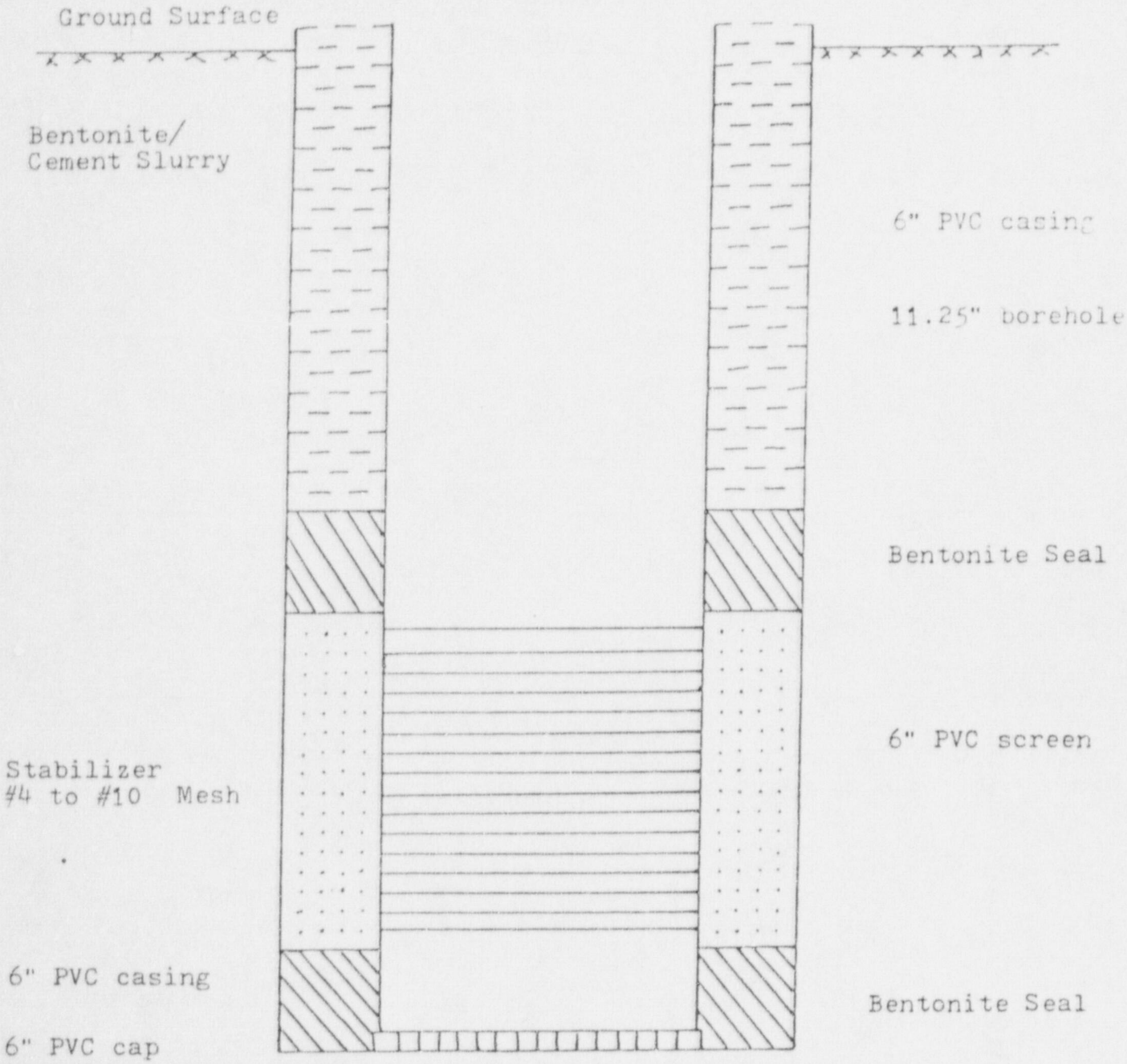
The proposed well design is based on previous experience and recommendations of other consultants and private firms (see Appendix A and References).

A cross-sectional view of a typical pumping well is shown in Figure 1. Detailed specifications and requirements related to well construction are presented in Appendix D. Each well will be drilled as described previously to a diameter of 11.25 inches except as noted in Appendix B and cased with 6 inch PVC.

The wells will be drilled and cased to a depth approximately 10 feet below the target formation. The bottom 10 feet will be sealed outside of the casing with Bentonite. The pump will be set in this bottom 10 feet allowing the maximum amount of drawdown to be obtained by pumping the water level to a point very near the bottom of the aquifer. The pump will be surrounded by a shroud to force water by the pump motors, reducing the potential for pump overheating.

won't dissolve? acid resistant?

Mr. Joe Renier, a Research Hydrologist with UOP, Inc. has recommended in personal communication (see Appendix A) that a formation stabilizer grain size be from 7 to 10 times larger than the 70 percent retained value of the finest



(Not to Scale)

Figure 1 - Cross Section of Pumping Well

grain size representative of a reasonable portion of that formation. He also recommended we rely heavily on information from those who have drilled in the area such as BAI and Shoemaker. Mr. John Shoemaker, a private consultant who has drilled numerous wells in the Gallup formation, recommended that a stabilizer grain size of small gravel may be appropriate. The approximate grain size range of gravel pack material used in previous wells constructed at the site falls within Mr. Renier's recommendations. However, because of his recommendation to rely heavily on information from experts who have drilled in the area it is recommended that a small gravel size material be used per Mr. Shoemaker's recommendation. Therefore a formation stabilizer grain size on the order of #10 to #4 (0.08 to 0.16 inches) mesh size will be used. The well screen slot opening will be designed to retain approximately 95 to 100 percent of the stabilizer. The stabilizer will be placed by gravity feed. Placement of a stabilizer by the use of a tremie pipe is not necessary (UOP, Inc.; 1975; page 203). The actual height of the stabilizer in the well will be determined by periodic measuring with a steel tape. When the desired height of the stabilizer is reached (approximately 2 feet above the top of the formation), a 10 to 15 foot seal will be made by gravity feeding bentonite pellets. Bentonite pellets will be used because of their success in the past and their ease of use in field applications. A bentonite/cement grout will be added in the borehole on top of the bentonite seal to form a

conflicts w/EID comments

grouting seal and prevent interformational contact. The placement of the slurry will be accomplished by the use of a grout pipe and pump (Johnson UOP, Inc.; 1975). As Johnson indicates (UOP, Inc.; 1975), 3 to 5 pounds of bentonite clay should be added to a 94 pound bag of cement with 6.5 gallons of water to form the slurry. This will be the mix specifications of the slurry to be used.

Well Development:

Fresh water will be circulated through the drill stem into the annulus for approximately one half hour until drilling mud has been replaced (Sobott; 1976) after the well is drilled but prior to setting casing. Fracture development techniques will be used to maximize well yield. Air jetting using the drill rig and a bull plug will be used at the depth where the fractures were encountered prior to setting casing. Using the drill stem, water will then be circulated, as discussed above.

like what?

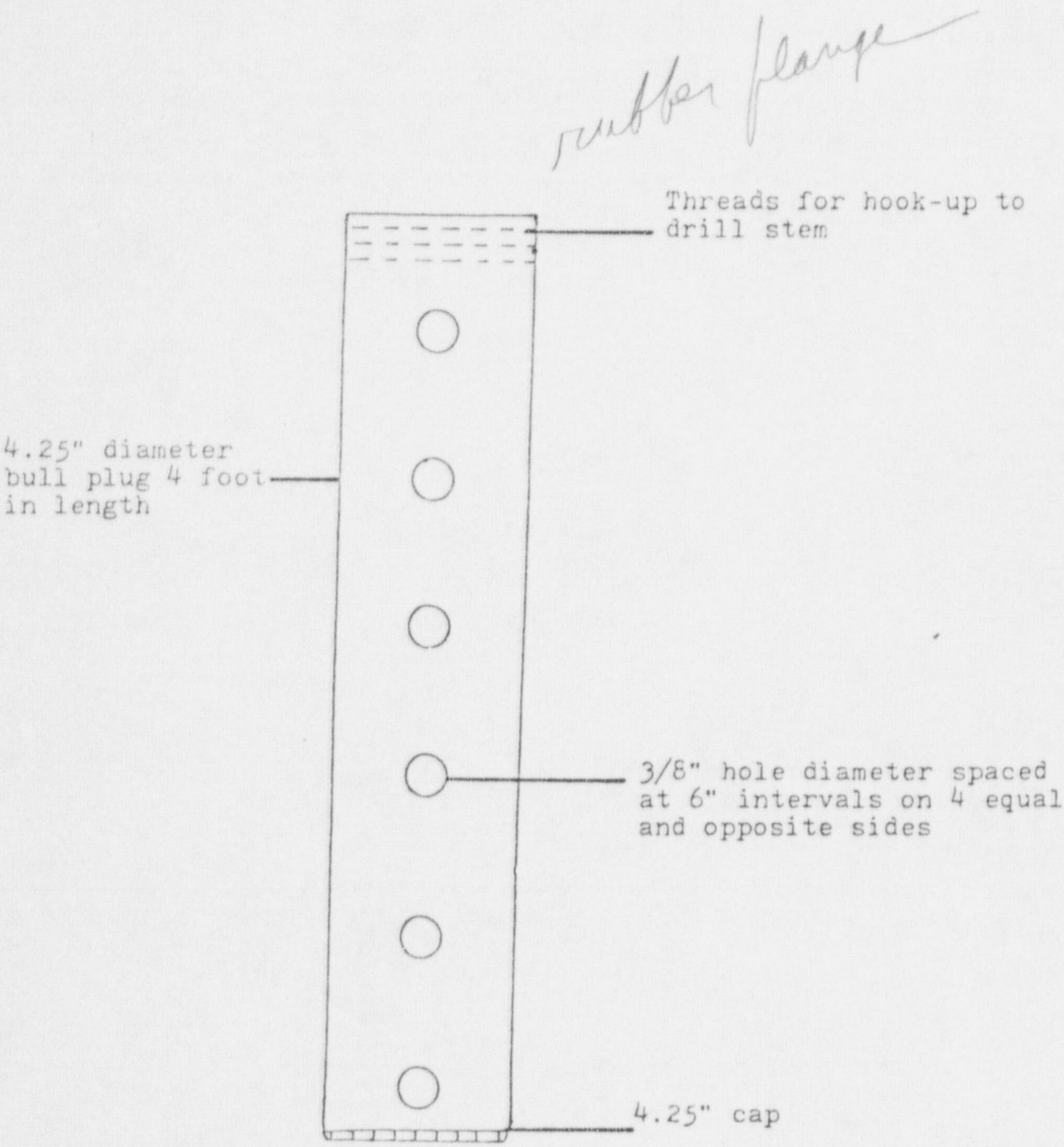
The following procedure for well development will occur after the casing is set. The well will first be air lifted using the drill rig and noting the amount of sand being lifted out of the well. The well will be allowed to recover for approximately one hour when it appears no further sand is being extracted. The well will then be bailed for approximately one hour using the bailer to bail and surge again using the drill rig. The well screen will be air jetted for approximately one hour or until the discharge is free from sand after the bailing is complete. Air jetting is accomplished by forcing compressed air through the drill stem and into the well bore. The process is aided by the use of a bull plug (see Figure 2) which, directs the flow of air directly onto the formation or well screen. Specifications and requirements related to well development are presented in Appendix E.

All water obtained from well development will be collected in a portable tank and pumped into a water truck for disposal into Borrow Pit #2. Upon completion of well development, the water in the mud pits will be disposed of in Borrow Pit #2 and the pits will be covered.

Bailing/Surging

The inside diameter of the casing/screen to be used is 5.7 inches. Therefore, a bailer with an outside diameter of approximately 4.25 inches will be used. Water will flow into the bailer from the top (see Figure 3). The bailer will be lowered to a specified depth next to the screen and raised and lowered rapidly. The effect is a surging action performed on the well screen. The well will then be bailed

how?



(Not to Scale)

Figure 2 - Bull Plug

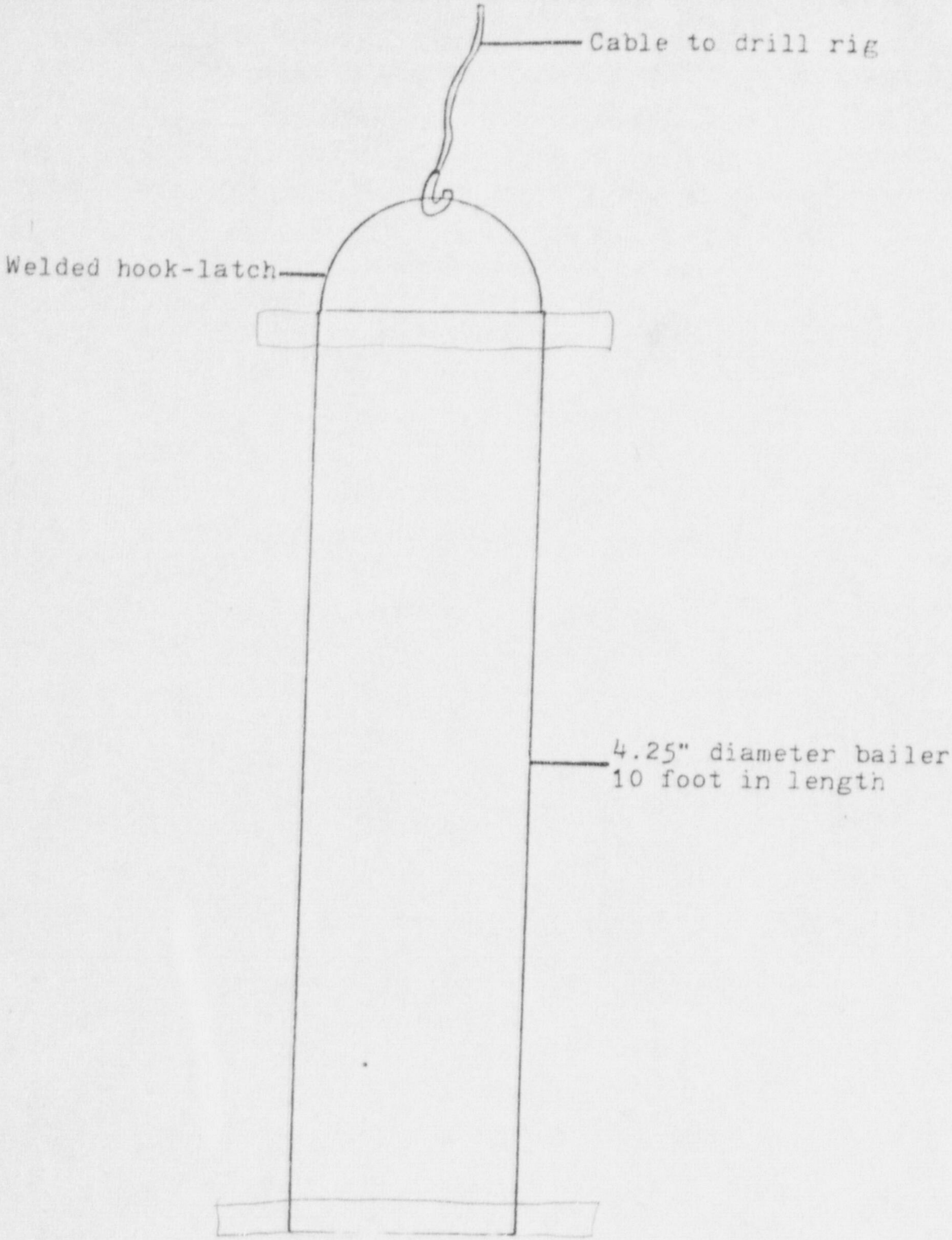


Figure 3 - Bailer/Surger

for approximately one hour after the entire screen depth has been surged.

Surveying:

Upon completion of well development, the wells will need to be surveyed for coordinates and elevations of ground surface and top of pipe.

Conclusion:

This report has been prepared as the initial step in installing a thorium seepage collection system. UNC Mining & Milling used the consulting services of Billings & Associates, Inc. and S. S. Papadopulos & Associates, Inc. In addition, the following municipal, state and federal agencies, private firms and consultants were contacted:

Johnson Division, UOP Inc.
City of Gallup
New Mexico State Engineer
John Shoemaker, Consulting Geohydrologist
National Water Well Association
United States Geological Survey
Public Health Service
Dennis Engineering

Appendix A lists the people contacted in these agencies and firms and the particular guidance they provided.

The results of this report indicate that the wells should be constructed as modified open boreholes with a screen and formation stabilizer used. It is our recommendation and the recommendation of others in consultanting and private firms to use a screen and stabilizer because of the potential for sluffing from a loosely consolidated formation. The potential for sluffing results from the following conclusions:

as contrasted to what?

1) Zones 1 and 3 at the site are near the outcrop area and are thus more susceptible to weathering resulting in a weaker matrix;
2) acid-leaching could have occurred thereby weakening the matrix;
3) the potential of sluffing is increased because of potential fracture(s) in the area;
4) previous drilling at the site has produced only a small amount of chips returned in the drilling fluid indicating a loosely cemented rock and
5) previous drilling at the site has indicated sluffing occurs in open boreholes (BAI; January, 1982).

A coarse grained stabilizer has been recommended to minimize effects on well efficiency although discussions with others (see Appendix A) and several water well design texts, manuals and papers indicate that the gravel pack materials used previously for wells at the UNC site would be satisfactory as a stabilizer. The grain size of the stabilizer will be 0.08 to 0.16 inches. The uniformity coefficient of less than 2.0 used in the past will also be specified here. The grains of the stabilizer will be well rounded in order to maximize the permeability of the stabilizer.

A size-50 (0.05 inch), V slot, PVC screen will be used to retain 95 to 100 percent of the stabilizer. A larger slot size will not be used because of the increased potential for screen collapse. The size-50 slot (0.05 inches) will transmit approximately 16 gallons per minute per foot of screen with an entrance velocity of 0.1 feet/sec. Given that anticipated yields should be much less than 16 gpm/foot of screen, the screen slot size as well as the stabilizer should not produce resistance effects that would cause well efficiency problems.

Should a fracture(s) be encountered in the drilling of the wells proposed herein, the approximate depth range of the fracture will be developed by the use of air lifting and jetting techniques at that depth before setting casing. The development procedure after the casing is set will be consistent with industry accepted practices including the use of surging techniques.

The personnel responsibilities as well as the responsibilities of the on-site hydrologist are presented in Appendix F.

Appendix A: Personal Communication with Outside Sources

1. Johnson Division, UOP Inc.

- Joe Renier

- if rock is consolidated, use an open borehole.
- to be safe from losing the well, use a formation stabilizer 7 to 10 times larger than the pertinent formation grain size.
- The rock is loosely consolidated if you get just a few chips from the cuttings (Typically, there are very few chips received from the cuttings.).
- Design features for unconsolidated rocks were also discussed but are not presented here.
- Suggested using a uniform formation stabilizer (uniformity coefficient less than 2) and a slot size necessary to retain all of the stabilizer. This avoids the settling effects from natural pack development and standard formation stabilizer applications.
- Suggested that we rely heavily on sources that have drilled in the area before.

2. City of Gallup

- William Petranovitch

- a gravel pack design was originally used for municipal wells drilled in the Lower and Upper Gallup formation. However, since that time open boreholes have been used with no sluffing or sanding problems.

3. <u>New Mexico State Engineer</u>

- Bob Rogers
  - knew of no special technique other than conventional (air lift, surge) for developing fractured sandstones without actually inducing the fractures.

- Charles Wohlenberg
  - knew of no special technique other than conventional (air lift, surge) for developing fractured sandstones.

4. <u>John Shoemaker</u>; Consulting Geohydrologist

- John Shoemaker
  - suggested using a stabilizer if experience has shown some indication of sluffing (sluffing has occurred at the UNC site - BAI; January, 1982).
  - his experience in the Gallup formation is not to put a pump in the ground unprotected. Use at least a screen and if the cost doesn't prohibit it, a formation stabilizer.
  - suggested using a small gravel sized uniform stabilizer and a slot size necessary to retain all of the stabilizer.
  - suggested that for development, use over-pumping or air lifiting.

5. <u>National Water Well Association</u>

- John Voytek

- if a gravel pack design is used, suggested taking return flow cuttings.
- did not think coring was necessary for design of gravel packed wells.
- suggested the developing of fractured sandstones is best accomplished by blowing or pumping a concentrated flow of air or water in the fracture area.

6. United States Geological Survey

   - Ed Welder

   - doesn't know of any particular technique other than conventional (air lift, surge) for developing fractured sandstones.

7. Public Health Services - Window Rock

   - Masud Zaman

   - his experience in the Gallup formation is to develop the well by air lifting. Use air lift and foam if the well is deep (i.e., greater than 400 feet).

8. Dennis Engineering

   - Ray Dennis

   - discussed the procedures and problems involved with sieve analysis techniques.

Appendix B: Well Drilling Specifications and Requirements

Specifications & Requirements

Site Preparation

- Excavation of Mud Pits
- After well development water in the mud pits will be pumped and discharged into Borrow Pit #2 and mud pits will be recovered.

Drilling Technique

- Rotary
- Drilling will be accomplished with air until such time as difficulty in returning cuttings is obtained. By drilling with air, an approximation of the depth of the first water encountered will be made.

Drill Bit

- 11.25" diameter
- Tri Cone
- Note: Because 450 A was drilled with a 12.25" borehole, this well will have to be drilled with a 13.00" drill bit.

Drilling Fluid

- Revert (biodegradable)
- Mix in quanitities thick enough to remove cuttings

Estimated Depths

- 4 Zone 3 wells - 125 feet
- 3 Zone 1 wells - 195 feet
- Note: Gallup 3 (Zone 3 well) may have to be reamed to a depth of approximately 200 feet, depending on its present depth. This well will also have to be sealed from its present depth to the target formation depth.

Mud Pits

- 2 pits for each hole
- 10 feet x 6 feet x 4 feet deep

<u>Driller's log</u> (to be prepared and presented to the on-site hydrologist)

- Reference point for all depth measurements
- Depth at which each change of formation occurs
- Depth at which the first water was encountered
- Depth at which each stratum was encountered
- Thickness of each stratum
- Identification of the material of which each stratum is composed
- Depth at which hole diameters (bit sizes) change
- Total depth of the well
- Any and all other pertinent information for a

complete and accurate log

- Depth and location of any loss or gain of drilling fluid
- The relative rate of penetration of the drill bit of each foot of formation

Appendix C: Specifications and Requirements for Geophysical Logging and Surveying

Geophysical Logging

Specifications

- Each well will be geophysically logged for the following parameters:
  - Caliper
  - Gamma
  - Spontaneous Potential
  - Resistance
  - Neutron - Neutron
- The vertical scale will be on the order of 1 inch per 10 feet of depth
- A field copy will be presented to the on-site hydrologist
- A final copy and the digital tape will be mailed to UNC at a later date

Surveying

Specifications

- All wells will be surveyed for their coordinates as well as ground surface and top of pipe elevations.

Appendix D: Well Construction Specifications and Materials

Specifications

Screen

- 6" diameter
- Schedule 40
- 50 V slot (0.05 inches)
- Wound Plastic

Casing

- 6" diameter
- Schedule 40
- Bell End

Stabilizer

- 95 percent passing #4 mesh (0.16")
- 5 percent passing #10 mesh (0.08)
- Uniformity Coefficient less than 2.0
- Well rounded gravel, not crushed rock
- Clean, quartz gravel, non-calcareous (i.e., no lime material)
- On site quality control of the material will be made by obtaining 10 random samples and having these samples analyzed for the above specifications by a testing laboratory. From this analysis, the on-site hydrologist will determine if the materials meet specifications.

End Caps

- Schedule 40
- 6" diameter

Slip Couplings

- Schedule 40
- 6" diameter

Bentonite Pellets

- 1/2 inch diameter

Grout Mixture

- One 94 pound bag of cement
- 4 pounds of bentonite clay (loose bagged)
- 6.5 gallons of water
- Mix bentonite and water first, then add cement to the clay- water suspension

why bentonite?

Grout Placement

- Using a grout pipe, pump the slurry into the annulus beginning at the desired bottom depth and pushing the grout upward, slowly removing the grout pipe
- The mixing and placement must be in one continuous operation

Bentonite Pellet Placement

- Bentonite pellets will be added from the ground surface into the annulus and taped to correct depths

Stabilizer Placement

- The stabilizer will be added from the ground surface into the annulus and taped to correct depth

Screen/Casing Placement

- The screen/casing shall be placed with the aid of the drill rig by gluing and covering each successive screen/casing joint. This procedure is defined as EPA guideline 47.040-000-000 (EPA-570/9-75-000).

Materials

Zone 3; 4 wells

Material	Units	Quantity
Screen	feet	280
Casing	feet	420
Bentonite Pellets	pounds	4,000
Stabilizer	cubic feet	140
End Caps	each	8
Slip Couplings	each	40
PVC Primer	cans	6
PVC Glue	cans	6
Primer Brushes	each	6
Grout - cement, bentonite (loose bagged), water	cubic feet	160

Note: A maximum of 50 extra cubic feet grout may be needed for well 613 (Gallup 3 reamed) depending upon the present depth of Gallup 3.

Materials

Zone 1; 3 wells

Material	Units	Quantity
Screen	feet	180
Casing	feet	480
Bentonite Pellets	pounds	3,750
Stabilizer	cubic feet	105
End Caps	each	6
Slip Couplings	each	40
PVC Primer	cans	6
PVC Glue	cans	6
Primer Brushes	each	6
Grout - cement, bentonite (loose bagged), water	cubic feet	220

Appendix E: Well Development Specifications and Requirements

Specifications

Fracture Development

- Air lifting and surging the estimated fracture depth with the use of the drill rig's compressor and a bull plug (see Figure 2). The bull plug will be supplied by the driller.
- The air compressor will be capable of delivering up to 30 cubic feet per minute of air at a pressure of not less than 100 psi.

Well Development

- Air lifting using the drill rig's compressor
- Bail/surge using the drill rig and a bailer (see Figure 3). The bailer is to be supplied by the driller.
- Air Jetting using the drill rig and bull plug
- Total development time approximately 6-7 hours per well.

Discharge of Water

- All water derived from well development will be collected by the use of a portable tank. This water will then be pumped into a water truck for disposal into Borrow Pit #2.

Appendix F: Personnel Responsibilities and Time Estimates As Related to Each Phase of the Project

Drilling (7 hours per well)

- Drill Rig and Crew (duration) - see Appendix B
- On-site Hydrologist (duration) - verification of requirements and material specifications (Attachments 1 and 2)
- Senior Hydrologist (2 days)

Geophysical Logging (3 hours per well)

- Geophysical crew and truck - see Apppendix C
- On-site Hydrologist (duration) - verification of requirements and material specifications - responsible for notifying logger to appear on site immediately after the well is drilled

Construction (4 hours per well)

- Drill rig and Crew (duration) - see Appendix D
  - Crew to place casing/screen, stabilizer, bentonite pellets and grout.
- On-site Hydrologist (duration) - verification of requirements and material specifications (Attachment 1)

Development (7 hours per well)

- Drill Rig and Crew - see Appendix E
  - Rig and crew to perform air jetting, air lifting, bailing and surging
- On-site Hydrologist (duration) - verification of requirements and material specifications (Attachment 1)

Surveying (4 hours)

- Surveying Crew - See Appendix F
  - UNC personnel
- On-site Hydrologist (duration) - verification of requirements and material specifications

Stabilization (10 hours)

- On-site Hydrologist (duration) - verification of requirements and material specifications

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