NYE COUNTY NUCLEAR WASTE
REPOSITORY PROJECT OFFICE

TEST PLAN

TITLE: **Pumping Tests with Thermal Logging in Early Warning Drilling Program Wells Using Distributed Temperature Sensor Equipment**		Revision: 0 Date: 11/01/2010 Page: 1 of 18
TEST PLAN NUMBER: **TPN-6.3**	SUPERSEDES: **None**	
APPROVAL Director 11/1/10 Date	CONCURRENCE Geoscience Manager 11/2/10 Date Principal Investigator 11/2/10 Date Quality Assurance Officer 11/2/10 Date	

1.0 INTRODUCTION

This test plan (TPN) provides detailed instructions for the collection of temperature data in observation wells during pumping operations in Nye County Nuclear Waste Repository Project Office (NWRPO) Early Warning Drilling Program (EWDP) wells using the Silixa Ultima High Spatial Resolution Distributed Temperature Sensor (DTS) data acquisition system starting in November 2010.

The work described in this TPN will be conducted by Nye County personnel in collaboration with the University of Nevada – Reno (UN-R) utilizing a system available from the National Science Foundation sponsored Centers for Transformational Environmental Sensing Programs (CTEMPs).

NWRPO work plan WP-6.0, *Early Warning Drilling Program Geophysical Logging Work Plan*, provides the background, purpose, and general objectives of geophysical data collection in EWDP boreholes and wells.

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2.0 BACKGROUND AND PURPOSE

While conducting various phases of tracer testing activities at Site 22 in boreholes NC-EWDP-22S, -22PA, and -22PC, beginning in November 2004 and continuing through November 2009 (in accordance with NWRPO Test Plan TPN-9-5), it became apparent that discrete intervals within individual well screens in Zone 2 in these wells may be producing water at varying rates. Nye County believes that more detailed information on these features and others similar to them will lead to a better understanding of groundwater flow pathways in Valley Fill Aquifer system.

The collection of temperature data in existing observation wells 22PA and 22PC during pumping of well 22S using the DTS method described in this TPN will aid in identifying preferential flow pathways and improving estimates of flow and transport properties within individual screened units.

The technique will be tested at well NC-EWDP-4PD and nearby observation wells prior to testing at Site 22. Site 22 is located in Forty Mile Wash downgradient from Yucca Mountain in the southwest corner of the Nevada Test Site, and well 4PD is located downgradient of Site 22 in Forty Mile Wash outside of the Nevada Test Site boundary.

3.0 SCOPE OF WORK

3.1 Responsibilities

The Principal Investigator (PI) is responsible for supervising the data collection activities described in this TPN. NWRPO personnel, including staff and contract geologists and technicians, are responsible for conducting the activities described in this TPN.

The Field Safety Supervisor (FSS) is responsible for monitoring the health and safety of workers relative to the guidelines established in the NWRPO Site Specific Health and Safety Plan (SSHASP).

The Site Supervisor is responsible for ensuring the completion of work in a safe manner according to the guidelines established in this TPN.

Nye County Field Personnel, as assigned by the PI, FSS or Site Supervisor are responsible for the completion of the activities described in this TPN.

Initial setup and calibration of DTS field equipment will be done by UN-R personnel following CTEMPS guidelines as directed by the PI. Subsequent setup and calibration of DTS field equipment may be done by Nye County Field Personnel as directed by the PI in consultation with the Geoscience Manager.

3.2 Well Locations

Figure 1 shows the locations of existing EWDP wells. Temperature logging work will be conducted in wells 4PA and 4PB during pumping in well 4PD, and in wells 22PA and 22PC during pumping in well 22S. Well completion diagrams for these wells are found on Figures 2 through 7.

3.3 Equipment Requirements

The equipment required for DTS temperature logging shall be used according to manufacturer's specifications or methods detailed in this TPN and are listed in Table 1. Existing pumps and associated downhole and surface discharge and sampling equipment as discussed in TPN-9.5 for Site 22 and TPN-10.0 for other locations shall be used as directed by the PI.

Table 1
DTS Logging Equipment

Item (In Alphabetical Order)	Amount
Control Panel for heater wire (240 volts at 33 amps)	1
Electric wireline winch	1
Fiber optic cable, 2-fiber, 50/125, indoor/outdoor with E2000 connector	2x 1350
Field Trailer, air conditioned	1
Generator (25 kilowatt [KW] minimum), 240 Volts	1
Heater wire (14-AWG 2-conductor)	2x 1350
Polyvinyl chloride (PVC) pipe ¾-inch (in.) diameter	12 inches
PVC Tape, 10-mil	1 roll
3M™ Scotchcast™ electrical insulating resin	2
Silixa Ultima high spatial resolution DTS temperature logger, associated software and monitor	1
PT 100 thermistor string	1
In-Situ LevelTroll (30 PSI or 100 PSI range) with backshell hanger	2
In-Situ LevelTroll (500 PSI range) with backshell hanger	1

3.4 Safety

NWRPO personnel shall adhere to the safety practices described in the SSHASP. Hazard Analysis worksheets will be completed by the FSS prior to commencement of work to determine what hazards are present and the control measures or personal protective equipment (PPE) necessary to mitigate them. All personnel shall wear appropriate PPE at all times and stop work if life-threatening or otherwise unsafe conditions develop or are observed. Work shall resume only when actions have been taken to correct unsafe conditions and all on-site personnel have been briefed.

Note that the Silixa Ultima DTS is a Class 1M laser product, and care should be taken to avoid looking directly into or magnifying the laser while it is energized. Users should refer to the manufacturer's documentation (Silixa Ultima Quick Start Guide) for the DTS safety warnings and precautions.

4.0 PUMP INSTALLATION AND DATA COLLECTION

Preparation for possible pump operations shall include the following steps:

1. Place the generator specified onsite on secondary containment, as specified in the SSHASP. Hang a suitable pump control panel on the generator.

2. At the direction of PI, direct the pumping contractor to lift the submersible pump and motor, with the pumping rig, slightly off the ground so that the pump is in a vertical position.

3. Tape a 250-psia SAM as close as possible to the top of the 5-foot-long pump. The SAM must be less than 7 feet above the pump intake. Protect the SAM with the spider centralizer.

4. Record the distance between the midpoints of the pump intake and the SAM in the scientific notebook.

5. Run the submersible pump into well on the 2-inch galvanized steel pipe, being careful to avoid damaging the SAM cable. Tape the SAM cable to the pipe above and below each collar as it is being fed into the hole.

6. Set the bottom of the pump 3 feet above the top of the existing PVC pipe/MP55 casing connection to maximize available drawdown for the pump.

7. Record all depth control information on a Tubing and Casing Record, found in TP-7.0, *Drill Site Management*.

8. Ensure that the pumping contractor remains onsite until the submersible pump has been restarted.

9. Connect a 4-inch galvanized steel pipe and 3" flexible discharge line to the submersible pump at the wellhead similar to the piping schematic shown on Figure 8. Ensure that a 2-inch water meter is in a straight run of pipe at least 3 feet from any upstream or downstream flow disturbance, such as bends or valves, and upstream from the control gate valve.

10. Connect a PT100 thermister with compression fitting supplied by UN-R to the ¼" sample port on the discharge line as shown on Figure 8. Prior to starting pump, UN-R personnel will set up PT100 thermister in flow through cell to measure discharge temperature.

11. Photograph the discharge line to comply with permit regulations.

12. Use a manual water level probe to measure the depth to water in Screen 2 in 22S, 22PA, and 22PC; or in 4PD, 4PA, and 4PB. Record these measurements in the Scientific Notebook.

13. Attach the Westbay transducer in pumping well to the data logger, and set the recording interval to 5 seconds for the first 1 hour of pumping and 30 seconds thereafter, and begin recording readings. Continue logging until the pumping described in Section 6 is stopped and the PI or FSS directs logging to stop.

5.0 DTS INSTRUMENTATION AND DATA COLLECTION

The DTS system will utilize a Silixa Ultima high spatial resolution 1M laser system available from the National Science Foundation sponsored Centers for Transformational Environmental Sensing Programs (CTEMPs). The system will consist of a minimum 2 channel DTS and associated on-board computer and data acquisition system. Data will be stored on board the system. The systems will be capable of collecting and stacking distributed temperature data along the length of a fiber optic cable at user-defined intervals at a spatial resolution of 25 cm.

Raw stokes/anti-stokes intensity data will be processed in the field based on initial calibration using proprietary software from Silixa. Further processing of field data based on downhole LevelTroll temperature data, discharge temperature data, and calibration bath data will be done by UN-R after completion of field work.

Be sure to collect manual water level measurements as directed in Section 4 prior to installation of DTS equipment.

5.1 Cable Preparation

The downhole end of the heater wire should be prepared as follows:

1. Split the two conductor wires apart approximately 2-inches (in.) at the end of the wire;
2. Strip 1-in. insulation from the end of each wire;
3. Twist the two wires together and solder the connection;
4. Place the wires inside a 6-in. long section of ¾-in. outside diameter (O.D.) PVC pipe; and
5. Mix and pour Scotchcast™ electrical insulation resin into the pipe, around the wires and let set up overnight.

Once the resin has set, the heater wire is ready to be installed.

The downhole end of the fiber optic cable should be prepared in a similar manner:

1. Fold the end of the fiber optic cable over approximately 1-in. from the end of the cable, crimp the bend with pliers, and secure with electrical tape;
2. Place the folded end of the fiber optic cable inside a short section of ¾-in. O.D. PVC pipe; and
3. Mix and pour Scotchcast™ electrical insulation resin into the pipe, around the cable and let set up overnight.

Once the resin has set, the fiber optic cable is ready to be installed.

5.2 Temperature Profiling

A temperature profile log will be run prior to cable installation in each observation well:

1. Program 500 PSI LevelTroll to record a temperature and pressure data at one second intervals.
2. Install backshell hanger with o-ring on LevelTroll.
3. Connect LevelTroll to cable on Westbay reel.
4. Lower LevelTroll to water level in well
5. Conduct temperature profile log by lowering LevelTroll to bottom of observation well at approximately 30 ft/min and then raising LevelTroll to top of water column at same rate.
6. Remove LevelTroll from observation well.
7. Download temperature and pressure data from LevelTroll.
8. Repeat steps 1 through 7 for second observation well.

5.3 Cable Installation and Removal

5.3.1 Cable Installation

Heater and fiber optic cables should be installed in monitoring wells at each site. It is preferable to use an electric winch cable as a support member due to the weight of the heater wire and fiber optic cables (approximately 0.07 lbs [pounds]/ft together). The procedure for installing cables using a winch is as follows:

1. Set up a tripod and sheave block over the well to be instrumented and position spools on spool stands so each cable will feed into the well without interference;

2. Run the heater cable over the sheave block and position the cable head at the top of the well casing;

3. Tape the resin-sealed fiber optic cable ends to the heater cable end after running heater cable through sheave;

4. Determine the depth in the well at which the 100 or 30 PSI In-Situ LevelTroll will be submerged to approximately 75% of its pressure range;

5. Program LevelTroll as directed in Section 5.4.5;

6. Install backshell hanger with o-ring on LevelTrolls;

7. Strap 500 PSI LevelTroll (without direct read surface cable) to downhole cable such that the transducer port will be located with the screened interval in observation well 4PB;

8. Strap 100 or 30 PSI LevelTroll (without direct read surface cable) to downhole cable assembly such that the transducer port will be at depth determined in Step 4 above;

9. Begin lowering the heater wire, LevelTrolls and fiber optic cable into the well ensuring the cables feed into the well without snagging, pinching or kinking;

10. Continue lowering the cables into the well, taping the heater wire, and fiber optic cables to the winch cable every 10 ft; and ensuring the cables feed into the well without snagging, pinching or kinking.

11. When the bottoms of the cables reach the desired depth, clamp the heater cable at the top of the well ensuring that the cable clamps do not breach the protective jacket on the heater cable. For data collection procedures, see section 5.4.

12. Run the remaining lengths of heater wire, and fiber optic cable inside PVC pipe to the office trailer, if present. Ensure that all lengths of cable at ground surface are protected from local fauna.

13. Plug the heater wires into generator. Plug the E2000 connectors on the end of the fiber optic cables into the Silixa Ultima DTS; and

14. Allow the cables to equilibrate to in situ temperatures (allow approximately 2 hours) before any data are collected.

5.3.2 Cable Removal

After data collection is complete, ensure that the system is de-energized and all power cables are disconnected from the heater wire and its control panel. Disconnect the fiber optic cable from the DTS. Remove the heater wire and fiber optic cables from the well according to the following instructions:

1. Power up the winch and use it to pull the support cable up until the clamp is off the top of the well. Remove the clamp.

2. Continue winching in the support cable until the first piece of tape passes the top of the well. Remove the tape, being careful not to crush or pinch the fiber optic cable, and reel the heater wire and fiber optic cables onto their respective spools.

3. Repeat step 2 until the LevelTroll has reached the top of the well casing. Remove LevelTroll from cable assembly.

4. Repeat step 2 until the resin-sealed ends of the wires have reached the top of the well casing. Remove them from the winch cable and secure the reels for transport, if necessary.

5.4 DTS Data Collection

Data collection shall comprise three separate phases: background, heating, and cooling data. A description of the DTS configuration and each phase can be found in the sections below.

5.4.1 Silixa Ultima DTS System Setup and Startup

Once cables are installed in the well, they should be allowed to equilibrate to in situ temperatures before any data are collected (allow approximately 2 hours). While the cables are equilibrating, set the DTS system up in the field trailer (e.g., attach the keyboard, monitor and power cords). Temperatures in the field trailer should be kept below 85 °Fahrenheit (F) to prevent the DTS from overheating. If a field trailer is not available, an insulated box of sufficient size may be used if ambient temperatures are less than 85 °F. The procedure for powering up the Silixa Ultima DTS and collecting data is outlined in the Silixa Ultima Quick Start Guide and will follow CTEMPs guidelines.

5.4.2 Background Data

Background data are used to help identify temperature conditions in the well or borehole prior to disturbance by heating and cooling.

After the fiber optic cable has equilibrated to in situ temperatures, collect background data overnight following the instructions in the Silixa Ultima Quick Start Guide, adding a note in the configuration file identifying the file as background data.

5.4.3 Data Collection during Pumping

1. Prior to starting pump start DTS data collection in observation wells as detailed in section 5.4.1.
2. After one cycle (15 minutes or 900 sec.) or longer as directed by the PI, start pump, and continue DTS data collection until after pumping operations are stopped.

5.4.4 Heating and Cooling Data

Heating and cooling data help identify zones in the well or borehole where groundwater may be moving. These zones appear as anomalous highs or lows in the temperature data. Heating data should be collected as follows:

1. Start data collection as detailed in the Silixa Ultima Quick Start Guide. After one cycle (15 minutes or 900 sec.) or longer as directed by the PI, turn the heater wire control switch to the "On" position. Note that the power output of the control panel is about 8000 watts.
2. Heating data should be collected for a minimum of 48 hours, at the discretion of the PI.
3. After 48 hours of data have been collected, turn the heater wire control switch to the "Off" position. Collect cooling data for the same length of time as heating data were collected; and
4. After collection of heating and cooling data is complete, stop logging according to the Silixa Ultima Quick Start Guide.

5.4.5 Pressure Transducer Data

Downhole pressure data will be collected in the DTS wells during pumping operations utilizing a 30 or 100 PSI (Upper) and 500 PSI (4PB Lower) In-Situ LevelTroll 700. Prior to installation, program LevelTrolls to collect a reading every 10 seconds.

5.5 Temperature Drift and Calibration Determination

Calibration of the DTS will follow standard CTEMPs recommended procedures for single ended measurements. During the entire experiment, two well mixed reference temperature baths will hold at least 20 meters of fiber optic cable, and will be monitored with independent PT100 thermistors. In addition, the downhole LevelTrolls will serve as additional calibration points. The two surface baths will consist of an ambient bath, and a slightly heated bath using a commercially available aquarium heater. It is not critical that the baths remain steady in temperature, only that they change temperature slowly in comparison to the monitoring interval, and are continuously monitored. Instrument drift, as well as any changes in the optical fiber properties can then easily be accounted for in the post-measurement calibration phase. Using three known temperatures, it is anticipated the temperature resolution will be as low as 0.03 C, while absolute temperature accuracy is controlled by the PT100's and LevelTrolls, and will be approximately 0.1 C or better.

All raw data and calibration data will be submitted to the NWRPO Quality Assurance Records Center (QARC), in accordance with Quality Assurance Procedure 12.1, Rev. 2, along with any additional field data collected during calibration.

5.6 Data Processing

Data are recorded by the DTS in text format. The location of these files on the hard drive can be noted in the scientific notebook at the time of data collection. The name of each data file will contain a well and zone designation, an eight-digit date, three-digit configuration file designation and five-digit sequential file identification number. For example, the filename *32P deep 20060608 002 00003.ddf* represents the third sequential data file, collected according to the second configuration file in the deep piezometer tube at well NC-EWDP-32P on June 8, 2006.

After a complete set of background, heating and cooling data has been collected (e.g., for a 120-hour period), files are to be transferred to a computer and processed using both the manufacturer's software and software available directly from CTEMPs for data collation, calibration and plotting.

6.0 PUMP OPERATIONS AND DATA COLLECTION

Prior to starting pump ensure that background DTS data has been collected overnight. If DTS data collection was terminated after the background period be sure that data collection has restarted and that pressure data collection has commenced in the pumping well as described in Section 5.

Pumping and Sampling

1. Record the water meter volume in the scientific notebook.

2. Start the pump. The pump will run continuously during the entire 48 hour heating and 48 cooling periods.

3. Grab samples will be collected twice daily from 22S during pumping as directed by the PI. No samples will be collected during testing at 4PD. After the pump has run for approximately 1 hour in 22S, obtain a grab sample. Collect grab water samples in pre-labeled 250-ml amber glass bottles. Cap the bottle and place the sample in a cooler with blue ice. Store all samples on ice until delivered to lab for analysis.

4. Copy and email pages from the scientific notebook for testing activities to the PI and Geoscience Manager at the end of each day of testing.

7.0 RECORDS

Data collected as part of this TPN are recorded electronically by the Silixa DTS and the Westbay and In-Situ dataloggers and are documented manually in the appropriate scientific notebook.

Data will be submitted, along with metadata describing their collection and limitations, to the NWRPO QARC for archival. Records in the QARC are available upon request.

8.0 REFERENCES

Applicable NWRPO Plans and Procedures

Silixa Ultima Quick Start Guide, Release Version 1.1 – August 2010.

Independent Scientific Investigations Program Health and Safety Program, *Site Specific Health and Safety Plan for General Field Activities.*

Quality Administrative Procedure QAP-5.2, *Preparation of Work Plans and Technical Procedures.*

Quality Administrative Procedure QAP-12.1, *Control of Measuring and Test Equipment.*

Work Plan 6, *Early Warning Drilling Program Geophysical Logging Work Plan*

Test Plan 9. *Natural Gradient Cross-Hole Tracer Test at Site 22.*

Test Plan 10-0. *Pumping/Injection Tests of Packed-Off Zones in Unscreened Open Boreholes or in Multiple Screen Boreholes with or without Observation Wells.*

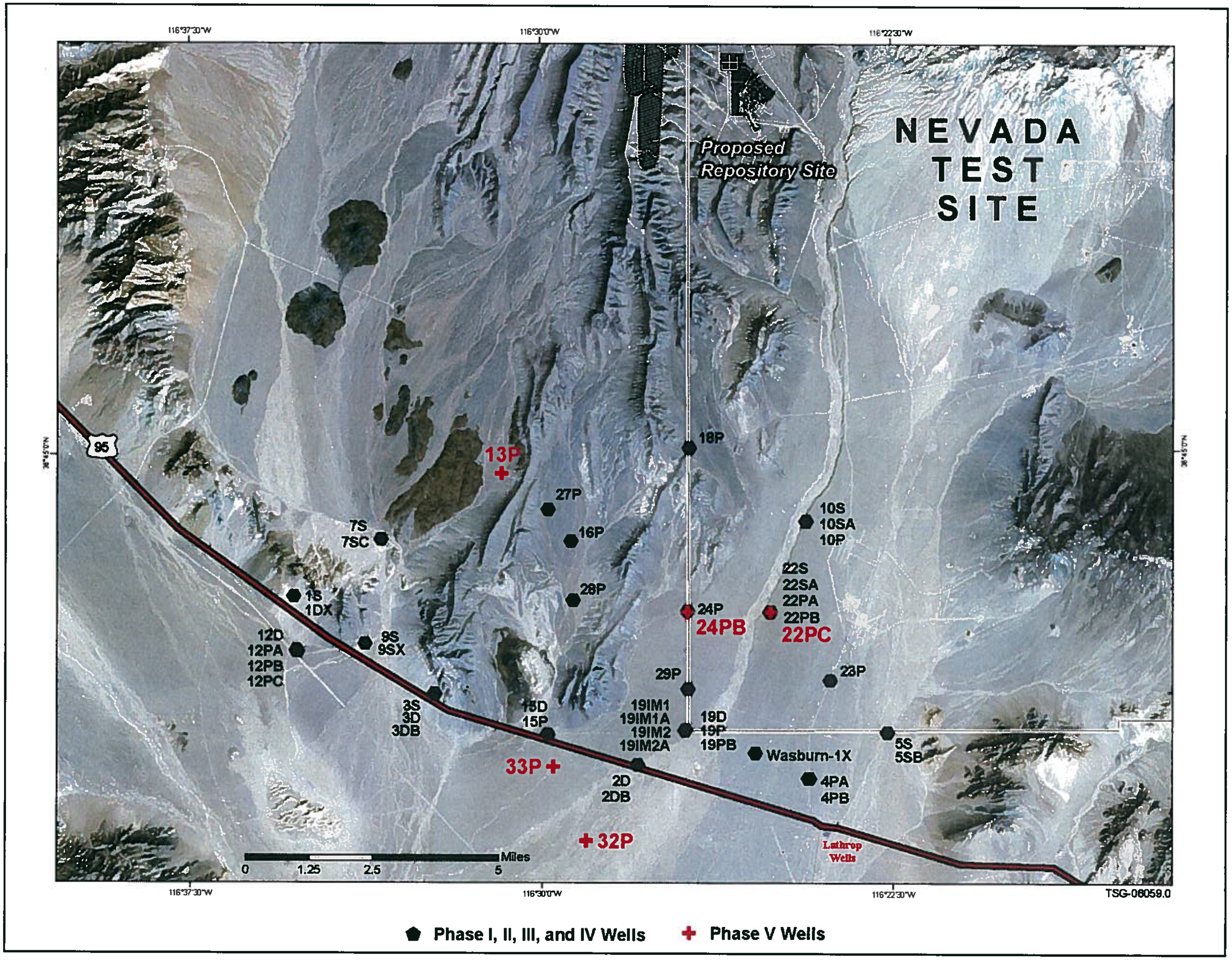

Figure 1
EWDP Well Location

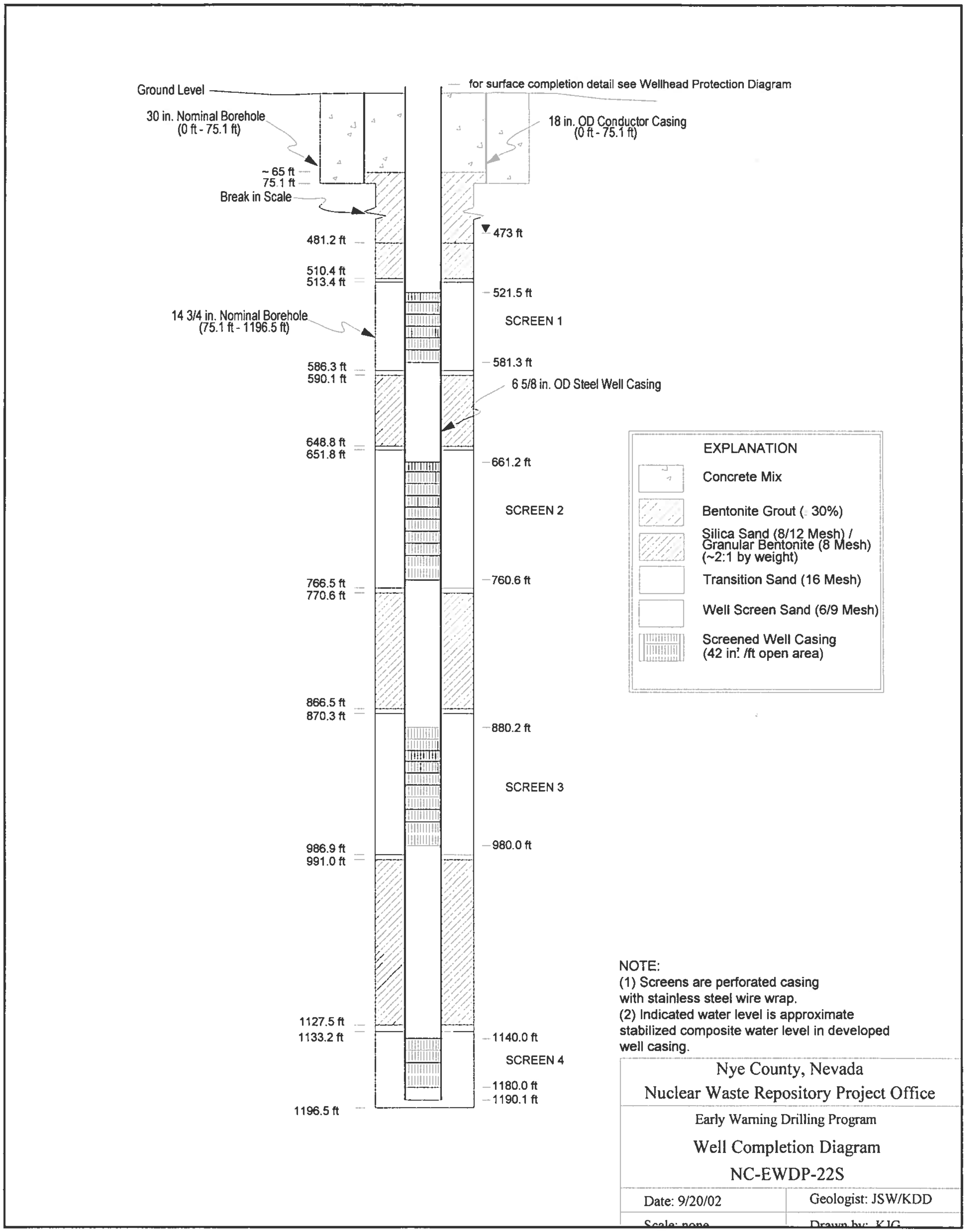

Figure 2
Completion Diagram for 22S

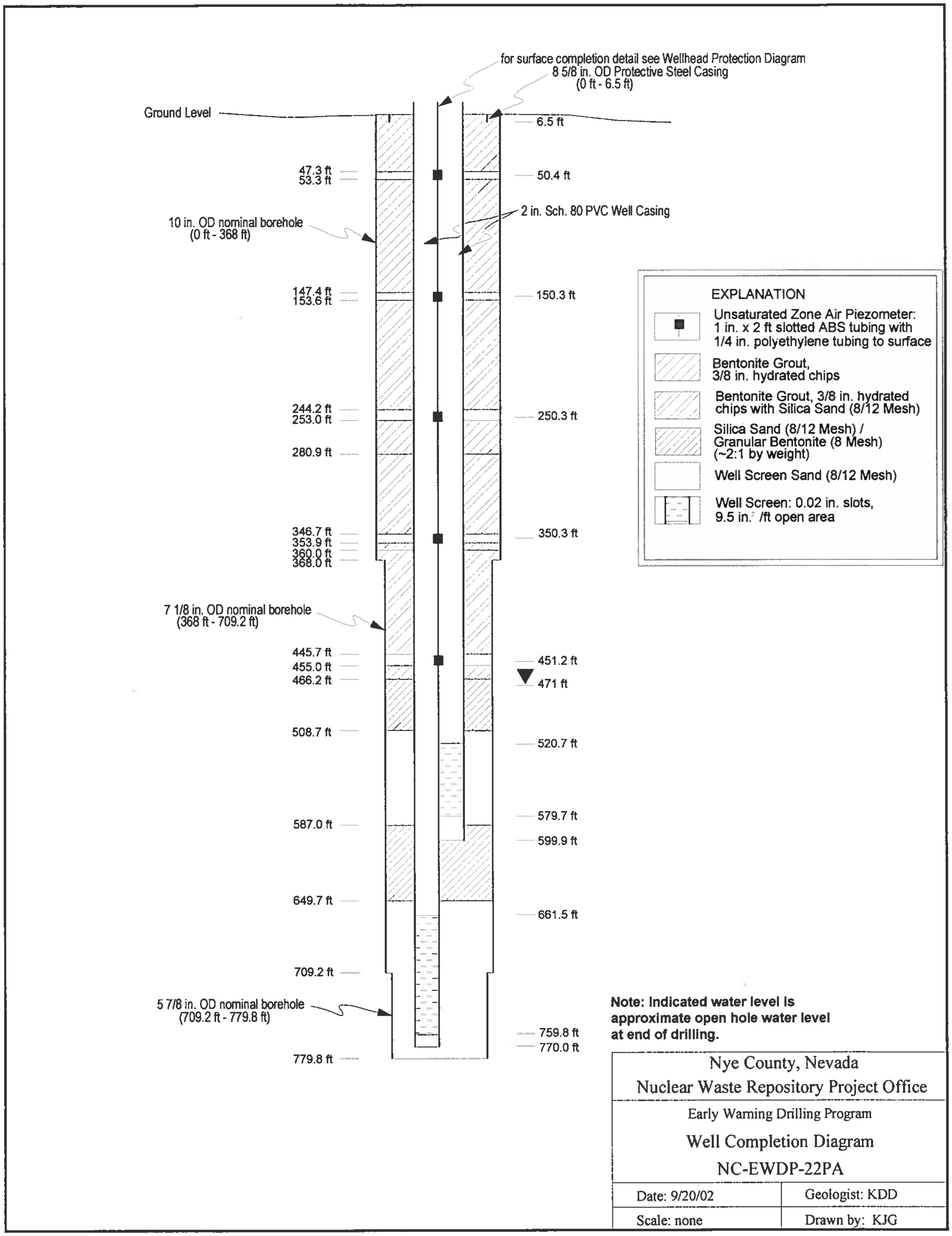

Figure 3
Completion Diagram for 22PA

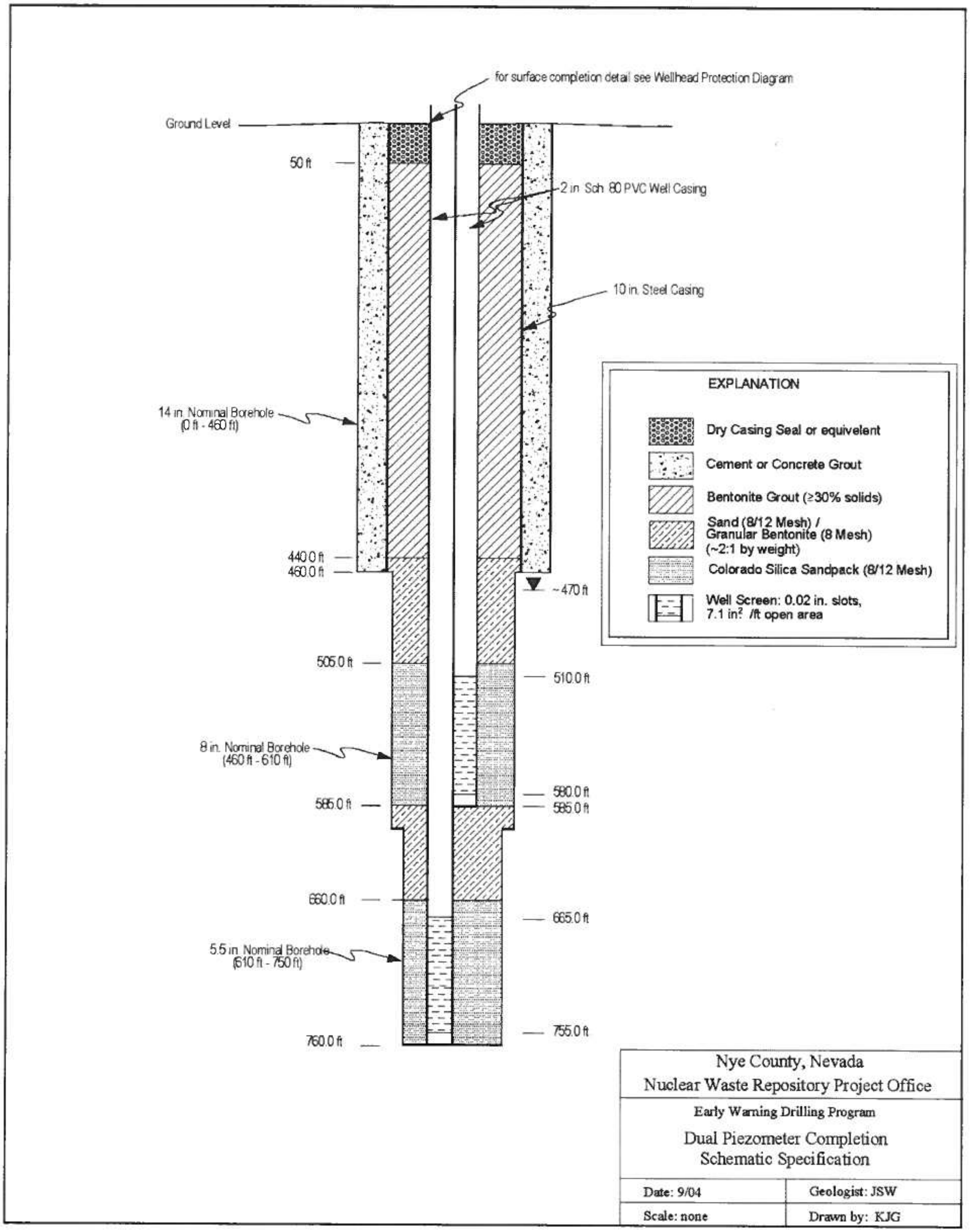

Figure 4
Completion Diagram for 22PC

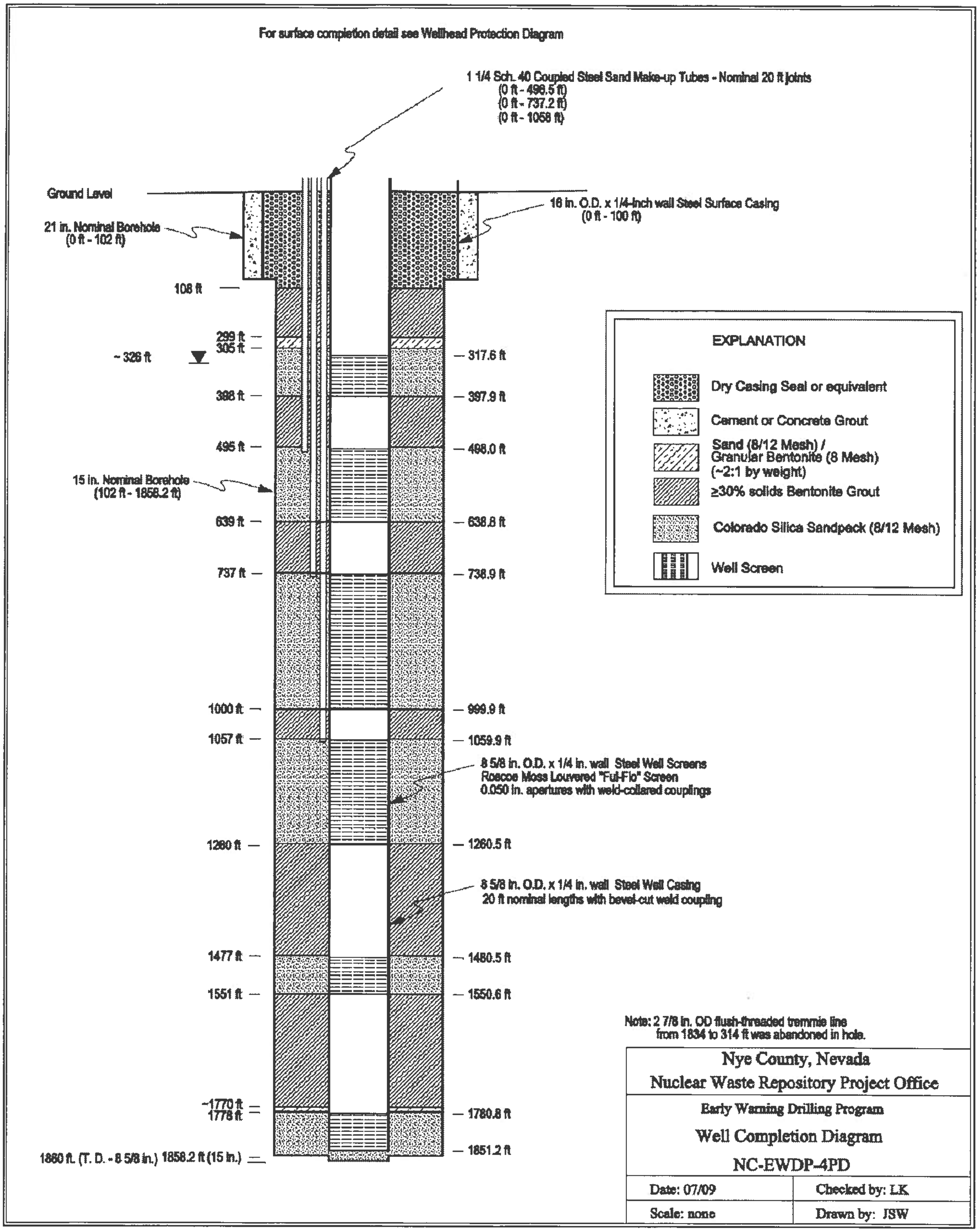

Figure 5
Completion Diagram for 4PD

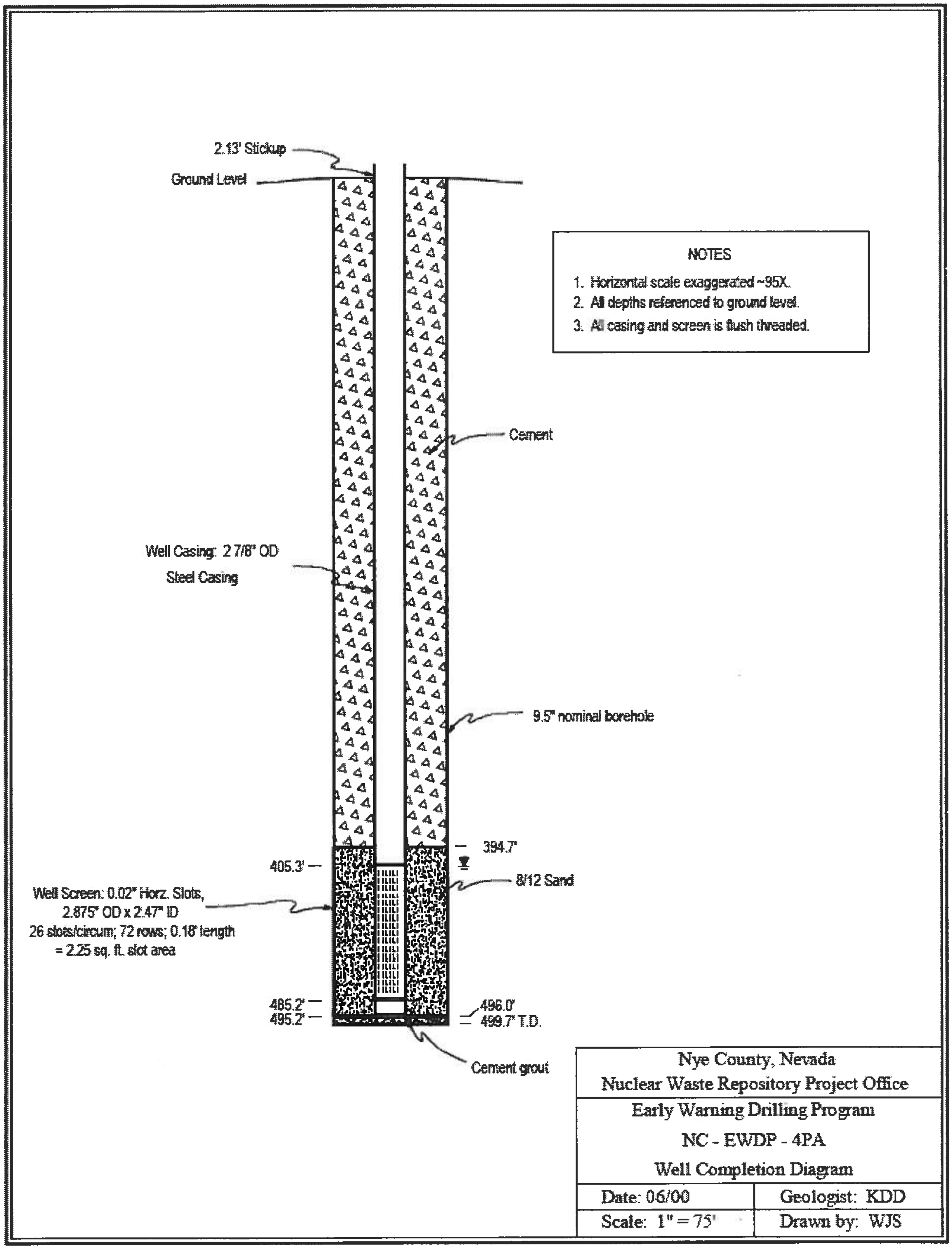

Figure 6
Completion Diagram for 4PA

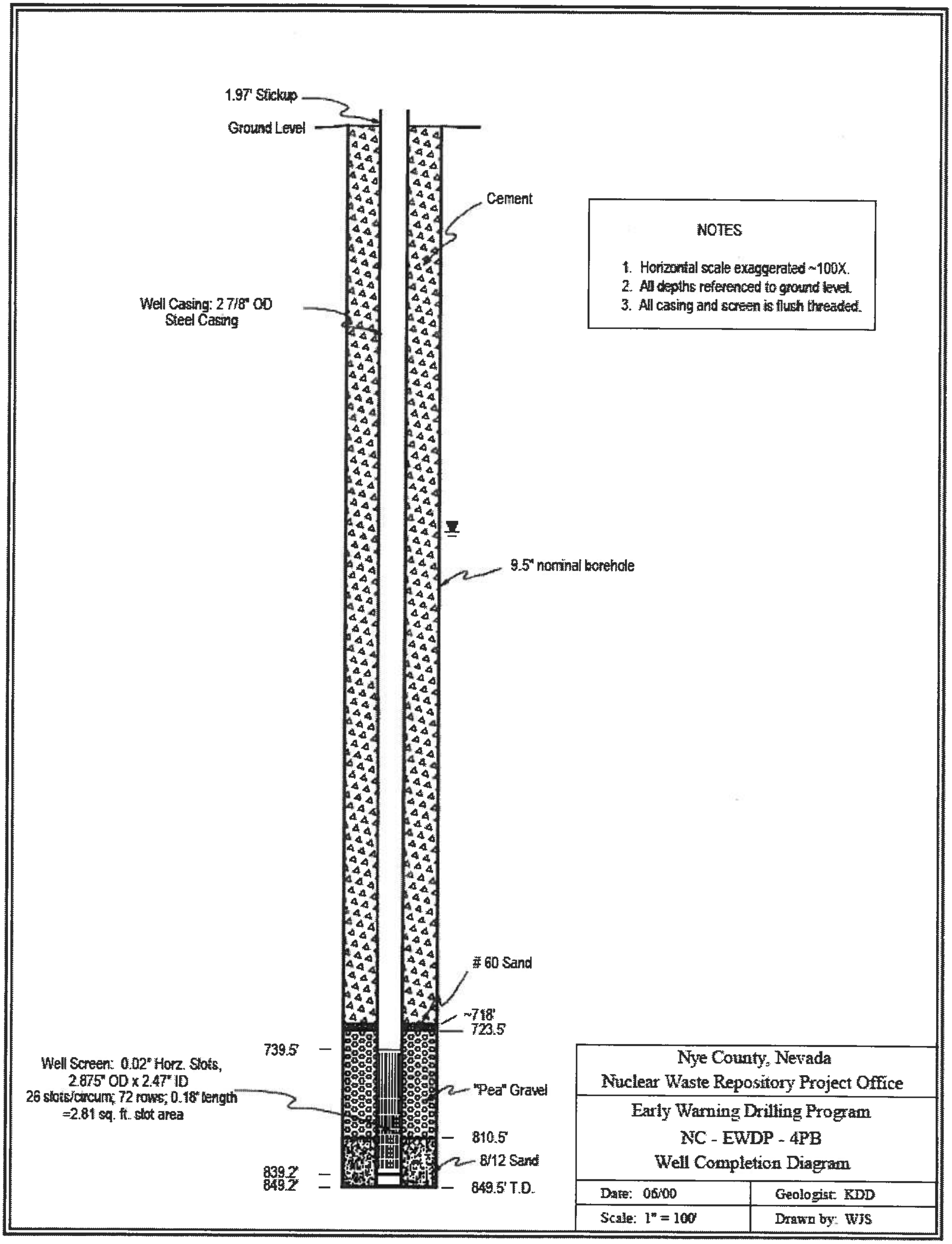

Figure 7
Completion Diagram for 4PB

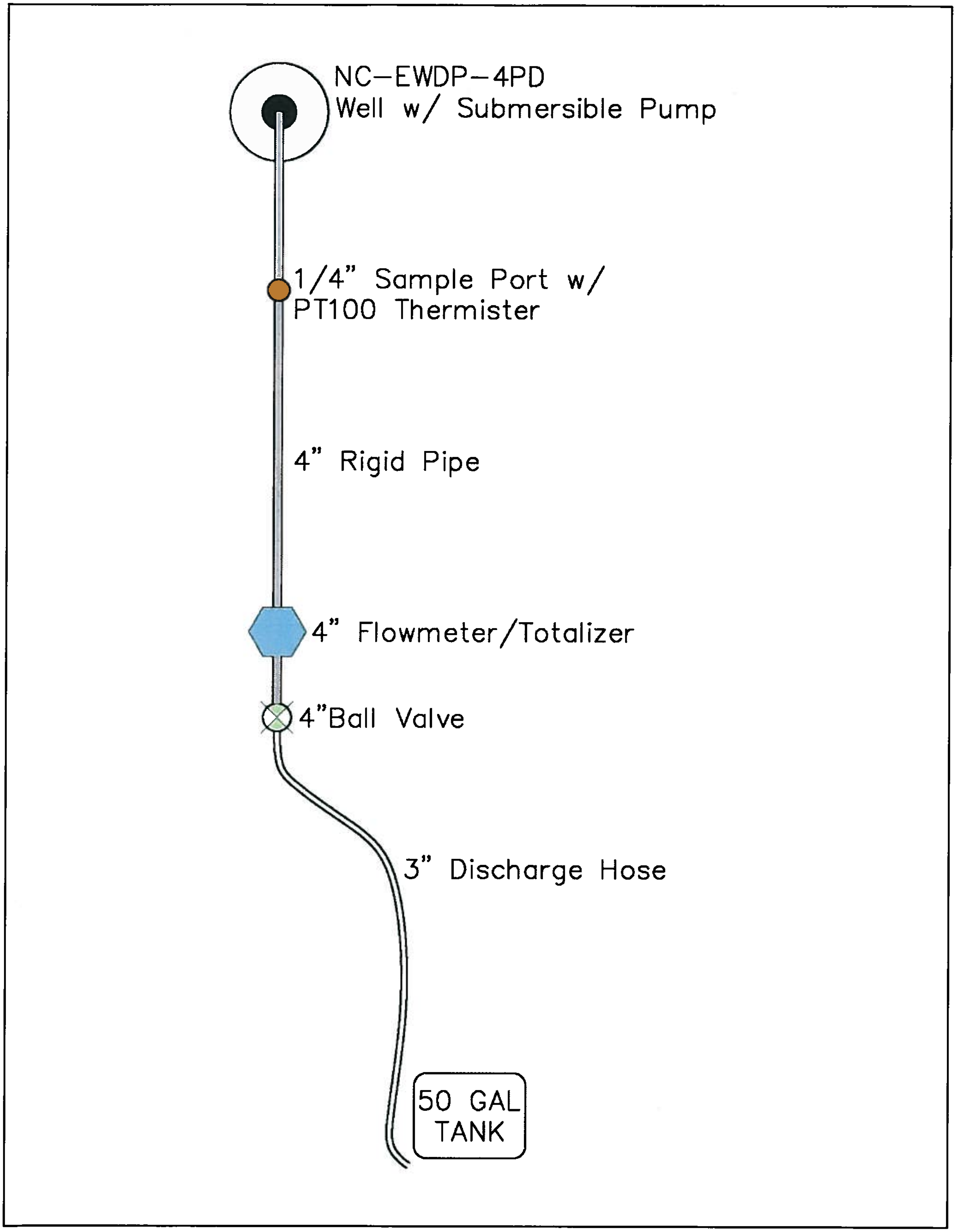

Figure 8
Piping Schematic for Discharge of Produced Water