CONTROL NUMBER 17

ALBUQUERQUE OPERATIONS MANUAL

SECTIONS 16, 17

JE

JACOBS ENGINEERING GROUP INC.
ENGINEERS • CONSTRUCTORS

3.10 Sample Bottles: Use pre-cleaned, oven dried containers as per EPA. A source of bottles is:

I-CHEM
23787 Eichler St., Bldg. F
Hayward, CA 94545
(415) 782-3905

3.11 Plastic Sheet(s) and Aluminum Foil

3.12 Parafilm or its equivalent

3.13 Rope

3.14 Pen, pencil, magic marker, paper, and masking tape

3.15 Sampling Data Forms: Water Quality Sampling Record, Chain-of-Custody Forms, etc.

4.0 CHEMICALS AND REAGENTS

NOTE: Whenever required by the procedure, JEG purchases and uses prepared, calibrated, and certified solutions from chemical supply firms. The following are listed in the event solutions are not readily available or are used whenever procedure parameters do not require certified solutions. In the event that solutions require preparation, they will be prepared at the laboratory before going into the field.

4.1 Hydrochloric Acid: HCl, 36-38%, ~12 M, (~12 N). Reagent Grade. Purchased from chemical supply firms. Handle bottle with rubber gloves and use a hood.

4.2 ~6 N HCl: Add 250 mL of concentrated Hydrochloric Acid to a 500 mL volumetric flask containing ~200 mL of distilled water, and mix solution well. Cool solution in an ice water bath. Add distilled water to 500 mL mark, stopper flask, and mix solution well. Store solution in a clean polyethylene bottle labelled with "~6 N HCl", "250 mL HCl/250 mL distilled water", "Corrosive Acid", date, and preparer's initials. NOTE: Always add acid to water. Shake 6 N HCl bottle to mix solution prior to use.

4.3 ~2 N HCl: Add 167 mL of concentrated Hydrochloric Acid to a 1000 mL volumetric flask containing 750 mL of distilled water and mix solution. Add distilled water to 1000 mL mark, stopper flask, and mix solution well. Store solution in a clean polyethylene bottle labelled with "~2 N HCl", "167 mL HCl/1000 mL distilled water", "Corrosive Acid", date, and preparer's initials. Shake solution prior to use.

4.4 Nitric Acid: HNO_3, ~70%, ~16 M (~16 N). Reagent Grade. Purchased from chemical supply firms. Handle bottle with rubber gloves and use a hood.

4.5 ~8 N HNO_3: Add 250 mL of concentrated Nitric Acid to a 500 mL volumetric flask containing 200 mL of distilled water and mix solution well. Cool solution in an ice water bath. Add distilled water to 500 mL mark, stopper flask, and mix solution well. Store solution in a clean polyethylene bottle labelled with "~8 N HNO_3", "250 mL HNO_3/250 mL distilled water", "Corrosive Acid", date, and preparer's initials. NOTE: Always add acid to water. Shake 8 N HNO_3 bottle and contents to mix solution prior to use.

4.6 Sulfuric Acid: H_2SO_4, ~98%, ~18 M (~36 N). Reagent Grade. Purchased from chemical supply firms. Handle bottle with rubber gloves and use a hood.

4.7 ~9 M H_2SO_4: While swirling water, slowly add 250 mL of concentrated H_2SO_4 to a 500 mL volumetric flask containing 200 mL of distilled water, and mix solution. Cool solution in an ice water bath. Add distilled water to the 500 mL mark, stopper flask, and mix solution well. Store solution in a clean polyethylene bottle labelled with "~9 M H_2SO_4 (~18 N)", "250 mL H_2SO_4/250 mL distilled water", "Corrosive Acid", date, and preparer's initials. NOTE: **Always add this acid to water.** Use caution when handling H_2SO_4: this acid is extremely corrosive and will sputter when adding to water. Keep a bottle of ~1 N NaOH to neutralize any spilled H_2SO_4 and a bottle of distilled water nearby.

4.8 Sodium Hydroxide: NaOH. Reagent Grade. In pellet form. Purchased from chemical supply firms.

4.9 ~18 N NaOH: Dissolve 72 grams of Sodium Hydroxide pellets in a 100 mL volumetric flask containing ~60 mL of distilled water. Swirl solution and cool in an ice bath. If necessary, add 20 mL of distilled water to dissolve remainder of NaOH pellets. Cool solution if necessary. Add distilled water to 100 mL mark of flask, stopper flasks, and mix solution well. Store solution in a polyethylene bottle labeled with "~18 N NaOH", "72 g NaOH/100 mL distilled water", date, and preparer's initials.

4.10 ~1 N NaOH: Dissolve 4.0 grams of Sodium Hydroxide in a 100 mL volumetric flask containing ~75 mL of distilled water and mix to dissolve NaOH pellets. Cool solution in an ice bath. Add distilled water to 100 mL mark of the flask, stopper flask, and mix solution well. Store solution in a polyethylene bottle labeled with "~1 N NaOH", "4.0 g NaOH/100 mL distilled water", date, and preparer's initials. NOTE: Prepare fresh solution every 30 days.

4.11 Zinc Acetate: $Zn(C_2H_3O_2)_2$, also $Zn(Ac)_2$. Reagent Grade. Purchased from chemical supply firms.

4.12 ~220 g $Zn(Ac)_2$/L: Dissolve 22 grams of Zinc Acetate in a 100 mL volumetric flask containing ~75 mL of distilled water and mix solution to dissolve the salt. If necessary, add ~15 mL of distilled water to dissolve remaining salt, and mix solution. Add distilled water to the 100 mL mark, stopper flask, and mix solution well. Store solution in a polyethylene bottle labeled with "~220 g $Zn(Ac)_2/L$", "22 g $Zn(Ac)_2/100$ mL distilled water", date, and preparer's initials. NOTE: Prepare fresh solution every 30 days and discard old solution.

4.13 Hexane. Reagent Grade. Purchased from chemical supply firms.

4.14 pH paper (1-10): Hydrion or its equivalent.

5.0 PROCEDURE: PREPARATION FOR THE COLLECTION OF WATER SAMPLES

Two (2) weeks prior to water sampling, the following steps must be initiated and completed by appropriate members of the TAC and its subcontractors.

5.1 The Site Hydrogeologist (SH) will determine the site locations to be sampled, number of samples per location, and analytes to be determined in each sample by the analytical laboratory.

5.1.1 Determine for which constituents each sample is to be analyzed. Prepare a work order plan and give to Water BOA TR. Attachment 16.2.1.3 is a blank work order plan.

5.1.2 The SH shall inform the JEG Water Samplers of any changes in site locations, samples to be collected, sample volume, nuclides/analytes, or other information which will enhance water quality determinations.

5.1.3 Group the samples into lots. A lot will consist of: 9 field samples, 4 replicates of one of the field samples, and one known or control sample. As far as it is practicable, lots should be composed of chemically similar samples. At least one out of two lots will contain splits. The TDS content of the known solution should be similar to that of the lot with which it is associated. One blank sample will be prepared for each site. Notify the Water Sampling Manager of the samples in a memo (see Attachment 16.2.1.2 as an example) including any special instructions and/or maps.

5.2 The SH or Technical Representative (Tech Rep) shall prepare a work order plan and a requisition, with information from 5.1 above, for review and approval by the Task Manager of Hydrological Services.

5.2.1 Upon approval and signature of the Task Manager, the Tech Rep shall deliver the plan and requisition to the designated Contract Representative for the Basic Ordering Agreement (BOA) Tech Rep.

5.2.2 Prepare UNC work order plan with cover letter to UNC (see Attachment 16. 2.1.4). Determine the desired TDS for each known solution from either the site hydrologist or previous analyzation rounds.

5.3 The BOA Tech Rep shall inform the analytical laboratory of the:

5.3.1 Planned collection of surface and/or groundwater samples,

5.3.2 Approximate number of surface and/or groundwater samples to be collected and shipped to the laboratory,

5.3.3 Analytes to be determined in each water sample, and

5.3.4 Approximate date samples to be delivered to the laboratory.

5.4 The JEG Water Sampling Manager shall perform the following duties:

5.4.1 Determine the water sampling schedule. Advise the Water BOA TR of any changes.

5.4.2 Prepare maps for the water samplers and the Health & Safety Group showing all sample locations. Inform the samplers in writing of the type of samples to be collected at each location. Make sure samplers have all required keys.

5.4.3 Coordinate with UNC the shipping date of the known or control samples to the laboratory.

5.4.4 Provide the water samplers with all equipment and supplies required for the site visit.

5.5 The JEG Water Samplers shall prepare for the collection of water samples by performing the following duties.

5.5.1 Inventory the equipment to make sure that required equipment is present. See Attachment 16.2.1.5.

5.5.2 Review data from previous sample collections. For example, obtain previous temperature, conductivity, and pH measurements for use as a field reference when sampling and testing water samples.

5.5.3 Make sure that there is a sufficient quantity of sample bottles in the proper sizes, filters (if required), and pre-addressed labels.

5.5.4 Make sure that there is a sufficient volume of reagents and/or solutions for preservation, field measurements, or field analysis(es).

6.0 PROCEDURE: COLLECTION OF SURFACE WATER SAMPLES

Surface water samples will be collected by the "grab" method (i.e., random immersion of a clean sample container into a body of surface water

4.23 Data Collection Sheets: Water Quality Sampling Record Forms, Chain-of-Custody Forms, and Sample Collection Procedures.

5.0 PROCEDURE: Field Measurements of a Collected Water Sample

5.1 Whenever practical, final field measurements are to be taken after at least three (3) borehole volumes have been pumped from the well and as close to the time of sampling as is possible.

5.2 Field measurements to determine temperature, conductivity, and pH are performed on a water sample as it is being collected and are to be recorded on Attachment 16.1.10.2.

5.3 Alkalinity is determined on an aliquot of the raw water sample and prior to shipment of the sample to the laboratory. Titration volumes at a specified pH are observed and recorded on Attachment 16.1.10.2, page 3 of 4. Known alkalinity solution data are observed and recorded on Attachment 16.1.10.3.

5.4 Total Acid determinations are performed on selected groundwater or lysimeter (pore water) samples. This data is recorded in the "COMMENTS" portion of Attachment 16.1.10.2.

6.0 PROCEDURE: Temperature Measurement

A conductivity meter and electrode with a thermometer built into the electrode are strongly recommended for this procedure.

6.1 Clean thermometer by washing it in a solution of soap and water. Use a brush to scrub the thermometer. Rinse thermometer well with distilled water and blot dry with lint-free tissue(s).

6.1.1 NOTE: **Always** blot dry thermometer and electrode with tissue. Water droplets remaining on these probes may dilute or otherwise affect measurement data. Rubbing probes with tissue may result in warming the thermometer or produce an electrostatic charge on the electrode and so directly alter meter readings.

6.1.2 If Conductivity Meter has a thermometer built into the electrode, use instructions of 6.1.

6.2 A combination conductivity-temperature probe is used in the field. This thermometer must be checked against a lab grade mercury thermometer at least once a month. At the same time, the conductivity meter is also tested for accuracy, using the following procedure.

6.2.1 Pour approximately 30 mL of lab prepared KCL solution of 4.3 above into a clean beaker. Place the clean temperature- conductivity probe into the solution. Place the beaker in an ice bath, and using a lab grade mercury thermometer, chill the solution to as near 0° C as possible. Salt should be placed on the ice to reach this low temperature.

6.2.2 When the KCL solution has reached a maximum of 3° C, read and record the temperature from the lab thermometer and the meter.
Also read and record the conductance.

NOTE: If meter has an automatic temperature compensator (ATC), turn off ATC or turn dial to "0." Do not use ATC for this test.

6.2.3 Remove the beaker from the ice bath to allow it to warm. Continue reading and recording temperature pairs as well as conductance at least every 2° C up to 25° C. Remove thermometer from the beaker, clean with distilled water, pat dry with tissue(s) and store.

6.2.4 Remove temperature-conductivity probe from beaker, rinse with distilled water, and blot dry with tissues. Pour approximately 20 mL of the other three KCl standards (at room temperature) into four separate clean beakers. Measure and record the conductance of each solution, being sure to rinse and dry the probe between measurements.

6.2.5 Remove temperature-conductivity probe from the final beaker, rinse with distilled water, dry with tissue(s) and store.

6.2.6 Using the data from 6.2.2, 6.2.3, and 6.2.4, plot lab thermometer temperature versus meter temperature on arithmetic graph paper. Plot meter temperature versus meter conductivity and meter conductivity versus known conductivity on arithmetic graph paper. Submit the data and graphs to the water sampling manager.

6.2.7 The meter is now ready for measuring temperature and conductance in the field.

6.3 Insert the dry and clean thermometer into the flow-through cell. Allow the temperature to stabilize. Record the temperature measurements periodically on Attachment 16.1.10.2 throughout the time of pumping.

6.3.1 Place the flow-through cell close to the wellhead. Be sure to keep the cell and discharge hose/tube out of direct sunlight.

6.3.2 Use the temperature data to adjust the pH temperature compensator.

6.4 When the sample bottle is full, shut off the pump, and carefully withdraw the thermometer from the flow-through cell. NOTE: If water
sample looks "dirty" and contains residue that will not be removed with distilled water, clean thermometer probe as stated in 6.1.

6.5 Rinse thermometer probe with distilled water and blot dry with lint-free tissue(s). The probe is now ready for another water sampling activity or storage.

6.5.1 If the probe is to be stored, place it in its carrying case. Label with "clean", date, and initials.

6.6 Clean equipment as described in 8.8 through 8.10 of Section 16.2.1.

6.7 If Conductivity, pH, Alkalinity, or Total Acidity determination is required, proceed with 7.0, 8.0, 9.0, or 10.0.

6.8 To prepare sample for filtration (if required), preservation (if required), and shipment of samples to the analytical laboratory, proceed with 12.0 of Section 16.2.1.

7.0 PROCEDURE: Conductivity Measurement

A Conductivity Meter and electrode with a thermometer built into the electrode is strongly recommended for this procedure. Because conductivity measurement instruments and instrument operation instructions
vary with each manufacturer, the analyst is advised to use the specific instructions for instrument operations that are provided with the conductivity meter to be used by the analyst.

If not already performed, test conductivity meter as described in Section 6.2.

7.1 Remove electrode and cable from carrying case, rinse well with distilled water, and blot dry with tissue.

7.1.1 **Always** blot dry electrode with tissue. Water droplet(s) remaining on the electrode may dilute or otherwise affect conductivity measurement(s). Rubbing electrodes with tissue may also produce electrostatic charges on the electrode and thus directly alter meter readings.

7.2 Insert clean and dry electrode/cable into the flow-through cell before water sampling is to begin. Read sample conductivity and record value(s) periodically throughout the sampling period and especially just after sampling is completed.

7.3 Withdraw electrode and cable, rinse well with distilled water, and blot dry with tissue paper. Electrode/cable now ready for another sampling activity or storage.

7.3.1 Label with "clean", date, and initials if electrode is to be stored.

7.4 If pH, Alkalinity or Total Acidity determination is required, proceed with 8.0, 9.0, or 10.0. If pH, Alkalinity or Total Acidity determination **is not** required, proceed with 12.0 of Section 16.2.1.

7.4.1 To prepare water sample(s) for filtration (if required), preservation (if required), and shipment to the analytical laboratory, proceed with 12.0 of Section 16.2.1.

7.5 Check Attachment 16.1.10.2 to make sure that all of the required sampling data has been recorded.

7.6 Proceed with 12.9 of Section 16.2.1 to complete required duties.

8.0 PROCEDURE: pH Measurement

A pH meter and electrode with a temperature compensator and a slope adjustment feature are strongly recommended for this procedure. Because pH measurement instruments and instrument operation instructions vary with each manufacturer, the analyst is advised to use the specific instructions for instrument operations that are provided with the pH meter to be used by the analyst. The meter and electrode can be readily adjusted to the temperature of the sample solution and can be calibrated with pH buffer solutions so that the analyst may easily and quickly work with samples having a pH range of 1-4, 4-7, 7-10, or 10.

8.1 Rinse the pH electrode with distilled water and blot dry with lint-free tissue(s).

8.1.1 **Always** blot dry pH electrode with tissue. Water droplet(s) remaining on the electrode may dilute or otherwise affect measurement data. Rubbing electrodes with tissue may result in producing an electrostatic charge on the electrode and so directly alter the meter readings.

8.1.2 When not using pH meter/electrode, **always** place pH electrode in a container of pH 4 buffer solution and seal with parafilm or its equivalent.

8.2 Prior to performing pH measurements in the field or in the lab, at least once per quarter, test the pH meter and Electrode: Determine Temperature and pH. The description below is for a meter with an Automatic Temperature Compensator (ATC). For meters not equiped with an ATC, the procedure is the same.

8.2.1 Prepare a pH 5.0 buffer solution as described on the pH tablet bottle and label as "pH 5.5 Buffer Solution", add date, and write initials on bottle.

8.2.2 Pour 30 mL of pH 5.0 buffer solution into each of three (3) beakers labelled as "A-pH 5.0" (beaker A), "B-pH 5.0" (beaker B), and "C-pH 5.0" (beaker C).

8.2.3 Place beaker A in an ice water bath, beaker B on the lab bench, and beaker C in a hot water bath. Allow beakers 10-15 minutes to acclimate to their media. Swirl beakers to mix solution.

8.2.4 With automatic temperature compensator (ATC) off or dialed to "0", place a clean and dry pH electrode and a clean and dry lab thermometer into beaker A. Read pH to the nearest 0.01 pH units and temperature to the nearest 0.1° C. Record pH and temperature on Attachment 16.1.10.1.

8.2.5 Withdraw electrode and thermometer, rinse each with distilled water, and dry with tissue.

8.2.6 Repeat 8.2.4 and 8.2.5 with beaker B.

8.2.7 Repeat 8.2.4 and 8.2.5 with beaker C. Store clean electrode as stated in 8.1.2. Store clean thermometer as stated in 6.5.

8.2.8 Plot pH and temperature data on semi-log graph paper (pH versus temperature). Attach this data to Attachment 16.1.10.1.

8.2.9 Unless foregoing data indicates that pH meter/electrode are not operating properly, pH meter/electrode is ready for sample collection trip in the field or laboratory work.

8.3 Calibrate the pH meter and electrode with standardized pH buffer solutions. NOTE: See 4.13 to 4.21.

8.3.1 If pH meter **has a slope adjustment feature**, calibrate pH meter and electrode with buffer solutions which bracket the sample pH.

A. Set ATC on pH meter to the temperature of the water sample. Use temperature data from 6.3. Alternatively, if the pH meter **does not** have an ATC, chill the pH buffer solution(s) to equal the water sample temperature.

B. To calibrate pH meter/electrode for pH 4-7 range, insert clean and dry pH electrode into a labelled beaker containing a fresh solution of pH 7 buffer. Measure pH. Adjust pH reading to 7.0. Withdraw electrode, rinse with distilled water, and blot dry with tissue. Insert clean and dry pH electrode into a labelled beaker containing a fresh solution of pH 4. Measure pH. Adjust the slope to give a pH reading of 4. Withdraw electrode, rinse with distilled water, and blot dry with tissue.

- To calibrate pH meter/electrode for pH 1-4 range, use pH 1 and pH 4 buffer solutions. Use pH 4 buffer solution instead of pH 7 buffer solution and pH 1 instead of pH 4 as stated in B. above.
- To calibrate pH meter/electrode for pH 7-10 range, use pH 7 and pH 10 buffer solutions. Use pH 7 buffer solution and pH 10 buffer solution instead of pH 4 as stated in B. above.
- To calibrate pH meter/electrode for pH 10-12.45 range, use pH 10 and pH 12.45 buffer solutions. Use pH 10 instead of pH 7 buffer solution and pH 12.45 buffer solution instead of pH 4 as stated in B. above.

C. Insert clean and dry pH electrode into a labelled beaker containing a fresh solution of one of the buffers which bracket the sample. Measure pH. Withdraw electrode, rinse with distilled water, and blot dry with tissue. Repeat with the other buffer which brackets the sample.

- If pH is within ±0.02 units, depending on certification of pH buffer solution, proceed with 8.4 and with pH measurements of water samples.

- If pH is not within ±0.02 units, depending on certification of pH buffer solution, repeat A, B, and C until pH meter/electrode gives repetitive readings. Repeat at least twice. If pH meter/electrode does not work satisfactorily, see Troubleshooting Instructions for pH meter and electrode.

8.3.2 <u>If the pH meter does not have a slope adjustment feature</u>, set ATC on pH meter to the temperature of the water sample. Use temperature data from 6.3. Alternatively, if the pH meter does not have an ATC, chill the pH buffer solution(s) to be used for the calibration or calibration checks to equal the water sample temperature.

A. Insert a clean and dry pH meter into a pH 7 buffer solution. If necessary, adjust pH meter to 7 or pH reading on pH 7 buffer bottle. Record pH meter reading. NOTE: Record all pH readings on Attachment 16.1.10.2.

B. Withdraw probe, rinse probe well with distilled water, and blot probe dry with tissue paper.

C. Repeat A and B.

D. Insert clean and dry pH probe into the sample solution, obtain pH reading, and record pH reading.

E. Repeat B.

F. Insert clean and dry pH probe into a pH buffer solution that best approximates the pH of the sample solution. Obtain and record pH reading.

G. Repeat B.

H. Repeat A and B. NOTE: Analyst should determine when and how often 1) pH meter should be recalibrated with pH 7 buffer solution, and 2) pH buffer solution that best approximates the sample pH should be used.

I. Analyst should continue with sample(s) until all of pH data has been obtained and recorded. Use A through H.

8.4 Insert clean and dry pH electrode into the flow-through cell soon after well pumping has begun. This will eliminate or reduce pH meter drift.

8.5 If the pH meter has an ATC, adjust the temperature setting on the pH meter to the temperature of the sample solution. NOTE: Use temperature measurement data from 6.3.

8.5.1 Alternatively, if the pH meter **has no ATC**, reduce the temperature of the pH buffer solutions when calibrating the pH meter.

8.6 Read pH and record measurement within five (5) minutes or after drift
has ceased, whichever is sooner. Rinse and blot dry electrode. If possible, perform pH measurement at least three (3) times during the purging of the well.

8.7 Periodically during purging, check accuracy of the pH meter with buffer solution(s) that bracket the sample solution and adjust pH meter as needed according to 8.3.1 or 8.3.2.

8.8 When purging is completed, withdraw the electrode from the flow- through cell, rinse the electrode with distilled water, and blot dry with tissue(s). Measure the final pH of each of the two (2) bracketing buffers, being sure to clean the electrode between use of the buffer solutions.

8.8.1 If the meter is accurate within 0.10 units of each buffer, record the results on Attachment 16.1.10.2. Proceed to 8.9.

8.8.2 If the meter is inaccurate (greater than 0.10 units variance with either buffer) recalibrate the meter. Continue purging and recording pH of the sample for at least four (4) to eight (8) liters of sample. Return to 8.7 and repeat until consistent pH reading within 0.10 units is achieved.

8.9 When a sufficient volume of sample has been collected in the sample bottle, remove hoses and pumps from the well hole.

8.10 Clean pH electrode: rinse with distilled water and blot dry with tissue. pH electrode now ready for another sampling activity or storage. To store electrode, see 8.1. Label with "clean", date, and initials.

8.11 Clean equipment as described in 8.8 through 8.10 of Section 16.2.1.

8.12 Check Attachment 16.1.10.2 to make sure that all of the sampling data has been recorded on the form.

8.13. If Alkalinity or Total Acidity determination is required, proceed with 9.0 or 10.0 respectively.

8.14 To prepare sample for filtration (if required), preservation (if required), and shipment to the analytical laboratory, proceed with 12.0 of section 16.2.1.

9.0 PROCEDURE: Alkalinity Measurement

Alkalinity determination (total carbonate) is performed on an aliquot of the raw, unfiltered, and unpreserved water sample by titration of the sample with an acid and measured by a pH meter.

9.1 Fill in all sample information on Attachment 16.1.10.2, page 3 of 4. NOTE: Record **all** procedure information on Attachment 16.1.10.2, page 3 of 4.

9.2 Wash the Erlenmeyer flask(s) and volumetric flask(s), to be used for this determination, with soap and water. Rinse the flasks THREE (3) times with 20 mL of distilled water. Discard rinses. Set flasks upside down to drain. After 10 minutes, remove remaining water droplets by shaking flasks vigorously.

9.3 Connect clean pH electrode to the pH meter and rinse electrode well with distilled water and blot dry with tissue.

9.4 Calibrate the pH meter/electrode as described in 8.3 and store electrode as described in 8.1.

9.5 Without too much splashing or other vigorous agitation of the water sample, **carefully pour** the water sample into a labelled 100 mL volumetric flask. Add water sample to the 100 mL mark. NOTE: Pour sample down the side of the flask.

9.6 With as little agitation as possible, **carefully pour** the water sample from the flask into a labelled 125 mL Erlenmeyer flask. If available, add a magnetic stirring bar, turn magnetic stirrer on, and stir sample slowly. Record sample aliquot volume on Attachment 16.1.10.2, page 3 of 4.

9.7 Insert the pH electrode into the sample and suspend the electrode in the water sample. Adjust the ATC on the pH meter to the temperature of the water sample. Determine sample pH and record value.

9.8 Place a 1.6 N H_2SO_4 cartridge in the titrator. Record the titrant lot number of the cartridge (on Attachment 16.1.10.2). Eject a few drops of titrant from the titrator tip, wipe tip with a clean tissue, and reset the counter to "0000".

9.9 While gently stirring the sample, titrate the sample with acid by turning the titrator delivery knob. Obtain pairs of pH and alkalinity readings at each pH value listed on Attachment 16.1.10.2, page 3 of 4. NOTE: The alkalinity value at the inflection point between pH 5 and pH 4 will be determined by the Site Hydrologist. The volume in mL equals digital titrator reading divided by 800.

9.9.1 Alkalinity titration endpoints depend upon the total alkalinity concentration. The following endpoints will be used:

Alkalinity	End Point
0-30 mg/L	pH 5.1
31-150 mg/L	pH 4.8
150 mg/L	pH 4.5

9.9.2 When the titration is complete, check pH meter calibration (See 8.3). If the meter is accurate within 0.2 units of each buffer value, record the results on Attachment 16.1.10.3. If the meter is inaccurate (greater than 0.2 units of each buffer value), recalibrate the meter and repeat the alkalinity test.

9.10 Repeat this procedure with a second Tech Rep performing the titration on a fresh aliquot of water sample.

9.11 Calculate the relative error (R.E.) as:

$$\text{R.E. } (\%) = \frac{X_1 - X_2 \times 100\%}{X_s}$$

Where X_1 is the first alkalinity measurement at pH endpoint, X_2 is the second alkalinity measurement at pH endpoint, and X_s is the lesser of X_1 or X_2.

9.12 If the percentage error is greater than ten percent (10%), repeat the foregoing procedure until two (2) consecutive measurements are within 10% relative error.

9.13 Perform alkalinity determinations on three (3) known solution(s) submitted to JEG by a quality control laboratory and record the pH and alkalinity values on Attachment 16.1.10.3. When performing this procedure, the standard solution identification, site identification, alkalinity test kit identification, pH meter identification, date, and Tech Rep name must be filled out on Attachment 16.1.10.3. Send this attachment to the Quality Control Laboratory

9.13.1 Send a copy of Attachment 16.1.10.3 to the Data Manager who will record this data on a form similar to Attachment 16.1.10.3 provided by a quality control laboratory.

9.13.2 Field alkalinity values and known solution values must agree within 10% of each other or the field test will have to be repeated until the values are accurate.

9.14 To prepare the sample(s) for filtration (if required), preservation (if required), and shipment, proceed with 12.0 of Section 16.2.1.

9.15 If Total Acidity is required, proceed with 10.0.

9.16 To complete duties, proceed with 12.9 of Section 16.2.1.

10.0 PROCEDURE: Total Acidity

This procedure is performed on selected groundwater or lysimeter (pore water) samples to determine the total acidity of the solutions and to determine the acid-neutralizing potential of carbonate materials within silty soils or sediments.

Digital Titration with HACH Cartridge

10.1 Record site identification, location identification, date, and all titration data under "Comments" on the Soil Water Sampler Data Record, under "Notes" of Attachment 16.1.10.2, or on a separate data sheet.

10.2 Calibrate the pH meter/electrode as described in 8.3 and store pH electrode as described in 8.1.

10.3 Rinse a 100 mL graduated cylinder and a 125 mL Erlenmeyer flask with distilled water. Place cylinder and flask upside down to allow excess water to drain. Remove residual water droplets by vigorously shaking the cylindar and flask. NOTE: If a 100 mL cylinder is unavailable, use a 100 mL volumetric flask.

10.4 **Carefully pour** a 100 mL aliquot of the unfiltered water sample into the graduated cylinder and then carefully pour the sample into the 125 mL titration flask. NOTE: Pour sample down the side of the cylinder and flask.

10.4.1If necessary, use a sample aliquot of less than 100 mL to perform a second titration. NOTE: Two (2) sample aliquots of 50 mL each with titrations on each aliquot are preferred to one (1) sample aliquot of 100 mL and one (1) titration.

10.5 Place clean pH electrode into the water sample, add a magnetic stirring bar, place sample on a magnetic stirrer and gently stir sample. Record the initial sample pH. Withdraw pH electrode, rinse electrode with distilled water and blot dry with tissue.

10.6 Place a 1.6 N NaOH cartridge in the titrator. Record the HACH titrant lot number of the NaOH cartridge. Eject a few drops of titrant from the titrator tip, wipe tip with clean tissue, and reset the counter to "0000".

10.7 While gently stirring the sample, turn titrator delivery knob and start titration. Record sample pH and corresponding volume of NaOH titrant after every 1-2 turns of the titrator delivery knob (volume in mL = digital titrator reading divided by 800). If pH endpoint of 8.3 is obtained after less than eight (8) turns, then re-do the titration.

10.7.1 Do not use color indicator tablets to determine the pH endpoint.

10.7.2 Use a 0.16 N NaOH cartridge to re-do the titration. Record use of 0.16 N NaOH on the data sheet Form 10.1.

10.8 Rinse all glassware with distilled water. Set glassware upside down to allow excess water to drain.

10.9 Calculate the total acidity as follows:

$$\text{Acidity, u equiv/liter} = \frac{V_t \times N_t \times 10}{V_a}$$

Where V_t = Volume, in mL, of NaOH titrant used to obtain pH 8.3, N_t = Normality of NaOH used to titrate the sample, and V_a = Volume, in mL, of sample aliquot (should be 50 or 100 mL, unless lysimeter produces very little water). NOTE: Be sure to specify and record which NaOH and Volume of NaOH are used for the titration.

10.10 Repeat the titration procedure with a second Tech Rep performing the titration unless there is insufficient sample volume produced by the well or lysimeter.

10.11 Calculate the relative error in percent (R.E., %) as previously described in 9.11.

10.12 If the relative error is greater than 10%, repeat the procedure a third time, unless there is insufficient sample volume available.

10.13 Check Attachment 16.1.10.2 to see that all of the required data has been recorded on the forms.

10.14 See 12.9 of Section 16.2.1 to complete required duties.

11.0 ATTACHMENT(S): Supporting Document(s)

16.1.10.1 Equipment Checklist

16.1.10.2 Water Quality Sampling Record Form

16.1.10.2 Alkalinity Titration Form (page 3 of 4)

16.1.10.3 Standard Alkalinity Test

12.0 REFERENCES

12.1 APHA/AWWA/WPCF, 1985. Standard Methods for the Examination of Water and Wastewater, 16th Edition. American Public Health Association, Washington, D.C. 20005.

12.2 Korte, N. and P. Kearl, 1984. "Procedures for the Collection and Preservation of Ground Water and Surface Water Samples and for the Installation of Monitoring Wells," U.S. Department of Energy, Grand Junction, Colorado.

13.0 PROCEDURE REVIEW AND APPROVAL

Prepared By: 8-30-90
TAC Representative Date

Reviewed By: 9/7/90
Task Manager Date

Reviewed By: 9-7-90
Quality Assurance Manager Date

Approved By:
Project Manager/Deputy Project Manager Date

ATTACHMENT 16.3.10.1
EQUIPMENT CHECKLIST

(Fill out all blanks prior to leaving for field)

---

pH BUFFER	Yes	No	Comments
sufficient volume 4	______	______	
sufficient volume 7	______	______	
sufficient volume 10	______	______	
REAGENTS & BOTTLES			
Litmus paper	______	______	
Nitric acid (pres.)	______	______	
Sulfuric acid (pres.)	______	______	
not required * ____			
Other reagents	______	______	
not required ____			

Required sample bottles:

Number of 1000 ml plastic bottles for Al, M2, Po210, Th230, CN, S, Pb210, Ra226, Ra228 ______

Number of 500 ml plastic bottles for Gross Alpha-Beta, Nl ______

Number of 500 ml amber glass bottles for TOC ______

Number of 1000 ml amber glass bottles for TOX ______

	Yes	No	Comments
Sufficient bottles	______	______	
Alkalinity kit			
ck reagent volumes	______	______	
ck glass for breakage	______	______	

---

* If required, must explain under Comments.

ATTACHMENT 16.1.10.1

EQUIPMENT CHECKLIST
(Fill out all blanks prior to leaving for field)

____

OTHER EQUIPMENT — Comments

squeeze bottle ______

acid dispensette ______

deionized H_2O
quantity _____ gallons

distilled H_2O _____ gallons

water level sounder ______ batt ______
hand tape ______
cloth towels or wipes ______

FIELD FORMS AND MISCELLANEOUS EQUIPMENT:

Expected no. of samples ___ No. of forms ___

Clipboard with cover ___

Maps ___ marked with well locations ___

Well information (completion, depth, etc.) ___

Field instruction book ____

Key(s) to well(s) ___ To be picked up at ___

Clean pails ___ Transparent tape ___

WD-40 (for locks) ___ Strapping tape (nylon) ___

Marking pen ___

Coolers ___

Shipping address of lab(s):

______________________ ______________________
______________________ ______________________
______________________ ______________________
______________________ ______________________

ATTACHMENT 16.1.10.1

EQUIPMENT CHECKLIST

(Fill out all blanks prior to leaving for field)

Comments

Phone numbers and contact:

______________________ ______________________

______________________ ______________________

PUMPS AND FILTERS

Logic unit ____

Regulator ____

Wrenches ____

Air hose ____

Power cord ____

Logic unit cord ____

Water hose ____

PERISTALTIC PUMP

Battery cable ____

Clean? yes ___ no ___

Tubing ____ Length ____

Filter system:

Inspect filter housing for cracks ____

Filter unit legs ____

Number of filters ____

Filter size ____

Rechargeable battery ____

Battery charger ____

ATTACHMENT 16.1.10.2

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

Page 1 of 4

WATER QUALITY SAMPLING RECORD

SITE ID: ____________________

LOCATION ID: ____________________

SAMPLE ID: ____________________

STATIC WATER LEVEL (FT) ________

SAMPLE DEPTH (FT) ____________

SAMPLING DATE ____________

SAMPLING TIME:

START ____________________

COMPLETE ____________________

FINAL FIELD VALUE AT THE SURFACE

pH (S.U.) ________

Ec (µmhos/cm) ________

TEMP. (°C) ________

ALKALINITY (mg/l $CaCO_3$) @ pH 4.5 ________

TITRANT: 1.6 N H_2SO_4 LOT # ________

____________________ FILTER(S) USED

COMMENTS ____

____

LOCATION DESCRIPTION ________________________________

AIR TEMP. C D.O. (air) mg/l Eh soln.(.1M) ______ mV at °C

FIELD REP(S) ____________________ ____________________

DATE	TIME	TOTAL VOLUME WITHDRAWN		pH	Ec (µmhos/cm)	TEMP. (°C)	Eh (mV)	D.O. mg/l	COMMENTS
		(Gals)	(Bore Volumes)						
		0.0	0.0	–	–	–			START PUMPING

WATER QUALITY SAMPLING RECORD

ALKALINITY TITRATION

SITE ID: ____________________

LOCATION ID: ______________

DATE: ______________________

ERROR AT 4.50: $\left| \frac{X1 - X2}{X^{s}} \right| \times 100 =$ ___%

1st = _____ %

2nd = _____ %

pH CHECK AFTER TITRATION

7.00 = __________

4.00 = __________

pH	ALKALINITY (mg/l $CaCO_3$)		
	1st	2nd	3rd
INITIAL pH			
8.90			
8.60			
8.30			
8.05			
7.80			
7.50			
5.50			
5.70			
5.10			
4.80			
4.50			
4.25			
4.00			

SAMPLE ALIQUOT IS 100 ML UNLESS STATED OTHERWISE.

NOTES

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

EXHIBIT C
ATTACHMENT 4
SUBCONTRACT NO. 34-6705-S________

ACKNOWLEDGEMENT OF RECEIPT OF SAMPLES FOR DELIVERY ORDER NO. 0

SITE ID:__________ LOCATION ID:__________ SAMPLE ID: __________

SAMPLE SHIPMENT LIST

LOT#________

SAMPLE MATRIX (Check one)

WATER ( ) SOIL ( )

BOTTLE ID	AMOUNT	REC'D (✓)	BOTTLE ID	AMOUNT	REC'D (✓)
A1	______	( )	Th 230	______	( )
A1-A	______	( )	GA/B	______	( )
M1	______	( )	N1	______	( )
M1-A	______	( )	CN	______	( )
M2	______	( )	S	______	( )
M2-A	______	( )	TOC	______	( )
Pb 210	______	( )	Alkalinity	______	( )
Po 210	______	( )			
Ra 226	______	( )			
Ra 228	______	( )			

DATE SHIPPED: ______________ METHOD OF SHIPMENT: ______________

COMMENTS: ____

To be completed by subcontracting laboratory

I hereby acknowledge receipt of the following on: ______________ (date)

Delivery Order No. ________ Work Order Plan dated: ______________

Subcontractor: ______________________
Name: ______________________
Title: ______________________

COMMENTS: ____

In accordance with Exhibits B and C of the Subcontract :
Water Quality Analytical

Results due to JEG by: ______________ (date)

ATTACHMENT 16.1.10.3

JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

STANDARD ALKALINITY TEST

STANDARD SOLUTION ID	KNOWN VALUE (mg/l $CaCO_3$)	ALKALINITY TEST VALUES	
		pH	mg/l $CaCO_3$
REQ# ______			
LAB# ______	______	______	______
______			
REQ# ______			
LAB# ______	______	______	______
______			
REQ# ______			
LAB# ______	______	______	______
______			

SITE ID: ______ FIELD REP ID: ______

ALKALINITY TEST KIT ID: ______ ______

pH METER ID: ______

DATE: ______ SEND TO: ______

COMMENTS: ______

______

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL	SECTION 16.1.11
	DATE 02/07/90
SAMPLE COLLECTION FOR ORGANIC SUBSTANCES	EFFECTIVE 04/25/90
	SUPERSEDES
	PAGE 1 OF 7

1.0 PURPOSE

To provide a procedure for the collection and shipment of water samples for analysis of organic hazardous constituents listed in Appendix I of 40 CFR 192. To satisfy the requirements of Appendix I, we will analyze for constituents listed in 40 CFR 264, Appendix IX. This procedure is to be used when sampling for dissolved organics, not immiscible phases.

2.0 SCOPE

This procedure is applicable to members of the TAC and its contractors and subcontractors with responsibilities and duties for the collection, preservation, and submittal of groundwater samples for laboratory analysis(es) of Appendix I organic substances. Section 16.1.10 entitled "Field Measurement of Water Samples for Temperature, pH, Conductivity, Alkalinity, and Total Acid" is also applicable to this procedure.

3.0 EQUIPMENT AND SUPPLIES

3.1 Bailer(s): use a teflon (tetrafluoroethylene) bailer that can be completely disassembled for the purpose of cleaning thoroughly. The bailer design should be such that it minimizes loss of volatile organics, and contamination by headspace air during sampling. An example of this type of bailer is shown in Attachment 16.1.11.1.

3.2 pH Meter and Electrode

3.3 Conductivity Meter and Electrode

3.4 Thermometer

3.5 Volumetric Flask(s), Class A: 250, 500, 1000 mL (Available at Laboratory). Required only if preparing solutions listed in 4.0.

3.6 Sample Bottle: use precleaned, oven-dried, certified containers as per EPA specifications.

3.7 Sample Bottle for Organic Substances Sampling: Use only glass containers with teflon-lined caps. Precleaned, certified containers will be supplied by the analytical laboratory to the water sampler.

3.8 Plastic Sheet(s) and Aluminum foil

3.9 Parafilm or its equivalent

3.10 Pen, pencil, magic marker, paper, and masking tape

3.11 Rope

3.12 Sampling Data Forms: Water Quality Sampling Record, Chain-of-Custody Forms, etc.

4.0 CHEMICAL AND REAGENTS

NOTE: Whenever required by the procedure, JEG purchases and uses prepared, calibrated, and certified solutions from chemical supply firms. The following are listed in the event certified solutions are not readily available or are used whenever procedure parameters do not require certified solutions. In the event that solutions require preparation, they will be prepared at the laboratory before going into the field.

4.1 Hydrochloric Acid: HCl. Reagent Grade. 36-38%: ~12 M (~12 N). Purchased from chemical supply firms.

4.2 ~2 N HCl: Add 167 mL of concentrated Hydrochloric Acid to a 1000 mL volumetric flask containing 750 mL of distilled water, and mix solution. Add distilled water to the 1000 mL mark, stopper flask, and mix solution well. Store solution in a clean polyethylene bottle labelled with "~2 N HCl", "167 mL HCl/1000 mL distilled water", date, and preparer's initials. Shake solution prior to use.

4.3 Sodium Hydroxide: NaOH. Reagent Grade. In pellet form. Purchased from chemical supply firms.

4.4 ~1 N NaOH: Dissolve 4.0 grams of Sodium Hydroxide in a 100 mL volumetric flask containing ~75 mL of distilled water, and mix solution to dissolve NaOH pellets. Cool solution in an ice bath. Add distilled water to the 100 mL mark of the flask, stopper flask, and mix solution well. Store solution in a polyethylene bottle labeled with "~1 N NaOH", "4.0 g NaOH/100 mL distilled water", date, and preparer's initials. NOTE: Prepare fresh solution every 30 days and add a new date.

4.5 Hexane: Reagent Grade. Purchased from chemical supply firms.

4.6 pH paper (1-10): Hydrion or its equivalent.

5.0 PROCEDURE: SAMPLE COLLECTION FOR ORGANIC SUBSTANCES

5.1 Sampling Principles

5.1.1 A consideration in organics sampling is what materials occur in the well from which the samples are obtained. Where PVC well casing is used to construct monitoring wells, casing sections should be connected via screw threading, not with organic cementing compounds, glues, or any solvents. This requirement should be specified in all Scopes of Work for well installation. Also, because the PVC casing may leach or adsorb trace organics, identically constructed PVC wells in upgradient background study areas are needed to provide sample "blank(s)" for PVC wells in contaminated areas.

5.1.2 When sampling for analysis of organic parameters (i.e., TOC, TOX, pesticides, and EPA Appendix IX organics), special procedures and equipment may be required. Many plastics such as PVC and polyethylene adsorb organic contaminants and also desorb other trace compounds from their surfaces. Teflon or stainless steel is preferred for organics sampling. The following should, therefore, be strictly observed and practiced.

A. Grab samples to be analyzed for volatile organic acids (VOA) are best obtained by use of a teflon bailer. NOTE: All sample tubing and pump parts should be made of either teflon or approved silicon. See 8.5 for additional guidance.

B. Samples should be refrigerated at the time of collection.

C. All organic compounds should be collected in opaque bottles and stored in the dark.

D. Specific needs for organic sampling should be determined in consultation with the support laboratory. See Sections 8.2 and 8.5 for additional guidance in sampling for organic substances. See Section 10.0 entitled "Sample Collection with a Bailer" of Section 16.2.1.

E. If possible, purge about three (3) pore volumes but not less than one (1) pore volume from well before collecting sample.

F. Use only glass or teflon sample containers with teflon-lined caps. See Section 3.7.

G. Review equipment checklist before leaving for the field (Attachment 16.1.11.2).

5.2 The site hydrologist (SH) is responsible for contacting the analytical laboratory at least two weeks prior to sampling. The laboratory will provide bottles for organic sampling.

5.2.1 The SH should request the required number of bottle sets and inform the laboratory of the location numbers so the bottles will be properly labeled.

5.2.2 One trip blank per site should also be requested. The bottle sets and trip blank should be shipped either to the UMTRA Project Office and transported to the field from there, or shipped directly to the motel the water samplers are staying at.

5.2.3 The trip blank will be transported to each of the sampling locations and returned to the analytical laboratory when sampling has been completed.

5.3 Unwrap a clean teflon bailer, rinse inside of bailer with distilled water, and discard rinse. Repeat TWICE more with distilled water. Shake bailer vigorously to remove excess water. NOTE: If bailer is not clean, clean bailer as described in Section 5.10.

5.3.1 Rinse outside of bailer several times with distilled water and discard rinse. Dry outside of bailer with tissue(s). Bailer now ready for sampling activity.

5.4 Purge well until the temperature, conductivity, and pH of the purged water stabilize. They may not stabilize within 10 percent of initial reading if the initial readings are taken on water that has been standing in the well for a long time. NOTE: To measure and record data for this and other steps of this procedure, use Sections 6.0, 7.0, and 8.0 of Section 16.1.10

5.5 After the well stabilizes, slowly submerge the bailer and fill the sample chamber completely. NOTE: Do not agitate water sample by splashing, etc. Volatile organics could escape due to the agitation.

5.6 Bring the bailer to the surface and, with a minimum of agitation, slowly drain the water into a labelled sample bottle until it overflows by about 1.5 bottle volumes. If possible, obtain and record temperature, conductivity, and pH of the sample on Attachment 16.1.11.3. NOTE: Drain sample down the side of the container. Avoid direct contact with a dirty surface; always rest the bailer(s) on a clean plastic sheet. Use a new bailer rope for sampling each well to avoid cross contamination.

5.7 Immediately cap the bottle, making sure that no headspace or bubbles exist within the bottle.

5.8 Place the sample(s) in a cooler that contains "blue ice" or its equivalent and ship to the analytical laboratory immediately. NOTE: Samples must arrive at the laboratory within 24 hours of collection.

5.8.1 Separate field samples into sample lots for packaging and shipment to the analytical laboratory.

5.8.2 A sample lot should consist of no more than nine (9) field samples, four (4) replicates of one of the field samples, and at least one (1) known solution.

5.8.3 Every field sample and known solution will also be split into a sample submitted for lab analysis(es) and a sample to be archived. NOTE: Archived samples are stored by the analytical laboratory and may be analyzed by that laboratory and, at the discretion of JEG, used for re-analysis(es) or other purposes.

5.9 Check Attachment 16.1.11.3 to make sure all of the required sampling data has been entered, comments made, any deviation(s) from the sampling procedure recorded, and reason(s) for such deviation(s).

5.10 Clean and decontaminate the bailer(s) used for sampling as soon as possible, and do not allow bailer(s) to air dry. NOTE: It is difficult to remove the contaminants adhering to the bailer when it is dry.

5.10.1 Thoroughly scrub and wash the bailer with warm tap water and detergent. Use a brush. Rinse bailer several times with tap water to ensure complete removal of the detergent.

5.10.2 Rinse the bailer at least three (3) times with hexane or ~2 N HCl, followed by at least three (3) rinses with distilled water.

5.10.3 Dry bailer exterior with a lint-free towel. Bailer is now ready for another sampling activity or storage.

5.10.4 If bailer is to be stored, wrap bailer with a clean plastic sheet and seal with tape. Label with "clean", date, and initials.

5.10.5 In cases where gross organic contamination or an immiscible phase is present, it may be necessary to dedicate a bailer to each sampling station.

5.11 To prepare the sample(s) for shipment to the analytical laboratory, proceed with 6.0.

5.12 Perform the following POST-COLLECTION DUTIES:

5.12.1 Clean up field equipment.

5.12.2 Replace expended items, filters, reagents, reagent solutions, etc.

5.12.3 Repair broken equipment or report/request replacement.

5.12.4 Make photocopies of all field forms associated with a given sample lot and distribute copies to the Site Hydrogeologist, Data Manager, Water Sampling Manager, and the BOA Tech Rep within two (2) weeks of the date of sample collection. Submit any additional information to the Data Manager.

5.12.5 Give original field form(s) containing the sampling information to JEG Document Control.

5.13 Notify the Site Manager, by a memorandum, of the collection of the field sampling data and delivery of this information to JEG Document Control.

6.0 PROCEDURE: PREPARATION OF WATER SAMPLES FOR PACKAGING, LABELLING, AND TRANSPORT

6.1 Label bottles with the TAC's preprinted labels. Fill in all appropriate information in the blank spaces.

6.2 Immediately put the samples requiring refrigeration into an insulated cooler containing "blue ice" or ice. Samples which do not require refrigeration should be placed in a box or other suitable container, filled with absorber material, sealed, and shipped to the analytical laboratory. NOTE: Keep all samples out of direct sunlight.

6.3 Put the address and telephone number of the UMTRA Project Office and the name of a JEG contact in the insulated container. Include a list giving the number of samples and sample identifications in each container. Use Attachment 16.1.11.4. This sample list will be completed by the laboratory and sent to the BOA Tech Rep so that records will be kept on the list of samples received. This list can be compared to a duplicate sample list which is retained with the water sampling data to assure that no samples were lost or misplaced during shipment.

6.4 Tape the container with strapping tape for shipping. Inform the laboratory of the sample arrival time and date.

6.5 Schedule sample collection/shipment so that the samples do not arrive at the lab after 4 p.m. on a Friday, or on a Saturday or on a Sunday. Whenever possible, ship the samples so that they arrive at the laboratory no later than 72 hours after they were collected.

6.6 Have the laboratory document sample lot arrival times, and report this information to the BOA Tech Rep.

7.0 ATTACHMENT(S): SUPPORTING DOCUMENT(S)

7.1 Schematic Drawing entitled "Point Source Bailer"

7.2 Equipment Checklist

7.3 Water Quality Sampling Record Form--3 Forms

7.4 Sample Receipt Acknowledgment Form

8.0 REFERENCES

8.1 Barcelona, Michael, John A. Helfrich, and Edward E. Garske, 1985. "Sampling Tubing Effects on Groundwater Samples." Anal. Chem., 57: 460-464.

8.2 Korte, N. and P. Kearl, 1984. "Procedures for the Collection and Preservation of Groundwater and Surface Water Samples and for the Installation of Monitoring Well." U.S. Department of Energy, Grand Junction, Colorado.

8.3 Miller, G. D., 1982. "Uptake and Release of Lead, Chromium, and Trace Level Volatile Organics Exposed to Synthetic Well Casings." Proc. 2nd Nat'l Symp. Aquifer Restoration and Ground Water Monitoring, 1982, 236-245.

8.4 Nielsen, D. M. (ed.), 1983. "Chemical Problems in Groundwater Monitoring Programs." Proc. 3rd Nat'l. Symp. Aquifer Restoration and Ground Water Monitoring, 1983: 263-271.

8.5 Pettyjohn, Wayne A., W. J. Dunlap, R. Cosby, and J. W. Keeley, 1981. "Sampling Ground Water for Organic Contaminants." <u>Groundwater</u>, 19 (2): 180-189.

8.6 USEPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

8.7 USEPA, 1985. Practical Guide for Ground Water Sampling. EPA 600/2-85/104

9.0 PROCEDURE REVIEW AND APPROVAL

Prepared By: Harold W. Tso (Harold W. Tso)

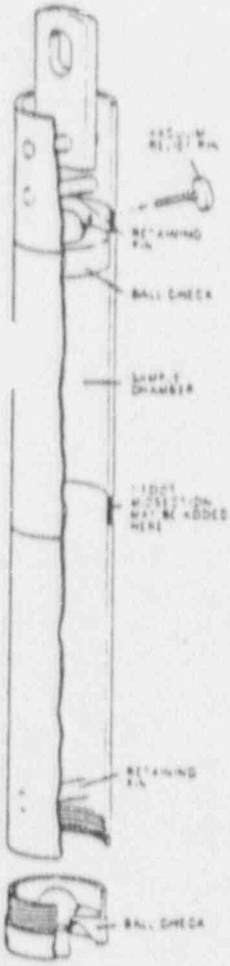
Reviewed By:
Task Manager

Reviewed By: for B. Boarden
Quality Assurance Manager

Approved By: Jim W. Holden for S. Hill
Project Manager

ATTACHMENT 16.1.11.1

Point Source Bailer



POINT SOURCE BAILER allows sampling at specific point within a monitoring well

•

Threaded and press fitted construction allows for ease of decontamination

•

Additional 1 foot midsection(s) may be added at the center to increase volume

•

Available in polyvinyl chloride (PVC) or all virgin polytetrafluoroethylene (PTFE), LEXAN™ or stainless steel

SIZES AVAILABLE

PTFE:
1 inch O.D. thru
4.5 inches O.D.
(25.4 mm - 114.30 mm)
Lengths: 2 thru 5 ft

TIMCO™ Bailers

EQUIPMENT CHECKLIST
(Fill out all blanks prior to leaving for field)

pH BUFFER	Yes	No	Comments
sufficient volume 4	____	____	
sufficient volume 7	____	____	
sufficient volume 10	____	____	

REAGENTS & BOTTLES			
Litmus paper	____	____	
Nitric acid (pres.)	____	____	
Sulfuric acid (pres.) not required * ____	____	____	
Other reagents not required ____	____	____	

Required sample bottles:

Number of 1000 ml plastic bottles for Al, M2, Po210, Th230, CN, S, Pb210, Ra226, Ra228 ____

Number of 500 ml plastic bottles for Gross Alpha-Beta, N1 ____

Number of 500 ml amber glass bottles for TOC ____

Number of 1000 ml amber glass bottles for TOX ____

Sufficient bottles	____	____	
Alkalinity kit ck reagent volumes	____	____	
ck glass for breakage	____	____	

---

* If required, must explain under Comments.

EQUIPMENT CHECKLIST
(Fill out all blanks prior to leaving for field)

OTHER EQUIPMENT — Comments

squeeze bottle ______

acid dispensette ______

deionized H_2O
quantity ____ gallons

distilled H_2O ____ gallons

water level sounder ______ battery check ______
hand tape ______
cloth towels or wipes ______

FIELD FORMS AND MISCELLANEOUS EQUIPMENT:

Expected no. of samples ___ No. of forms ___

Clipboard with cover ___

Maps ___ marked with well locations ___

Well information (completion, depth, etc.) ___

Field instruction book ___

Key(s) to well(s) ___ To be picked up at ___

Clean pails ___ Transparent tape ___

WD-40 (for locks) ___ Strapping tape (nylon) ___

Marking pen ___

Coolers ___

Shipping address of lab(s):

______________________ ______________________
______________________ ______________________
______________________ ______________________
______________________ ______________________

ATTACHMENT 16.1.11.2

EQUIPMENT CHECKLIST
(Fill out all blanks prior to leaving for field)

Comments

Phone numbers and contact:

______________________________ ________________ __________

______________________________ ________________ __________

PUMPS AND FILTERS

Logic unit _____

Regulator _____

Wrenches _____

Air hose ____

Power cord _____

Logic unit cord _____

Water hose _____

PERISTALTIC PUMP

Battery cable ____

Clean? yes ___ no ___

Tubing ____ Length ____

Filter system:

Inspect filter housing for cracks ______

Filter unit legs ____

Number of filters ____

Filter size ____

Rechargeable battery ____

Battery charger __ __

ATTACHMENT 16.1.11.2

ATTACHMENT 16.1.11.3

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

Page 1 of 4

WATER QUALITY SAMPLING RECORD

SITE ID: ______________________

LOCATION ID: ______________________

SAMPLE ID: ______________________

STATIC WATER LEVEL (FT) ________

SAMPLE DEPTH (FT) ______________

SAMPLING DATE ______________

SAMPLING TIME:

START ______________________

COMPLETE ______________________

FINAL FIELD VALUE AT THE SURFACE

pH (S.U.) ____________

Ec (µmhos/cm) ____________

TEMP. (°C) ____________

ALKALINITY (mg/l $CaCO_3$) @ pH 4.5 ____________

TITRANT: 1.6 N H_2SO_4 LOT # ____________

______________________ FILTER(S) USED

COMMENTS ____

____

LOCATION DESCRIPTION ____

AIR TEMP. ____ C D.O. (air) ____ mg/l Eh soln.(.1V) ____ mV at. ____ °C

FIELD REP(S) ____

DATE	TIME	TOTAL VOLUME WITHDRAWN		pH	Ec (µmhos/cm)	TEMP. (°C)	Eh (mV)	D.O. mg/l	COMMENTS
		(Gals)	(Bore Volumes)						
		0.0	0.0	–	–	–			START PUMPING

JEG-AL-ENG-44(2/90)

WATER QUALITY SAMPLING RECORD

BORE VOL CALCULATION
$(d/2)^2 \pi (h_1 - h_2)^*$

SAMPLING INFORMATION

SITE ID ______________ LOCATION ID ______________

DEPTH TO WATER (h_2) (FT.) ________
DEPTH OF WELL (h_1) (FT.) ________
WELL DIA (d) (FT.) ________
BORE VOL. $(FT.)^3$ ________
SCREENED INTERVAL (FT.) ________

WITHDRAWAL METHOD ________
FILTER SIZE .45 μ
THERMOMETER ID ________
Ec METER ID ________
pH METER ID ________
PUMP ID ________
Eh METER ID ________
D.O. METER ID ________

CALIBRATION INFORMATION

DATE OF LAST Ec CALIBRATION ________
TIME OF pH CALIBRATION ________
pH AFTER MEASUREMENT ________ FOR STANDARD pH ________
pH AFTER MEASUREMENT ________ FOR STANDARD pH ________

SHIPPING INFORMATION

LAB(S) SHIPPED TO: ________ ________ ________
DATE(S) SHIPPED: ________ ________ ________
METHOD OF SHIPMENT: ________ ________ ________

NOTES

* The value of $(\frac{d}{2})^2 \pi$ is: .022 for a 2" well
.088 for a 4" well

WATER QUALITY SAMPLING RECORD

ALKALINITY TITRATION

SITE ID: ____________________

LOCATION ID: ____________________

DATE: ____________________

ERROR AT 4.50: $\left| \frac{X1 - X2}{X^{s}} \right| \times 100 =$ ___ %

1st = _____ %

2nd = _____ %

pH CHECK AFTER TITRATION

7.00 = __________

4.00 = __________

pH	ALKALINITY (mg/l $CaCO_3$)		
	1st	2nd	3rd
8.90			
8.60			
8.30			
8.05			
7.80			
7.50			
6.50			
5.70			
5.10			
4.80			
4.50			
4.25			
4.00			

NOTES

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

EXHIBIT C
ATTACHMENT 4
SUBCONTRACT NO. 34-6705-S ______

ACKNOWLEDGEMENT OF RECEIPT OF SAMPLES FOR DELIVERY ORDER NO. 0

SITE ID: ______ LOCATION ID: ______ SAMPLE ID: ______

SAMPLE SHIPMENT LIST

LOT# ______

SAMPLE MATRIX (Check one)

WATER ( ) SOIL ( )

BOTTLE ID	AMOUNT	REC'D (✓)	BOTTLE ID	AMOUNT	REC'D (✓)
A1		( )	Th 230		( )
A1-A		( )	GA/B		( )
M1		( )	N1		( )
M1-A		( )	CN		( )
M2		( )	S		( )
M2-A		( )	TOC		( )
Pb 210		( )	Alkalinity		( )
Po 210		( )			
Ra 226		( )			
Ra 228		( )			

DATE SHIPPED: ______ METHOD OF SHIPMENT: ______

COMMENTS: ______

- -

To be completed by subcontracting laboratory

I hereby acknowledge receipt of the following on: ______
(date)

Delivery Order No. ______ Work Order Plan dated: ______

Subcontractor: ______
Name: ______
Title: ______

COMMENTS: ______

In accordance with Exhibits B and C of the Subcontract:
Water Quality Analytical

Results due to JEG by: ______
(date)

JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ACKNOWLEDGEMENT OF RECEIPT OF SAMPLES FOR ORGANICS ANALYSIS

SITE ID________ LOCATION ID________ SAMPLE NO.________

BOTTLE	REC'D (✓)
1 GAL. AMBER	____
VOA VIAL #1	____
VOA VIAL #2	____

DELIVERY ORDER NO.________

DATE SHIPPED________

METHOD SHIPPED________

COMMENTS________

____

SITE ID________ LOCATION ID________ SAMPLE NO.________

BOTTLE	REC'D (✓)
1 GAL. AMBER	____
VOA VIAL #1	____
VOA VIAL #2	____

DELIVERY ORDER NO.________

DATE SHIPPED________

METHOD SHIPPED________

COMMENTS________

____

I HEREBY ACKNOWLEDGE RECEIPT OF THE ABOVE SAMPLE(S) ON

________________.
DATE

SUBCONTRACTOR LABORATORY________

NAME________

TITLE________

ANALYSIS DUE DATE________ (IN ACCORDANCE WITH EXHIBIT B OF CONTRACT NO.________)

NEUTRON PROBE ACCESS HOLE CLOSURES

1.0 PURPOSE

To provide guidelines for neutron probe access hole abandonment and closures on UMTRA Project sites.

2.0 SCOPE

The scope of this procedure will encompass only the neutron access holes that are located on DOE UMTRA sites and are installed on remediated uranium mill tailing piles.

3.0 AUTHORITY AND NOTIFICATIONS

3.1 The DOE shall have the ultimate authority to designate abandonment and closure of neutron probe access holes. Recommendation to abandon and close these access holes shall be made by the technical staff in writing through the TAC Project Manager to the DOE and only in cases where data gathering activities are determined to be complete or no longer necessary.

3.2 When DOE has authorized the abandonment and closure of neutron probe access holes, the TAC shall take the necessary steps to ensure that abandonment and closure of access holes are appropriately performed in accordance with the prescribed methods listed below and related standard operating procedures.

3.3 The TAC shall notify all state and tribal government agencies in addition to the Nuclear Regulatory Commission and Department of Interior, as appropriate.

4.0 ENVIRONMENTAL, HEALTH AND SAFETY

4.1 All reasonable precautions shall be taken in the performance of this procedure to protect the environment and assure the health and safety of employees and the public. Work under this procedure shall be conducted in compliance with the established health and safety regulations of the Occupational Safety and Health Administration (OSHA), the Department of Energy (DOE), and other applicable Federal, state, and local regulations and requirements. Because this procedure involves excavation, particular attention is called to the recently amended OSHA rule on excavations (29 CFR 1926, Subpart P). The sides of any excavation will need to be adequately sloped or shored. The recommended means of cutting off the tube is the use of a pipe cutter, if feasible.

4.2 The personnel performing this procedure shall attend a fieldwork briefing before starting any work and shall use the following personnel protective equipment:

- o Hard hat
- o Safety boots
- o Eye protection
- o Hearing protection (if noise generating equipment is used)
- o Coveralls
- o Work gloves

4.3 Adequate fire extinguishers and first aid kits shall be available at the work site.

4.4 Accidents and/or injuries shall be reported to the TAC Environmental, Health and Safety Manager promptly. A verbal report by phone should be made as soon as possible, but in any event within 24 hours. Written reports of incidents resulting in lost work time or medical treatment shall be submitted within 48 hours after the complete information on the incident is known.

5.0 PROCEDURE

The Procedure to be used to close the hole shall be in accordance with the details provided in Figure 1 and in the following steps. Please note that in some instances a protective casing may not have been installed. Therefore references to the protective casing can be ignored when implementing the procedure.

5.1 Fill access tube with bentonite chips to the top of the radon barrier and add water to hydrate chips. One hour is required for complete hydration of chips.

5.2 Excavate access pit by hand using shovels, picks, and buckets. Ensure access pit sidewalls have low enough angle to avoid slumping and caving. Access pit must be of sufficient size to allow adequate working space. Stockpile excavated material into separate piles for easy reuse. Use buckets or plastic sheeting to contain and separate excavated material. The bottom of the access pit is to be excavated two to three inches into the filter bedding material. Do not excavate pit below the base of the filter bedding material. Be sure to stabilize protective casing and inner access tube during removal of material by attaching a durable guideline(s) for support.

5.3 Cut protective casing and inner access tube using torch or cutoff saw as close as possible to the bottom of the access pit. While cutting the casing and tube, lateral tension must be applied to the guideline(s) to prevent the protective casing and inner access tube from collapsing. As the cutting proceeds, the upper portion (protective casing/inner access tube) can be slowly lowered to one side of the access pit using the guidelines. Take particular care to avoid disturbance to cover components.

5.4 Remove the upper portion from the access pit. Depending on the installation procedure employed, this upper portion may be extremely heavy and cumbersome. Therefore, take necessary safety precautions to avoid undue risk to personnel.

5.5 Inspect the cement grout anchoring the protective casing into the radon barrier to ensure it is completed to the top of the radon barrier. If necessary add bentonite-cement grout to achieve the desired level. At least 24 hours are required for the cement grout to cure. During the curing process inspect and add as required additional grout to compensate for any settling and cracking that may have occurred.

5.6 Place additional bentonite chips in the inner access tube bringing the level of chips up to within 0.2 feet of the top of the tube and hydrate with water. After one hour is allowed for hydration place clean sand, comparable to the filter bedding material, within the annulus between the protective casing and the inner access tube. Fill the entire annulus and allow the clean sand to fill the 0.2 feet in the top of the inner access tube.

5.7 Replace filter bedding material and recompact material as close as possible to design specifications for moisture content and dry density.

5.8 Finally, replace rock riprap cover carefully to avoid damage to filter bedding material.

5.9 If any additional material is needed for the two layers excavated, the material must be as close as possible to design specifications.

6.0 ATTACHMENT

A schematic diagram is attached showing the idealized specifications for neutron probe access hole installation. The diagram is provided to assist in the abandonment procedure.

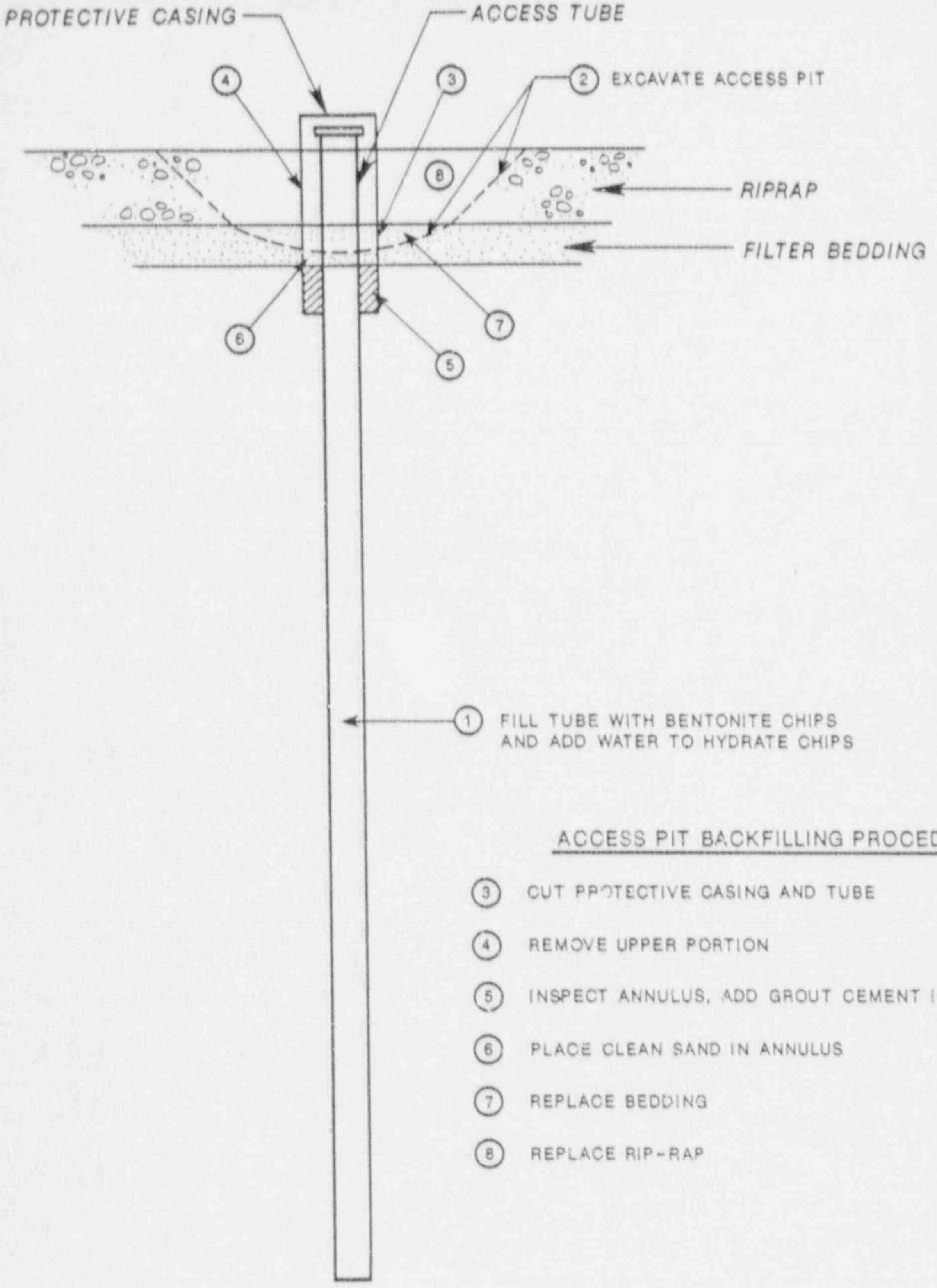
Prepared by: Kevin Lamberty

Reviewed by: Frank B.
Task Manager

Reviewed by: Bob
Quality Assurance Manager

Approved by:
Project Manager

ATTACHMENT 16.1.15



ACCESS PIT BACKFILLING PROCEDURE

③ CUT PROTECTIVE CASING AND TUBE

④ REMOVE UPPER PORTION

⑤ INSPECT ANNULUS, ADD GROUT CEMENT IF NECESSARY

⑥ PLACE CLEAN SAND IN ANNULUS

⑦ REPLACE BEDDING

⑧ REPLACE RIP-RAP

FIGURE 1

NEUTRON ACCESS TUBE CLOSURE DETAILS

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL

SAMPLE COLLECTION, PRESERVATION, AND SHIPMENT OF WATER SAMPLES

SECTION	16.2.1
DATE	02/07/90
EFFECTIVE	06/05/90
SUPERSEDES	08/31/87
PAGE	1 OF 18

1.0 PURPOSE

To provide a procedure by which field programs will conduct and document the collection of water samples for water quality determinations.

2.0 SCOPE

This procedure is applicable to members of the TAC and its contractors and subcontractors with responsibilities and duties for water quality determinations and for the collection, preparation, preservation, and submittal of surface water and groundwater samples for laboratory analysis(es). Appropriate portions of Section 16.1.10 as stated herein are also applicable to this procedure.

3.0 EQUIPMENT AND SUPPLIES

3.1 Pumps

3.2 Hoses/Tubes

3.3 Filter Apparatus

3.4 Filters

3.5 Bailer(s): Use a teflon (tetrafluoroethylene) bailer for sampling organics that can be completely disassembled for the purpose of cleaning thoroughly. The bailer design should be such that it minimizes loss of volatile organics, and contamination by headspace air during sampling. An example of this type of bailer is shown in Attachment 16.1. A PVC bailer may be used for sampling inorganics.

3.6 Flow-Through Cell

3.7 Volumetric Flask(s), Class A: 250, 500, 1000 mL (Available at Laboratory) Required only if preparing solutions listed in Section 4.0.

3.8 Sample Bottle: Carboy or its equivalent

3.9 Sample Bottle for Organic Substances Sampling: Use only glass containers with teflon-lined caps. Precleaned, certified containers will be supplied by the analytical laboratory to the water sampler.

to collect a full container of water). Criteria for exact location and number of grab samples should be based on the known tendency of wastes to mix slowly in surface water. See 17.2. Sample locations unlikely to be contaminated, situated upstream from contaminated sites, or classified as "Background Samples" should be collected <u>first</u> in order to prevent cross-contamination of the water samples.

6.1 Use a carboy for a sample container. Immerse the carboy into the surface water and fill the carboy with water to 1/10 capacity. NOTE: If the surface water is frozen, <u>do not</u> collect ice samples in lieu of water samples.

6.2 Swirl and rinse the carboy interior with the water. Go downstream about 5-10 feet and discard the water. Return upstream to the original sampling location. NOTE: For a lake or other standing surface water, discard the water at a site away from the sampling location.

6.3 Repeat Steps 6.1 and 6.2 TWICE more with fresh water.

6.4 Fill the carboy with raw water sample and mix the sample well. Obtain temperature, conductivity, and pH data on the sample solution as described in 6.0, 7.0, and 8.0 of Section 16.1.10. Record data on Attachment 16.2.1.6.

6.5 If alkalinity determination is required, carefully pour an aliquot of the sample from 6.4 down the side of and into a sample bottle labelled with "For Alkalinity Analysis". Save bottle for 6.9.

6.5.1 If alkalinity determination <u>is not</u> required, proceed directly with 6.6.

6.5.2 Record site location, sample number, sample volume, date collected, and collector name on Attachment 16.2.1.6.

6.6 If sample is to be filtered, preserved (if required), and shipped to an analytical laboratory, proceed with 12.0.

6.7 Clean and store thermometer, and conductivity and pH electrodes as described in 6.5, 7.3, and 8.1 of Section 16.1.10.

6.8 Check Attachment 16.2.1.6 to make sure that all of the required sampling data has been entered on the form.

6.9 If alkalinity determination is required, take sample bottle from 6.5, and proceed with 9.0 of Section 16.1.10.

6.10 Proceed with 12.9 to make sure all of the required duties are completed.

7.0 PROCEDURE: GENERAL GROUNDWATER SAMPLING RULES

7.1 Collect sample **first** from wells which are likely to be uncontaminated. Then collect samples from wells which could be contaminated.

7.2 Take water from domestic wells as close to the wellhead as is practical and downhole, if possible. NOTE: Do not take a sample downstream of any device which alters water quality (e.g., a water softener).

7.3 Whenever there is sufficient wellwater, pump water from the well and purge at least three (3) well volumes. **Record on Attachment 16.6 when this purging cannot be performed.**

7.4 Record any odors, colors, etc. present in the water sample on Attachment 16.2.1.6. Mark well location on a map. NOTE: When sampling domestic wells, request and record information regarding well depth, completion interval, use, diameter, etc.

7.5 Record any deviation(s) from or modification(s) to these general procedures as well as the rationale for these changes.

8.0 PROCEDURE: DIRECT SAMPLING OF A GROUNDWATER SAMPLE

A water sample is pumped directly from the well to a proper sample container. Dissolved constituent samples are filtered through a 0.45-mm filter and total constituent samples are not filtered.

8.1 Unwrap clean hose and pump. Connect hose to the clean pump.

8.2 Place hoses and downhole pump into the wellhole. Connect a flow-through cell and place outlet hose into a clean container to allow measurement of flow rate. Insert thermometer, conductivity, and pH electrodes into the flow-through cell. NOTE: Position pump intake a few feet above the screened interval and as near as possible to the well screen.

8.3 Start pump and begin purging well. Perform periodical temperature, conductivity, and pH measurements on water in flow-through cell as described in 6.0, 7.0, and 8.0 of Section 16.1.10 and record data on Attachment 16.2.1.6. These data are used to verify that temperature, pH, and conductivity have stabilized prior to sample collection. NOTE: Adjust pH temperature compensator, if necessary.

8.4 Begin collecting the wellwater sample after the temperature, conductivity, and pH of the discharging water has stabilized (i.e., within 0.1 units, for at least 10 minutes). Collect the required amount of sample. Close bottle and mix the water sample well.

8.4.1 Collect the unfiltered water samples upstream of the flow-through cell and preserve and store as required. See 12.0 and 15.0.

8.4.2 Collect the filtered water sample upstream of the flow-through cell. See Section 12.0.

8.5 If an alkalinity test is required, obtain an unfiltered sample upstream of the flow-through cell. Rinse the volumetric flask two times with well water, obtain a fresh sample, and proceed with 9.0 of Section 16.1.10.

8.6 Check Attachment 16.2.1.6 to make sure that all sample collection data has been entered on the form and that all sample bottles are appropriately labelled.

8.7 Clean and store thermometer, conductivity, and pH electrodes as described in 6.5, 7.3, and 8.1 of Section 16.1.10.

8.8 Dissassemble sampling apparatus. Drain hoses and pumps to ensure that all of the previous water sample is expelled. Clean hoses and pumps.

8.8.1 Pump 2000 mL of distilled water through the hoses and the pump. Continue pumping until all of the distilled water is expelled. Clean outside of hoses/pumps with distilled water and dry the hoses/pumps with tissues. The hoses/pumps are now ready for another sampling activity or storage.

8.8.2 If hoses and pumps are to be stored, place unit in a clean plastic bag and seal with tape. Label with "clean", date, and initials.

8.9 Clean flow-through cell with distilled water and discard rinse. Set cell to drain and shake cell vigorously to remove water. The cell is now ready for another sampling activity or storage.

8.9.1 If the cell is to be stored, wrap unit in a clean plastic bag and seal with tape. Label with "clean", date, and initials.

8.10 If a filter has been used, remove filter from holder and discard. Clean apparatus several times with distilled water. Make sure inlet and outlet openings are well rinsed. Rinse outside of filter apparatus and dry with tissue. Filter apparatus is now ready for a fresh filter and another sampling activity or storage.

8.10.1 If apparatus is to be stored, wrap unit in a clean plastic bag and seal with tape. Label with "clean", date, and initials.

9.0 PROCEDURE: GROUNDWATER SAMPLING FROM A PRODUCTION WELL

Raw samples from production wells will be collected by the "grab" sample method from public, private, and TAC water supply wells during pump tests or regular pumping.

9.1 Unwrap and connect clean hose(s) to the clean pump(s).

9.2 Connect one end of the sampling hose(s)/pump(s) to the well and the other end to a flow-through cell. Place cell outlet hose into a clean container to measure flow rate. Check all connections to make sure there are no leaks. Insert thermometer, conductivity, and pH electrodes into the flow-through cell.

9.3 Open flow regulator to allow water to pass through flow-through cell. Periodically, perform temperature, conductivity, and pH measurements as described in 6.0, 7.0, and 8.0 of Section 16.1.10 and record data on Attachment 16.6. This data is used to verify that temperature, pH, and conductivity have stabilized prior to sample collection. NOTE: Adjust pH temperature compensator, if necessary.

9.4 Begin collecting the water sample after the temperature, conductivity, and pH of the discharging water has stabilized (i.e., within 0.1 units, for at least 10 minutes). Collect the required amount of sample. Close bottle and mix the water sample well.

9.4.1 Collect the unfiltered water samples upstream of the flow-through cell and preserve and store as required. See 12.0 and 15.0.

9.4.2 Collect the filtered water sample upstream of the flow-through cell and proceed with 12.0.

9.5 If an alkalinity test is required, obtain an unfiltered sample upstream of the flow-through cell. Rinse the volumetric flask two times with well water, obtain a fresh sample, and proceed with 9.0 of Section 16.1.10.

9.6 Check Attachment 16.2.1.6 to see that all of the required sampling data has been entered.

9.7 Clean and store thermometer, conductivity, and pH electrodes as described in 6.5, 7.3, and 8.1 of Section 16.1.10.

9.8 Clean filter apparatus: remove filter paper and discard (if required), wash filter apparatus with detergent and water, and rinse well with distilled water. Dry filter apparatus with tissue. Filter apparatus now ready for another sampling activity or storage. NOTE: Be sure inlet/outlet hoses are also cleaned and rinsed.

9.8.1 If filter apparatus is to be stored, wrap unit with clean plastic bag and seal with tape. Label with "clean", date, and initials.

9.9 Clean flow-through cell: rinse well with distilled water. Be sure to rinse inlet and outlet hoses well with distilled water. Shake cell vigorously to make sure that all of the excess water has been expelled. Cell now ready for another sampling activity or storage. NOTE: If cell has been discolored by water substance(s), wash cell with soap and water, and rinse well with distilled water.

9.9.1 If cell is to be stored, wrap cell with a clean plastic bag and seal with tape. Label with "clean", date, and initials.

10.0 PROCEDURE: GROUNDWATER SAMPLING WITH A BAILER

Water samples should only be collected with a bailer whenever it is impossible to pump from the well. Bailers made of teflon, PVC, or stainless steel should be used whenever possible.

Samples to be collected and analyzed for EPA Appendix VIII/IX organic substances may preferably be collected by the bail method. See Section 16.1.11. Teflon is preferred for collection of samples containing organics.

10.1 If the bailer requires cleaning, clean bailer as described in 10.14.

10.1.1 NOTE: If bailer has previously been washed, rinse bailer thoroughly with distilled water. Drain and discard rinse. Repeat TWICE more with distilled water.

10.1.2 Rinse outside of bailer with distilled water. Dry outside of bailer with tissues. The bailer is now ready for sample collection.

10.2 Lower a clean bailer into the well and fill bailer ~1/3 full with water. NOTE: Omit 10.2 and 10.3 if well volume is insufficient for rinses. Proceed directly with 10.4.

10.3 Retrieve bailer, mix water in bailer, and discard water at a site away from the well. Repeat TWICE more with fresh wellwater.

10.4 Lower bailer into the well, fill bailer with water sample, and retrieve bailer. NOTE: Avoid direct contact with a dirty surface; always rest bailer(s) on a clean plastic sheet. Use a new bailer rope for sampling each well.

10.4.1 If bailer is used because well is "unpumpable," proceed with 10.7 and then to 10.14. Omit all other steps.

10.5 Drain bailer into a clean sampling container such as a carboy. Also, fill the flow-through cell with sample water. Unwrap and connect clean hose and pump. Place one end of hose into carboy and remaining end of hose into a sample bottle. Check connections to make sure that they are tight. Insert clean thermometer, conductivity, and pH electrodes into the flow-through cell and tighten connections.

10.6 Perform temperature, conductivity, and pH measurements on each carboy as described in 6.0, 7.0, 8.0 of Section 16.1.10 and record data on Attachment 16.2.1.6.

10.7 Pump the unfiltered water samples from the carboy into the sample bottles and preserve and store as required. See 12.0 and 15.0.

10.7.1 Next collect the filtered water sample according to 12.0.

10.8 If an alkalinity test is required, obtain an unfiltered sample from the carboy. Rinse the volumetric flask two times with well water and obtain a fresh sample and proceed with 9.0 of Section 16.1.10.

10.9 If the uncollected sample is insufficient, repeat 10.4 and until the required sample volume has been collected.

10.10 Check Attachment 16.2.1.6 to see that all of the sampling data has been entered.

10.11 Clean and store thermometer, conductivity, and pH electrodes as described in 6.5, 7.3, and 8.1 of Section 16.1.10.

10.12 Clean filter apparatus several times with detergent and water and rinse with distilled water. Rinse outside of filter apparatus with distilled water and dry with tissue. The filter apparatus is now ready for another sampling activity or storage.

10.12.1 If filter apparatus is to be stored, wrap unit with a clean plastic sheet and seal with tape. Label with "clean", date, and initials.

10.13 Disassemble sampling apparatus, drain hoses/pumps to ensure that all of the previous water sample is expelled, and clean hoses and pumps.

10.13.1 Pump ~2000 mL of distilled water through the hoses and pumps. Continue pumping until all of the distilled water is expelled. Clean outside of hoses/pumps with distilled water and dry with tissues. The hoses/pumps are now ready for another sampling activity or storage.

10.13.2 If hoses/pumps are to be stored, wrap unit in a clean plastic sheet and seal with tape. Label with "clean", date, and initials.

10.14 If possible, disassemble bailer and wash with detergent and warm water. Use a brush. Rinse well with distilled water to remove detergent.

10.14.1 Rinse bailer at least three (3) times with hexane or ~2 N HCl, followed by at least three (3) rinses with distilled water.

10.14.2 Reassemble bailer and rinse again with distilled water. Rinse outside of bailer with distilled water and dry with tissue. Shake bailer vigorously to remove water. Bailer now ready for another sampling activity or storage.

10.14.3 If bailer is to be stored, wrap unit with a clean plastic sheet and seal with tape. Label with "clean", date, and initials.

11.0 PROCEDURE: GROUNDWATER SAMPLING FROM SEEPS AND SPRINGS

When seeps or springs are present within a study area, it is desirable to obtain a water sample. If the seep or spring discharge is small, it will be difficult to obtain a large sample. For large discharge springs, the sample should be collected by the grab method just as a sample is collected from a discharging well or collected with a peristaltic pump. In either case, the steps taken to collect and prepare the sample should be well documented. A typical procedure to collect samples follows, but it may be necessary to improvise to obtain a sample.

11.1 If the seep discharge is small, place a clean and unused bottle where the seep will drip into the container. If necessary, dig out the soil matrix to increase the flow, but document this on Attachment 16.2.1.6. NOTE: if possible, determine temperature, conductivity, and pH data as described in 6.0, 7.0, and 8.0 of Section 16.1.10.

11.1.1 Be sure to note and record how long it takes to obtain a sample.

11.2 Pump sample through a filter into a clean, unused, and labelled bottle. Record sample volume on Attachment 16.2.1.6. Discard filter unless directed by the SH to save the filter for lab analysis.

11.2.1 A small sample volume of as little as 10 mL can be analyzed for uranium. NOTE: If seep flow is small, collect a small sample and consult SH for further instructions.

12.0 PROCEDURE: FILTRATION AND PRESERVATION OF WATER SAMPLE(S)

Whenever water samples are to be analyzed for soluble (or dissolved) analytes, insoluble matter must be removed or this material may interfere with the analysis(es) and could seriously affect detection instrument operations. In addition, the insoluble material in a water sample may sometimes require analysis(es) and must be separated from the dissolved analytes. The soluble and insoluble analytes are separated by filtration. The soluble analytes pass through a filter while the insolubles are retained by the filter. Then, if required, the insoluble matter with the filter is saved and submitted for laboratory analysis(es). The JEG Water Samplers should consult with the Site Hydrogeologist prior to sampling to determine if sample(s) should be filtered and whether the insoluble material should be saved for analysis or discarded. This should be recorded on Attachment 16.2.1.6.

12.1 Assemble clean hose(s) and clean pump(s). Insert a filter apparatus containing a new filter between the water source and the sample bottle. Check all connections to make sure that they are tight. NOTE: If the equipment has not been cleaned, clean the equipment as described in 12.7.

12.2 Before collecting any samples, run a few hundred mL of the water sample through the filter. Discard this water at a site away from the water source. NOTE: If filter becomes clogged during this step or during Step 12.3, replace filter as described in 12.8.1. <u>Do not</u> clean filter or back flush filter with the water sample.

12.3 Fill the sample bottles. Allow no dirt or dust to blow into the bottles or onto the bottle caps. Rinse the inside of the bottle caps with filtered water and screw cap onto bottle. Shake the bottle to mix the sample. NOTE: While filling the sample bottle, and once the sample is in the bottle, do not allow the water sample to touch anything but the bottle walls. **Never** stick anything into the bottle. Do not smoke near open bottles.

12.4 If required, add an appropriate amount of preservative after filling the sample bottles. Refer to Attachment 16.2.1.7 for volumes required and preservation techniques. Record the type of preservative on the sample label. **If preservative is not required, proceed with 13.0.** NOTE: Keep the water samples out of direct sunlight.

12.4.1 If Nitric Acid (HNO_3) is to be added, add 5 mL of $\sim$8 N HNO_3 per liter of sample, mix sample well, and check pH of sample solution. pH should be <2. If pH is >2, add $\sim$8 N HNO_3, mL by mL, with mixing after each addition until pH of sample solution is <2. NOTE: Concentrated HNO_3 may be used as an alternate: add 3 mL of HNO_3 per liter of sample and mix sample solution well.

12.4.2 If Hydrochloric Acid (HCl) is to be added, add 5 mL of $\sim$6 N HCl per liter of sample, mix sample well, and check pH of sample solution. pH should be <2. If pH is >2, add $\sim$6 N HCl, mL by mL, with mixing after each addition until pH of sample solution is <2. NOTE: Concentrated HCl may be used as an alternate: add 3 mL of HCl per liter of sample and mix sample solution well.

12.4.3 If Sulfuric Acid (H_2SO_4) is to be added, add 5 mL of $\sim$9 M H_2SO_4 per liter of sample, mix sample well, and check sample pH. pH should be <2. If pH is >2, add $\sim$9 M H_2SO_4, mL by mL, with mixing after each addition until pH of sample solution is <2. NOTE: Concentrated H_2SO_4 may be used as an alternate: add 2 mL of H_2SO_4 per liter of sample and mix sample solution well.

12.4.4 If Sodium Hydroxide is to be added, add 2 mL of $\sim$18 N NaOH per liter of sample. Mix sample well and check sample pH. If pH is <10, add NaOH mL by mL until pH is >10. Mix sample solution well after each addition of NaOH.

12.4.5 If Sodium Hydroxide and Zinc Acetate solution are to be added, add 2 mL of $\sim$18 N NaOH per liter of sample and mix sample solution well. Check sample pH. If pH is <10, add NaOH mL by mL until pH is >10. Add 2 mL of Zinc Acetate solution (220 g/L) per liter of sample and mix sample solution well.

12.5 Pour a few drops of the preserved water sample onto the bottle cap and dip the tip of the litmus paper into the bottle cap to check the pH of the water sample. If the pH is >2, add acid, or <10, add base as appropriate. Discard cap contents, place cap on bottle and tighten. NOTE: Keep sample(s) out of direct sunlight.

12.6 Check Attachment 16.2.1.6 to make sure that all sampling data has been correctly entered. This should include any comments or deviation(s) from the procedure.

12.7 Clean equipment by draining hoses and pumps to make sure that all of the water sample is expelled.

12.7.1 Pump ~2,000 mL of distilled water or its equivalent through the hoses/tubes and pump. Continue pumping until all of the distilled water is expelled.

12.7.2 Rinse outside of hoses and pumps with distilled water and dry hoses/pumps with tissue(s). Hoses/pumps now ready for another sample or storage. NOTE: Dry hoses/pumps before inserting them into the well, before connecting them to another pump, or before putting them into a carboy.

12.7.3 If hoses and pumps are to be stored, place apparatus in a clean plastic bag and seal with tape. Label with "clean", date, and initials.

12.8 If using disposable filters, disregard 12.8 and proceed to 12.9. Clean the filter apparatus by disassembling the unit, discard the filter (if required), and rinse all surfaces which come into contact with the water sample with distilled water. Dry filter apparatus with lint-free tissue(s). Filter apparatus now ready for another sampling activity or storage.

12.8.1 With clean hands, install a new filter, touching the filter only along its perimeter. Re-assemble the filter apparatus. NOTE: Use a pair of tweezers, if necessary, to handle the filter. Allow no dirt or dust to blow onto the cleaned apparatus or filter.

12.8.2 If the filter apparatus is to be stored, place apparatus in a clean plastic bag and seal with tape. Label with "clean", date, and initials.

12.9 Perform the following POST-COLLECTION DUTIES:

12.9.1 Clean up field equipment.

12.9.2 Replace expended items, filters, reagents, reagent solutions, etc.

12.9.3 Repair broken equipment or report/request replacement.

12.9.4 Make Xerox copies of all field forms associated with a given lot of samples and distribute copies to the Site Hydrogeologist, Data Manager, Water Sampling Manager, and the BOA Tech Rep within two (2) weeks of the date of sample collection. NOTE: Submit the final field values for pH, temperature, conductivity, and alkalinity to the Data Manager who will include this data in the water quality data base.

12.9.5 Give original field form(s) containing the sampling information to JEG Document Control.

12.10 Notify the Site Manager, by memorandum, of the collection of the field sampling data and delivery of this information to JEG Document Control.

13.0 PROCEDURE: PREPARATION OF SPLIT SAMPLES

13.1 Thoroughly rinse the split jug with about one (1) gallon of distilled water or its equivalent. Drain rinse through both the inlet and outlet hoses.

13.2 Pump ~10 L of the filtered water sample into the split jug and rinse jug thoroughly with the sample. Drain rinse through both the inlet and outlet hoses/tubes.

13.3 Whenever possible, pump more than enough filtered water sample into the split jug to fill all of the sample sets. As a minimum, pump more than enough filtered water sample to fill all of the bottles used for identical analyses. Swirl the jug contents thoroughly to mix the water sample.

13.4 Dispense sample types consecutively, i.e., fill one anion bottle immediately after the other, one metals bottle immediately after the other, etc.

14.0 PROCEDURE: PREPARATION OF SAMPLE SPLITS, KNOWN SOLUTIONS, AND ARCHIVED SAMPLES

14.1 Separate field samples into sample lots for packaging and shipment to the analytical laboratory.

14.1.1 A sample lot should consist of no more than nine (9) field samples, four (4) replicates of one of the field samples, and at least one (1) known solution.

14.2 Every field sample and known solution may also be split into a sample submitted for lab analysis(es) and a sample to be archived. NOTE: Archived samples are stored by the analytical laboratory and may be analyzed by that laboratory and, at the discretion of JEG, used for re-analysis(es) or other purposes.

15.0 PROCEDURE: PREPARATION OF WATER SAMPLES FOR PACKAGING, LABELLING, AND TRANSPORT

15.1 Label bottles with the TAC's pre-printed labels. Fill in all appropriate information in the blank spaces.

15.2 Immediately put the samples requiring refrigeration into an insulated cooler containing "blue ice" or ice. Samples which do not require refrigeration should be placed in a box or other suitable container, filled with absorber material, sealed, and shipped to the analytical laboratory. NOTE: Keep all samples out of direct sunlight.

15.3 Put the address and telephone number of the UMTRA Project Office and the name of a JEG contact in the insulated container. Include a list giving the number of samples and sample identification in each container. Use Attachment 16.2.1.4. This sample list will be completed by the laboratory and sent to the BOA Tech Rep so that records will be kept on the list of samples received. This list can be compared to a duplicate sample list which is retained with the water sampling data to assure that no samples were lost or misplaced during shipment.

15.4 Tape the container with strapping tape for shipping. Inform the laboratory of the sample arrival time and date.

15.5 Schedule sample collection/shipment so that the samples do not arrive at the lab after 4 p.m. on a Friday, Saturday or on a Sunday. Whenever possible, ship the samples so that they arrive at the laboratory no later than 72 hours after they were collected.

15.6 Have the laboratory document sample lot arrival times, and report this information to the BOA Tech Rep.

16.0 ATTACHMENT(S): SUPPORTING DOCUMENT(S)

16.2.1.1 Schematic Drawing entitled "Point Source Bailer"

16.2.1.2 Site Hydrologist to Water Sampling Manager memo

16.2.1.3 Site Hydrologist Work Order Plan

16.2.1.4 UNC Cover Letter

16.2.1.5 Equipment Checklist

16.2.1.6 Water Quality Sampling Record Form--4 Forms

16.2.1.7 Potential Sample Overview

17.0 REFERENCES

17.1 Barcelona, Michael, John A. Helfrich, and Edward E. Garske, 1985 "Sampling Tubing Effects on Groundwater Samples." Anal. Chem.. 57: 460-464.

17.2 Korte, N. and P. Kearl, 1984. "Procedures for tne Collection and Preservation of Groundwater and Surface Water Samples and for the Installation of Monitoring Well." U.S. Department of Energy, Grand Junction, Colorado.

17.3 Miller, G. D., 1982. "Uptake and Release of Lead, Chromium, and Trace Level Volatile Organics Exposed to Synthetic Well Casings." Proc. 2nd Nat'l Symp. Aquifer Restoration and Ground Water Monitoring, 1982, 236-245.

17.4 Nielsen, D. M. (ed.), 1983. "Cnemical Proolems in Groundwater Monitoring Programs." Proc. 3rd Nat'l. Symp. Aquifer Restoration and Ground Water Monitoring, 1983: 263-271.

17.5 Pettyjohn, Wayne A., W. J. Dunlap, R. Cosby, and J. W. Keeley, 1981. "Sampling Ground Water for Organic Contaminants." Groundwater, 19 (2): 180-189.

17.6 USEPA, 1983. Methods for Cnemical Analysis of Water and Wastes. EPA-600/4-79-020. Revised, March 1983.

17.7 USEPA, 1985. Practical Guide for Ground Water Sampling. EPA 600/2-85/104

18.0 PROCEDURE REVIEW AND APPROVAL

Prepared By: ______________________ 5-30-90
TAC Representative Date

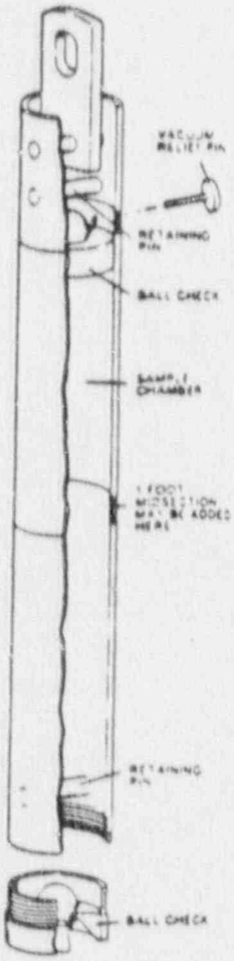
Reviewed By: ______________________ 5/31/90
Task Manager Date

Reviewed By: ______________________ 5/31/90
Quality Assurance Manager Date

Approved By: ______________________ 5/31/90
Project Manager/ Date
Deputy Project Manager

ATTACHMENT 16.2.1.1

Point Source Bailer



POINT SOURCE BAILER allows sampling at specific point within a monitoring well

•

Threaded and press fitted construction allows for ease of decontamination

•

Additional 1 foot midsection(s) may be added at the center to increase volume

•

Available in polyvinyl chloride (PVC) or all virgin polytetrafluoroethylene (PTFF), LEXAN™ or stainless steel

SIZES AVAILABLE

PTFE:
1 inch O.D thru
4.5 inches O.D
(25.4 mm - 114.30 mm)
Lengths: 2 thru 5 ft

TIMCO™ Bailers

ATTACHMENT 16.2.1.2

JEGG/JEG/1188-0620

JACOBS ENGINEERING GROUP INC., ALBUQUERQUE OPERATIONS

TO: JFritts

FROM: RHeydenburg

DATE: November 14, 1988

SUBJECT: Water Quality Sampling at Spook, WY

Water quality sampling of monitor wells and lysimeters at the Spook site should begin on November 28, 1988.

LOT 1

SPK01 - 910
- 911
- 913
- 914
- 915
- 919
- 920
- 921
- 922
- 923
- 938
- 941
- 702 (lysimeter)
- 991 UNC Known

LOT 2

SPK01 - 912
- 918
- 927
- 928
- 935
- 936
- 937
- 939
- 940 splits 951, 952, 953, 954
- 942
- 993 UNC Known

LOT 3

SPK01 - 916
- 917
- 924
- 925 splits 955, 956, 957, 958
- 931
- 932
- 933
- 934
- 943
- 944
- 995 UNC Known

Slug tests will be performed in monitor wells 913, 928, and 933 through 944.

Attempt to collect samples from all lysimeters. See attached memo of October 5, 1988 regarding location and sample bottle priorities. If water is obtained from lysimeters in addition to 702, include samples in LOT 1.

Note that monitor wells 929 and 930 will not be sampled.

RH:rc
Attachments

cc: BBearden
EBanks
MGilbert (w/out attachments)
FTitus
Document Control

JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

WORK ORDER PLAN - ANALYSIS OF WATER SAMPLES

PAGE 1 OF 2

WORK ASSIGNED BY: ______________________

SITE: ______________________

DATE ASSIGNED: ______________________

SAMPLE I.D. ______________________

Bottle Name	Cl	SO4	Na	K	Mg	Ca	B	F	CN	S	TKN	NH4	NO3 + NO2	NO3	SiO2	PO4	Br	Al	Sb	As	Ba	Be	Cd	Cr	Co	Gross Alpha/Beta
Total # of Tests																										

COMMENTS:

ATTACHMENT 16.2.1.3

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

WORK ORDER PLAN - ANALYSIS OF WATER SAMPLES

PAGE 2 OF 2

WORK ASSIGNED BY: ____________________

SITE: ____________________

DATE ASSIGNED: ____________________

SAMPLE I.D. ____________________

Bottle Name	Cu	Fe	Pb	Mn	Hg	Mo	Ni	Se	Ag	Sr	Sn	Ti	U	V	Zn	TDS	TOC & DOC	Pb-210	Po-210	Ra-226	Ra-228	Th-230
Total # of Tests																						

COMMENTS:

ATTACHMENT 16.2.1.4

JEGA/UNC/0889-0043

August 1, 1989

Mark Hollenbach
UNC Technical Services, Inc.
2597 B 3/4 Rd.
P.O. Box 14000
Grand Junction, CO 81502

Dear Mr. Hollenbach:

Please prepare known solutions as indicated below. Labeled bottles will be sent to you by our sampling team manager. The known solutions should be bottled as indicated on the attached Work Order Plan. Please send the known solutions to Core Laboratories, 1300 South Potomac, Suite 130, Aurora, Colorado 80012.

Very truly yours,
JACOBS ENGINEERING GROUP INC.

Kent Bostick

Frank B. Titus
Manager, Hydrological Services

FBT:jw
Enclosure

cc: MGilbert (w/attachments)
[redacted] (w/attachments)
LCoons (")

SITE: Gene.

APPROXIMATE DATE REQUIRED:

SAMPLE IDENTIFICATION NUMBER	APPROXIMATE TDS DESIRED (mg/l)
699	5000
975	6000

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

SECTION ______
PAGE 1 OF 3

EQUIPMENT CHECKLIST

(Fill out all blanks prior to leaving for field)

---

pH BUFFER	Yes	No	Comments
sufficient volume 4	______	______	
sufficient volume 7	______	______	
sufficient volume 10	______	______	

REAGENTS & BOTTLES			
Litmus paper	______	______	
Nitric acid (pres.)	______	______	
Sulfuric acid (pres.)	______	______	
not required * ____			
Other reagents	______	______	
not required ____			

Required sample bottles:

Number of 1000 ml plastic bottles for A1, M2, Po210, Th230, CN, S, Pb210, Ra226, Ra228 ______

Number of 500 ml plastic bottles for Gross Alpha-Beta, N1 ______

Number of 500 ml amber glass bottles for TOC ______

Number of 1000 ml amber glass bottles for TOX ______

Sufficient bottles	______	______	
Alkalinity kit			
ck reagent volumes	______	______	
ck glass for breakage	______	______	

---

* If required, must explain under Comments.

ATTACHMENT 16.2.1.5

EQUIPMENT CHECKLIST
(Fill out all blanks prior to leaving for field)

OTHER EQUIPMENT — Comments

squeeze bottle ______

acid dispensette ______

deionized H_2O
quantity ____ gallons

distilled H_2O ____ gallons

water level sounder ______ battery check ______
hand tape ______
cloth towels or wipes ______

FIELD FORMS AND MISCELLANEOUS EQUIPMENT:

Expected no. of samples ___ No. of forms ___

Clipboard with cover ___

Maps ___ marked with well locations ___

Well information (completion, depth, etc.) ___

Field instruction book ___

Key(s) to well(s) ___ To be picked up at ___

Clean pails ___ Transparent tape ___

WD-40 (for locks) ___ Strapping tape (nylon) ___

Marking pen ___

Coolers ___

Shipping address of lab(s):

______________________ ______________________
______________________ ______________________
______________________ ______________________
______________________ ______________________

EQUIPMENT CHECKLIST
(Fill out all blanks prior to leaving for field)

____

Comments

Phone numbers and contact:

______________________ ______________________

______________________ ______________________

PUMPS AND FILTERS

Logic unit _____

Regulator _____

Wrenches _____

Air hose ____

Power cord _____

Logic unit cord _____

Water hose _____

____

PERISTALTIC PUMP

Battery cable ____

Clean? yes ___ no ___

Tubing ____ Length ____

Filter system:

Inspect filter housing for cracks __ ___

Filter unit legs ____

Number of filters ____

Filter size ____

Rechargeable battery ____

Battery charger ____

ATTACHMENT 16.2.1.5

ATTACHMENT 16.2.1.6

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

Page 1 of 4

WATER QUALITY SAMPLING RECORD

SITE ID: ____________

LOCATION ID: ____________

SAMPLE ID: ____________

STATIC WATER LEVEL (FT) ________

SAMPLE DEPTH (FT) ________

SAMPLING DATE ____________

SAMPLING TIME:

START ____________

COMPLETE ____________

FINAL FIELD VALUE AT THE SURFACE

pH (S.U.) ________

Ec (µmhos/cm) ________

TEMP. (°C) ________

ALKALINITY (mg/l $CaCO_3$) @ pH 4.5 ________

TITRANT: 1.6 N H_2SO_4 LOT # ________

____________ FILTER(S) USED

COMMENTS ____________

LOCATION DESCRIPTION ____________

AIR TEMP. C D.O. (air) mg/l Eh soln.(.1M) mV at °C

FIELD REP(S) ____________

DATE	TIME	TOTAL VOLUME WITHDRAWN		pH	Ec (µmhos/cm)	TEMP. (°C)	Eh (mV)	D.O. mg/l	COMMENTS
		(Gals)	(Bore Volumes)						
		0.0	0.0	–	–	–			START PUMPING

JEG-AL-ENG-44 (2/90)

WATER QUALITY SAMPLING RECORD

BORE VOL CALCULATION
$(d/2)^2 \pi (h_1 - h_2)^*$

SAMPLING INFORMATION

SITE ID ____________

LOCATION ID ____________

DEPTH TO WATER (h_2) (FT.) ________

DEPTH OF WELL (h_1) (FT.) ________

WELL DIA (d) (FT.) ________

BORE VOL. (FT.)^3 ________

SCREENED INTERVAL (FT.) ________

WITHDRAWAL METHOD ________

FILTER SIZE .45µ

THERMOMETER ID ________

Ec METER ID ________

pH METER ID ________

PUMP ID ________

Eh METER ID ________

D.O. METER ID ________

CALIBRATION INFORMATION

DATE OF LAST Ec CALIBRATION ________

TIME OF pH CALIBRATION ________

pH AFTER MEASUREMENT ________ FOR STANDARD pH ________

pH AFTER MEASUREMENT ________ FOR STANDARD pH ________

SHIPPING INFORMATION

LAB(S) SHIPPED TO:			
DATE(S) SHIPPED:			
METHOD OF SHIPMENT:			

NOTES

---

* The value of $(\frac{d}{2})^2 \pi$ is: .022 for a 2' well
.088 for a 4' well

WATER QUALITY SAMPLING RECORD

ALKALINITY TITRATION

SITE ID: ______________________

LOCATION ID: ________________

DATE: ________________________

ERROR AT 4.50: $\left| \frac{X1 - X2}{X^{5}} \right| \times 100 =$ ___%

1st = _____ %

2nd = _____ %

pH CHECK AFTER TITRATION

7.00 = ___________

4.00 = ___________

pH	ALKALINITY (mg/l $CaCO_3$)		
	1st	2nd	3rd
8.90			
8.60			
8.30			
8.05			
7.80			
7.50			
6.50			
5.70			
5.10			
4.80			
4.50			
4.25			
4.00			

NOTES

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

EXHIBIT C
ATTACHMENT 4
SUBCONTRACT NO. 34-6705-S________

ACKNOWLEDGEMENT OF RECEIPT OF SAMPLES FOR DELIVERY ORDER NO. 0

SITE ID:__________ LOCATION ID:__________ SAMPLE ID: __________

SAMPLE SHIPMENT LIST

LOT#________

SAMPLE MATRIX (Check one)

WATER ( ) SOIL ( )

BOTTLE ID	AMOUNT	REC'D (✓)	BOTTLE ID	AMOUNT	REC'D (✓)
A1	______	( )	Th 230	______	( )
A1-A	______	( )	GA/B	______	( )
M1	______	( )	N1	______	( )
M1-A	______	( )	CN	______	( )
M2	______	( )	S	______	( )
M2-A	______	( )	TOC	______	( )
Pb 210	______	( )	Alkalinity	______	( )
Po 210	______	( )			
Ra 226	______	( )			
Ra 228	______	( )			

DATE SHIPPED: ______________ METHOD OF SHIPMENT: ______________

COMMENTS: ____

- -

To be completed by subcontracting laboratory

I hereby acknowledge receipt of the following on: ______________
(date)

Delivery Order No. ________ Work Order Plan dated: ______________

Subcontractor: ______________________
Name: ______________________
Title: ______________________

COMMENTS: ____

In accordance with Exhibits B and C of the Subcontract :
Water Quality Analytical

Results due to JEG by: ______________
(date)

POTENTIAL SAMPLE OVERVIEW

Bottle I.D.	Bottle type	Volume (ml)	Preservation techniques	Analytes
A	Polyethelene	2000	Filtered, 4^{0}C	F, Cl, So_4, PO_4 SiO_2, B, TDS, Br
M	Polyethylene	1000	Filtered, HNO_3 to pH<2	Na, K, Mg, Ca, Sr, Ba, Mo, As, Cd, Cr, Hg, Pb, Sb, Se, Al, Fe, Mn, Ag, Co, Cu, Ni, Sn, V, Zn, U, Be, Tl
N1	Polyethylene	500	H_2SO_4 to pH<2, 4^{0}C	NH_4, NO_2 + NO_3, NO_3
CN	Polyethylene	1000	NaOH to pH>12, 4^{0}C	CN^-
S	Polyethylene	1000	NaOH to pH>9, 2.5 ML of 220g/L zinc acetate solution per liter	S^{2-}
TOC	Amber glass w/ Teflon liner	500	4^0 C H_2SO_4 to pH<2	TOC
TOX	Amber glass w/ teflon liner and septum	1000	4^{0}C	TOX
Pb210	Polyethylene	1000	Filtered, HNO_3 to pH<2	Pb210
Po210	Polyethylene	1000	Filtered, HNO_3 to pH<2	Po210
Ra226	Polyethylene	2000	Filtered, HNO_3 to pH<2	Ra226
Ra228	Polyethylene	2000	Filtered, HNO_3 to pH<2	RA228
Th230	Polyethylene	1000	Filtered, HNO_3 to pH<2	Th230
GA&GB	Polyethylene	500	Filtered, HNO_3 to pH<2	GA&GB

Any deviations from the above table will be noted on the Acknowledgement of Receipt of Sample form which accompanies the samples to the laboratory.

ATTACHMENT 16.2.1.7

ACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL

WATER SAMPLING FOR TRITIUM ANALYSIS

SECTION	16.2.2
DATE	06/09/89
EFFECTIVE	11/20/89
SUPERSEDES	05/28/87
PAGE	1 OF 3

1.0 PURPOSE

To provide a procedure for the collection of water samples from soil water suction samplers or from pumped wells for tritium analysis.

2.0 SCOPE

This procedure is applicable to members of TAC and its contractors and subcontractors with responsibilities and duties for the collection and submittal of water samples for tritium analysis.

3.0 EQUIPMENT

3.1 Sample Bottles (4 bottles per sampling site): Glass bottles; 250 mL, amber, new, certified clean, and dry

3.2 Polyseal or similar caps

3.3 Argon Gas; tank of compressed gas. Tank should contain sufficient amount of gas to purge glass bottles with argon gas

3.4 Regulator: for Argon Gas tank

3.5 Tubing: rubber. To transport argon gas from tank into glass bottle(s).

3.6 Clamps: for hose/tube

3.7 Control valve: to regulate argon gas flow from tank to sample bottle(s).

3.8 Shipping Container: with packaging material

3.9 Sample Labels

3.10 Address Labels

3.11 Strapping Tape

3.12 Tool Box

3.13 Sampling Record Form(s): Water Quality Sampling Record Forms

4.0 PROCEDURE

- o Water is recovered from the soil zone with a suction water sampler and from most wells with a bladder-type pump. Refer to the separate Standard Operating Procedures on soil water suction samples (16.1.7) and well sampling (16.2.1) for information on the use of these devices. Sampling water for tritium analysis is similar to sampling for other analytical purposes, except that contact of the solution with the open atmosphere should be minimized to limit contamination by water vapor in the air.

- o CAUTION: Due to the use of tritium in modern luminous dial watches, samplers should make sure that these watches and other self-luminescent devices are not in the vicinity of open sample containers or during sample collection activities

- o A minimum of 100 mL of water is needed from each sampling site to provide enough solution for tritium measurement at the required detection limit of 3.2 pCi/mL (0.1 Tritium Units) NOTE: Actual value is 3.231 pCi/mL based on tritium half-life of 12.30 years.

- o If possible, collect four (4) 250-mL samples for analytical and statistical purposes.

4.1 Using the appropriate procedure, prepare the suction sampler or bladder-pump to deliver a water sample.

4.2 Purge an amber bottle with argon to remove air.

4.3 Insert clean tube from the water sampler to the bottom of the bottle.

4.4 Allow water to fill bottle until there is a one-inch head space.

4.5 Remove the tube from the bottle and fit with polyseal cap.

4.6 Label bottle with site identification, location identification, sampler number, date, and time of sampling (use military time), and name of sampler. State that the sample is for tritium analysis and note any special sampling circumstances (e.g., color, turbidity of solution, prolonged sampling period, etc.).

4.7 Fill out the same information on Attachment 5.1 or its equivalent. If the tritium water sample is taken during regular sampling of a well, then the information on the sampling record pertinent to purging the well need not be repeated. However, if the tritium sample is the only one taken from the well, then the data on well-purging should be recorded on the tritium sampling record. If the sample was taken with a soil water suction sampler, fill out only the information listed in 4.6 on the appropriate soil water sampling record.

4.8 Place sample in shipping container and protect from breakage with packaging material.

4.9 When samples are tightly capped there are no special time or temperature requirements during storage or transit; however, temperature extremes should be avoided and holding time(s) should be kept to a minimum.

4.10 Obtain additional 250-mL samples from this sampling site at this time. If this is not possible because of insufficient water supply, prepare the suction sampler for later sampling.

4.11 When sampling is completed at all sites, send samples by the fastest available means to the analytical laboratory. Include a packing sheet with the samples that lists all the samples and states that they are for tritium analysis by enrichment and low-level counting. If possible, include a purchase requisition number with the samples.

4.12 Clean, wrap (if necessary), and store equipment. Label with "Clean", date, and initials.

4.13 Inform the Site Hydrologist of the time at which the samples were sent to the analytical laboratory and their expected arrival times at the laboratory.

4.14 Make copies of the sample collection field forms for document control and for the Site Hydrologist.

5.0 ATTACHMENT(S): Supporting Documents

5.1 Attachment 5.1 Water Quality Sampling Record Form

5.2 Attachment 5.2 Acknowledgement of Receipt of Samples

Prepared By: ______________________
TAC Technical Representative

Reviewed By: ______________________
Task Manager

Reviewed By: Bob R Bender
Quality Assurance Manager

Approved By: ______________________
Project Manager

JE JACOBS ENGINEERING GROUP INC
ALBUQUERQUE OPERATIONS

Page 1 of 4

WATER QUALITY SAMPLING RECORD

SITE ID:

LOCATION ID:

SAMPLE ID:

STATIC WATER LEVEL (FT)

SAMPLE DEPTH (FT)

SAMPLING DATE

SAMPLING TIME:

START

COMPLETE

FINAL FIELD VALUE AT THE SURFACE

pH (S.U.)

Ec (µmhos/cm)

TEMP. (°C)

ALKALINITY (mg/l $CaCO_3$) @ pH 4.5

TITRANT: 1.6 N H_2SO_4 LOT #

FILTER(S) USED

COMMENTS

LOCATION DESCRIPTION

FIELD REP(S)

DATE	TIME	TOTAL VOLUME WITHDRAWN		pH	Ec (µmhos/cm)	TEMP. (°C)	COMMENTS
		(Gals)	(Bore Volumes)				
		0.0	0.0	-	-	-	START PUMPING

WATER QUALITY SAMPLING RECORD

BORE VOL CALCULATION
$(d/2)^2\pi(h_1-h_2)$*

SAMPLING INFORMATION

SITE ID ____________

LOCATION ID ____________

DEPTH TO WATER (h_2) (FT.) ____________

DEPTH OF WELL (h_1) (FT.) ____________

WELL DIA (d) (FT.) ____________

BORE VOL. $(FT.)^3$ ____________

SCREENED INTERVAL (FT.) ____________

WITHDRAWAL METHOD ____________

FILTER SIZE .45μ

THERMOMETER ID ____________

Ec METER ID ____________

pH METER ID ____________

PUMP ID ____________

CALIBRATION INFORMATION

DATE OF LAST Ec CALIBRATION ____________

TIME OF pH CALIBRATION ____________

pH AFTER MEASUREMENT ____________ FOR STANDARD pH ____________

pH AFTER MEASUREMENT ____________ FOR STANDARD pH ____________

SHIPPING INFORMATION

LAB(S) SHIPPED TO:	____________	____________	____________
DATE(S) SHIPPED:	____________	____________	____________
METHOD OF SHIPMENT:	____________	____________	____________

NOTES

* The value of $(\frac{d}{2})^2\pi$ is: .022 for a 2' well
.086 for a 4' well

ATTACHMENT 5.2

WATER QUALITY SAMPLING RECORD

SUBCONTRACT NO. ____________________

Acknowledgement of Receipt of Samples for Delivery Order No. 0

SITE ID:_____ _____ LOCATION ID:__________ SAMPLE ID: __________

SAMPLE SHIPMENT LIST

LOT#_______

BOTTLE ID	AMOUNT	REC'D	BOTTLE ID	AMOUNT	REC'D
A1		( )	Th 230		( )
A1-A		( )	GA/B		( )
M1		( )	N1		( )
M1-A		( )	CN		( )
M2		( )	S		( )
M2-A		( )	TOC		( )
Pb 210		( )	TOX		( )
Po 210		( )	SiO2		( )
Ra 226		( )			
Ra 228		( )			

DATE SHIPPED: _______________ METHOD OF SHIPMENT: _______________

COMMENTS:____

- -

I hereby acknowledge receipt of the following on: ____________________
(date)

( ) Delivery Order No. __ (Work Order Plan) dated:____________________

Subcontractor: ______________________________
Name: ______________________________
Title: ______________________________
Date: ______________________________

Complete Analysis Due: ___________

COMMENTS: ____

Delivery of Analysis in accordance with Exhibits B and C of the Subcontract is due no later than:

Complete to JEG by: ______________________________
(date)

ALBUQUERQUE OPERATIONS MANUAL	SECTION 16.2.3
	DATE 5/28/87
EVALUATION OF CHEMICAL ANALYSES OF WATER SAMPLES	EFFECTIVE 08/18/88
	SUPERSEDES 8.3.9 5/10/85
	PAGE 1 OF 3

1.0 PURPOSE

To define the procedure used in the UMTRA Project to evaluate and document the precision and accuracy of laboratory analyses of water samples.

2.0 SCOPE

This procedure outlines the criteria for the systematic submission of water samples for laboratory analysis and the evaluation and documentation of the resultant data. This procedure is applicable to all members of the UMTRA Project for submitting water samples to laboratories and evaluating results of laboratory analyses of water samples.

3.0 PROCEDURE

3.1 Water samples contained in plastic or glass bottles will be shipped to laboratory subcontractors by Jacobs Engineering Group, Inc. representatives.

3.2 Before and after analysis, samples will be stored in a manner approved by Jacobs so as to minimize the precipitation of unstable constituents. Any remaining portions of samples after analyses, and all archive samples, shall be retained by the laboratory until direction is given by the Jacobs Technical Representative for disposal of the samples or shipment to another laboratory.

3.3 All laboratory analyses will be specified in writing by Jacobs Engineering Group (JEG) from the list of constituents on Figure 1. Figure 1 lists the acceptable detection limit for each water chemistry parameter.

3.4 The subcontractor laboratory shall maintain approved quality assurance/control programs, including appropriate chain-of-custody procedures, to ensure adequate sample traceability, that the data transmitted are correct, and that the laboratory analyses were performed in accordance with EPA approved methods, or other JEG approved methods, which result in verifiable accuracy ranges as stated below.

3.5 Pre-established accuracy criteria and cation-anion balance checks will be used to evaluate the acceptability of laboratory analyses. Instructions of the details of methods and calculations to be used are specified in Technical Memo No. 3 "Instructions for evaluating the accuracy, cation-anion balance, and precision of laboratory analyses of water samples."

3.6 JEG representatives will group the water samples into lots. A lot is defined as a group of field samples associated with at least one solution of known composition. Lots will consist of not more than nine field samples plus known solutions and splits. Known solutions will be shipped to the laboratory with the field samples within that lot.

3.7 Instructions for initiating water sampling, bottling, labeling, and preservation of samples are provided in Technical Memo No. 2, Revision 3, by George Rice.

3.8 Instructions regarding preparation of splits, blanks, and alkalinity solutions for submittal to laboratories are given in Technical Memo No. 4, Revision 1, by George Rice.

3.9 Technical Memo No. 3, Revision 5 (referenced above), will be followed by JEG hydrologists in evaluating the accuracy and precision of each lot of samples. The actual evaluation of the lab data will include the following:

1. Computation of the acceptable range of each constituent from the known solution.
2. Values reported by the laboratory will be compared with the ranges computed above.
3. Each analysis shall satisfy the cation-anion balance criterion. The balance must be within plus or minus.

3.10 When the reported value of any constituent in a known solution falls outside its acceptable range, the laboratory will be instructed to re-analyze the entire lot for that constituent. When a sample analysis does not satisfy the cation-anion balance criterion, the laboratory will be instructed to re-analyze that sample until the anion-cation balance criterion is met.

3.11 DOCUMENTATION OF WATER QUALITY RESULTS

3.11a The JEG water quality analytical results form (Figure 2) shall be utilized by each subcontractor laboratory to report the results of all analyses.

3.11b The evaluation of accuracy and precision by the UMTRA hydrologists shall be documented according to Technical Memo No. 3 on a form that is filed with the UMTRA Document Control Center.

Prepared By: ______________________
Hydrologist

Reviewed By: ______________________
Task Manager

Reviewed By: ______________________
Quality Assurance Manager

Approved By: ______________________
Project Manager

FIGURE 1

REVISED LIST OF CONSTITUENTS AND DETECTION LIMITS FOR WATER ANALYSES

Constituent	Detection Limit (mg/l)	Constituent	Detection Limit (mg/l)
Chloride (Cl)	1.0	Lead (Pb)	0.01
Sulfate (SO)	0.1	Manganese (Mn)	0.01
Sodium (Na)	0.002	Mercury (Hg)	0.0002
Potassium (K)	0.01	Molybdenum (Mo)	0.01
Magnesium (Mg)	0.001	Nickel (Ni)	0.04
Calcium (Ca)	0.01	Selenium (Se)	0.005
Boron (B)	0.1	Silver (Ag)	0.01
Flouride (F)	0.1	Strontium (Sr)	0.1
Cyanide (CN)	0.01	Tin (Sn)	0.005
Hydrogen Sulfide (H_2S)	0.1	Uranium (U)	0.003
Ammonium (NH_4)	0.1	Vanadium (V)	0.01
Nitrite (NO_2)	0.1	Zinc (Zn)	0.005
Nitrite (NO_3)	1.0	Total Dissolved Solids	
Nitrate & Nitrate	1.0	(TDS)	10
Silica (SiO_2)	2.0	Total Organic Carbon	
Phosphate (PO_4)	0.1	TOC	1.0
Iron FE	0.03	TOX	1.0
Aluminum (Al)	0.1	Radionuclides	pCi/l
Antimony (Sb)	0.003	Lead 210 (Pb-210)	1.5
Arsenic (As)	0.01	Polonium 210 (Po-210)	1.0
Barium (Ba)	0.1	Radium 226 (Ra-226)	1.0
Cadmium (Cd)	0.001	Radium 228 (Ra-228)	1.0
Chromium (Cr)	0.01	Thorium 230 (Th-230	1.0
Cobalt (Co)	0.05	Gross Alpha	0.2
Copper (Cu)	0.02	Gross Beta	1.0

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

WATER QUALITY ANALYTICAL RESULTS

Sheet ___ of ___

SITE ID: ____________ LOCATION ID: ____________ SAMPLE ID: ____________

LOT CONTROL NO. ____________

SAMPLE TYPE ____________ DATE SAMPLED: ____________

LAB NAME: ____________ DATE REC'D: ____________

LAB SAMPLE ID: ____________

DATE ANALYZED: ____________ CHECKED BY: ____________

SAMPLE CONDITION (ON RECEIPT): ____________

COMMENTS: ____________

PARAMETER	RESULTS				DETECTION LIMIT		COMMENTS
	PRIMARY	UNITS	DUPLICATE	UNITS	VALUE	UNIT	

SAMPLE TYPES: A - ACID BLANK F - FIELD K - KNOWN R - REPLICATE

RECEIVED BY JEG ____________ DATE ____________ APPROVED BY JEG ____________ DATE ____________

JEG-AL-ENG-15 (6/87)

FIGURE 2

JACOBS ENGINEERING GROUP, INC., ALBUQUERQUE OPERATIONS

TO: Hydro Group and Water Samplers

JRM

FROM: SRice/BDeutsch/DMiller

DATE: January 28, 1986

SUBJECT: Technical Memo No. 2, Rev. 3
Instructions for Initiating Water Sampling
and Bottling, Labeling, and Preservation of Samples

These instructions are to be followed by site Geohydrologists, the Water BOA TR, and the Water Sampling Teams.

DUTIES OF THE SITE GEOHYDROLOGIST

No later than three weeks before sampling is to begin the site Geohydrologist will:

(1) Determine the number of samples to be collected and group them into lots. A lot will consist of no more than nine field samples, plus four splits of one of the field samples, plus at least one solution of known composition. As far as is practicable, lots should be composed of chemically similar samples. At least two lots will contain splits. One set of splits should be for a sample with a high TDS content, the other set for a sample with a low TDS content. The TDS content of the known solution should be similar to that of the lot with which it is associated.

(2) Determine which constituents each sample is to be analyzed for. All TOX analyses will be performed by ACCU-LABS.

(3) Tell the water BOA TR how many known solutions are to be prepared and the approximate TDS values desired. In most cases, known solutions will be prepared for nearly all of the constituents chosen in Step 2. If Bendix is to analyze any samples, tell the TR how many and what types of analyses they are to perform. Prepare required paperwork (Attached).

(4) Determine the number of sample bottles required. Notify the water sampling team manager.

(5) Prepare a work order plan and requisition. Give them to the water BOA TR (see attached example). See section titled Duties of Water Samplers for Information Concerning Bottle Types, Constituents, Labeling, etc.

(6) Prepare maps for the water samplers and the Health and Safety Group showing all sample locations. Tell samplers the type of sample to be collected at each location. Make sure samplers have all required keys.

DUTIES OF THE WATER BOA TR

(1) Review work order plans to assure they are appropriate and complete. Upon approval, sign attached requisition and deliver to contracts within two days.

(2) Tell Bendix how many known solutions are to be prepared and what analyses they are to perform, as per step 3 above.

(3) Order sample bottles as requested by the manager of the water sampling teams. The bottles are to be pre-cleaned and oven dried as per EPA recommendations. They are not to contain any preservatives. A source of bottles is:

I-CHEM Research
23787 Eichler St., Bldg. F
Hayward, California 94545
415-782-3905

DUTIES OF THE WATER SAMPLERS

Samples will be bottled as follows.

BOTTLE I.D.	BOTTLE TYPE	VOLUME (ml)	PRESERVATION TECHNIQUES	ANALYTES
A1	Polyethylene	2000	Filtered 4°C	B, F, Cl, NO_3, SO_4, SiO_2, PO_4, TDS
M2	Polyethylene	1000	Filtered HNO_3 to pH<2	Ba, As, Cd, Cr, Hg, Pb, Se, Al, Fe, Mn, Ag, Co, Cu, Ni, V, Zn, U, Ca, Mg, Na, K, Sr, Mo, Sb, Sn

BOTTLE I.D.	BOTTLE TYPE	VOLUME (ml)	PRESERVATION TECHNIQUES	ANALYTES
Pb210	Polyethylene	1000	Filtered, HNO_3 to pH<2	Pb210
Po210	Polyethylene	1000	Filtered HNO_3 to pH<2	Po210
Ra226	Polyethylene	2000	Filtered HNO_3 to pH<2	Ra226
Ra228	Polyethylene	2000	Filtered HNO_3 to pH<2	Ra228
Th230	Polyethylene	1000	Filtered HNO_3 to pH<2	Th230
$G\alpha$ & $G\beta$	Polyethylene	500	Filtered HNO_3 to pH<2	$G\alpha$ & $G\beta$
N1	Polyethylene	500	H_2SO_4 to pH<2, 4°C	NO_2+NO_3 NH_4
CN	Polyethylene	1000	NaOH to pH>12, 4°C	CN
S	Polyethylene	1000	NaOH to pH>9, 2.5 M of 220g/l zinc acetate solution per liter	S
TOC	Amber glass w/ teflon liner	500	4°C H_2SO_4 to pH<2	TOC
TOX	Amber glass w/ teflon liner and septum	1000	4°C	TOX

Each set of samples sent to a laboratory will contain a table listing the number of samples and sample I.D.'s contained in the shipment. Any departure from the above procedures will be noted on the table.

Known solutions will be handled as follows. Sample bottles will be labeled according to the site geohydrologist's instructions and sent to Bendix. Bendix will fill them and send them back to the sampling team. In cases where Bendix does not provide known solutions for certain constituents the sampling team will make up phony solutions and preserve them just as real solutions are preserved. Known solutions are to be sent to the laboratory at the same time as their associated lots are sent.

Keep an inventory of sample bottles. When more bottles are required, notify the water BOA TR.

GR/BD/DM/cfm

Ron Chessmore
Bendix Field Engineering Corporation
P.O. Box 1569
Grand Junction, Colorado 81502

Dear Mr. Chessmore:

Please prepare known solutions as indicated below. Labeled bottles will be sent to you by our sampling team manager. The known solutions should be bottled as indicated on the attached work order plan.

Very truly yours,
JACOBS ENGINEERING GROUP INC.

John Thackston
Manager, Hydrological Services

SITE:

APPROXIMATE DATE REQUIRED:

# OF KNOWN SOLUTIONS	APPROXIMATE TDS DESIRED (mg/l)
________	________
________	________
________	________
________	________
________	________

WORK ORDER PLANS # 1 - for water samples sent to E.D.A or Accu-LABS.

WORK ORDER PLAN - ANALYSIS OF WATER SAMPLES

NAME ASSIGNED BY: ____________________

DATE ASSIGNED: ____________________

CONTRACT COMPLETION DATE: ____________________

SAMPLE I.D. ____________________

SITE: ____________________

DATE(S) SENT: ____________________

Bottle Name	Cl	SO4	Na	K	Mg	Ca	B	F	CN	S	TOX	NH4	NO3 + NO2	NO3	SIO2	PO4	Br	Al	Sb	As	Ba	Cd	Cr	Co	Gross Alpha	Gross Beta
A1	✓	✓					✓	✓						✓	✓	✓										
M2			✓	✓	✓	✓												✓	✓	✓	✓	✓	✓	✓		
Pb^{210}																										
Po^{210}																										
Ra^{226}																										
[illegible]^{230}																										
Gα/β																									✓	✓
CN									✓																	
S										✓																
TOC																										
TOX											✓															
NI												✓	✓													
TOTAL # OF TESTS																										

Work order plan #1 for water samples sent to E.D.A or ACCU-LABS.

WORK ORDER PLAN - ANALYSIS OF WATER SAMPLES (Concluded)

WORK ASSIGNED BY: ______
DATE ASSIGNED: ______
CONTRACT COMPLETION DATE: ______
SAMPLE I.D. ______
SITE: ______
DATE(S) SENT: ______

Bottle I.D.	Cu	Fe	Pb	Mn	Hg	Mo	Ni	Se	Ag	Sr	Sn	U	V	Zn	TDS	TOC	Pb-210	Po-210	Ra-226	Ra-226	Th-230
Al															✓						
mz	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓							
Pb^{210}																	✓				
Po^{210}																		✓			
Ra^{226}																			✓		
Ra^{228}																				✓	
Th^{230}																					✓
Gα/β																					
CN																					
S																					
TOC																✓					
TOX																					
NI																					
TOTAL # OF TESTS																					

WORK ORDER PLAN #2 - for the Bendix known solutions

WORK ORDER PLAN - ANALYSIS OF WATER SAMPLES

WORK ASSIGNED BY: ______________________ SAMPLE I.D. ______________ SITE: ______________
DATE ASSIGNED: ______________________ DATE(S) SENT: ______________
CONTRACT COMPLETION DATE: ______________________

Bottle Number	Cl	SO4	Na	K	Mg	Ca	B	F	CN	S	TRE	NH4	NO3 + NO2	NO3	SiO2	PO4	Br	Al	Sb	As	Ba	Cd	Cr	Co	Gross Alpha	Gross Beta
A1	✓	✓					✓	✓						✓	✓	✓										
M1																		✓	✓	✓	✓	✓	✓	✓		
M2			✓	✓	✓	✓																				
Pb^{210}																										
Po^{210}																										
Ra^{226}																										
Ra^{228}																										
Th^{230}																										
Gα/β																									✓	✓
N1												✓	✓													
CN									✓																	
S										✓																
TOC																										
TOX											✓															
TOTAL # OF TESTS																										

WORK ORDER PLAN #2 - FOR The Bendix Known Solutions.

WORK ORDER PLAN - ANALYSIS OF WATER SAMPLES (Concluded)

WORK ASSIGNED BY: ____________________

DATE ASSIGNED: ____________________

CONTRACT COMPLETION DATE: ____________________

SAMPLE I.D. ____________________

SITE: ____________________

DATE(S) SENT: ____________________

Bottle I.D.	Cu	Fe	Pb	Mn	Hg	Mo	Ni	Se	Ag	Sr	Sn	U	V	Zn	TDS	TOC	Pb-210	Po-210	Ra-226	Ra-228	Th-230
AL															✓						
M1						✓					✓										
M2	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓							
Pb^{210}																	✓				
Po^{210}																		✓			
Ra^{226}																			✓		
Ra^{228}																				✓	
Th^{230}																					✓
Gα/β																					
NI																					
CN																					
S																✓					
TOC																					
TOK																					
TOTAL # OF TESTS																					

JACOBS ENGINEERING GROUP, INC., ALBUQUERQUE OPERATIONS

TO: Hydrology Staff

FROM: GRrice

DATE: June 27, 1986

SUBJECT: Technical Memo #3 Rev. 5
Instructions for Evaluating the Accuracy, Cation-Anion Balance, and Precision of Laboratory Analyses of Water Samples

This memo accompanies the SOP "Evaluation of Chemical Analyses of Water Samples." It outlines steps to be taken after laboratory analyses of water samples are received.

EVALUATION OF ACCURACY

A solution of known composition will be associated with each sample lot (see Technical Memo #2: "Instructions for Initiating Water Sampling and; Bottling, Labeling, and Preservation of Samples"). The accuracy criteria require the reported value of each constituent in a known solution to fall within an acceptable range. If the reported value is unacceptable, all analyses for that constituent in the entire lot are unacceptable. The evaluation will be performed as follows.

(1) The acceptable range of each constituent in the known solution will be computed.

(2) The reported values will be compared with the ranges computed above.

(3) If all reported values fall within their acceptable ranges the lot is acceptable with respect to the accuracy evaluation.

(4) If the reported values of any constituents fall outside their acceptable ranges, notify the water BOA TR. The laboratory will be instructed to re-analyze the entire lot for those constituents.

The above steps will be completed no later than seven days after analyses are received.

(5) If any reported values from re-analyses do not fall within their acceptable ranges, notify the water BOA TR. The laboratory may choose to perform further re-analyses. The entire lot is unacceptable with respect to a given constituent until the re-analysis falls within its acceptable range.

CALCULATIONS

Calculate the acceptable ranges for reported values of known solutions as follows:

(1) Account for the uncertainty in preparing the known solution. The known concentration may vary from:

$$X\ (1-U) \text{ to } (1+U)$$

Where:

X = Known concentration as reported by Bendix

U = Control sample uncertainty as reported by Bendix

(2) Use the allowable deviation (D, in percent) from the attached accuracy criteria to calculate the acceptable range.

$$\text{Acceptable Range} = \left(\frac{X(1-U)}{\frac{D}{100}+1}\right) \text{to} \left(\frac{D}{100}+1\right) X(1+U)$$

EXAMPLE:

Bendix reports the known concentration of Cl in a known solution at 36 mg/l ± 3%.

The known concentration may vary from:

36 mg/l (1-0.03) to 36 mg/l (1+0.03) = 34.9 mg/l to 37.1 mg/l

From the accuracy criteria, Group III, for concentrations greater than 1 mg/l, the allowable deviation is 10%.

The acceptable range is:

$$\left(\frac{34.9\ \text{mg/L}}{\frac{10}{100}+1}\right) \text{to} \left(\frac{10}{100}+1\right) * \left(37.1\ \text{mg/L}\right) = 31.7\ \text{mg/L to } 40.8\ \text{mg/L}$$

* Any reported value out of this range is unacceptable.

WATER BOA
REVISED ACCURACY CRITERIA
FOR ANALYSIS OF WATER SAMPLES

Criteria for Approval of Analyses

Allowable Deviation

GROUP I: Sb, As, Ba, Cd, Cr, Pb, Hg, Mo, Se, U, Pb-210*, Po-210*, Ra-226*, Ra-228*, Th-230*.

The allowable deviations for the Group I constituents may be derived from the following table:

Concentration (mg/L)	Allowable Deviation (percent)
<0.01	100
≥0.01 to<0.1	50
≥0.1 to <1.0	15
≥1.0	10

If a constituent is incorrectly reported as being below the detection limit, that limit will be used as the reported concentration in the above equation.

*Convert Radioactivity (pCi/L) to mass (mg/L) as follows:

RADIONUCLIDE	CONVERSION
Pb 210	1.31×10^{-11} mg/pCi
Po 210	2.23×10^{-13} mg/pCi
Ra 226	1.01×10^{-9} mg/pCi
Ra 228	3.67×10^{-12} mg/pCi
Th 230	5.15×10^{-8} mg/pCi

Group II: B, CN, H_2S, NH_4, NO_2, PO_4, Co, Cu, Ni, Ag, Sr, Sn, V, Zn, TOC.

The allowable deviations for the Group II constituents may be derived from the following table:

Concentration (mg/L)	Allowable Deviation (percent)
<0.01	200
≥0.01 to <0.1	100
≥0.1 to 1.0	50
≥1	20

If a constituent is incorrectly reported as being below the detection limit, that limit, will be used as the reported concentration in the above equation.

GROUP III: Cl, SO_4, NO_3, Na, K, Mg, Ca, F, Al, Fe, Mn, SiO_2, TDS.

The allowable deviations for the Group III constituents may be derived from the following table:

Concentration (mg/L)	Allowable Deviation (percent)
<0.01	200
≥0.01 to <0.1	100
≥0.01 to 1.0	50
≥1.0	10

If a constituent is incorrectly reported as being below the detection limit, that limit will be used as the reported concentration in the above equation.

EVALUATION OF CATION-ANION BALANCES

(1) The cation-anion balance of each field sample (not known solutions) will be computed.

(2) If the lysis satisfies the balance criterion it is acceptable

(3) If the analysis does not satisfy the balance criterion, notify the water BOA TR. The laboratory will be instructed to re-analyze the sample for constituents of its own choosing.

The above steps will be completed no later than seven days after analyses are received.

(4) If the re-analysis does not satisfy the balance criterion, notify the water BOA TR. The laboratory may choose to re-analyze the sample. The entire sample analysis is unacceptable unless it satisfies the balance criterion.

CALCULATIONS

The balance may be computed using the DBMS. The steps presented be w show how to do it by hand. An example is given at the end of this sectic

(1) Alkalinity Calculations

(a) Account for uncertainty in the field alkalinity measurement. This will be done using data provided by Bendix (see memo by GRice: Splits, Blanks, Alkalinity Solutions; April 1985).

(b) Convert the alkalinity reported as mg/L $CaCO_3$ to meq/L by dividing the alkalinity by 50.0. The resulting value can be summed with the other anions (in meq/L) in the balance calculation (step 3).

(2) Convert concentrations of cations and anions from mg/l to meq/l by dividing them by constituent equivalent weight. Consider only those constituents which comprise more than 0.1% of the sample's TDS. Compute for both oxidizing and reducing conditions.

EQUIVALENT WEIGHTS OF ANIONS

All Conditions		Oxidizing Conditions	Reducing Conditions
F	19.00	____________	____________
SO_4	48.03		
NO_2	46.00		
NO_3	62.00		
Br	79.90		
CN	26.02		
HS	33.07		
S	16.03		
PO_4 (as H_2PO_4)	94.98		
Cl	35.45		
Mo (as $MoO_4^{=}$)	47.97		

EQUIVALENT WEIGHTS OF CATIONS

All Conditions		Oxidizing Conditions	Reducing Conditions
Na^+	22.99		
K^+	39.10		
Mg	12.15		
Ca	20.04		

NH_4	18.04		
Al	8.99		
Mn		13.74	27.47
Fe		18.62	27.92
Sr	43.81		
Co		19.64	29.46
Ni		19.57	29.36
Cu		31.78	63.55
Zn	32.69		
Sb		24.35	40.58
Ba	68.67		
Cd	56.20		
Pb		51.80	103.60
Hg		100.30	200.60
Ag	107.87		
Sn		29.67	59.34

(3) Calculate Balance:

$$\frac{\text{meq Cations} - \text{meq Anions}}{\text{meq Cations} + \text{meq Anions}} \times 100$$

Use the values which result in the lowest absolute values, i.e., an alkalinity value and values for oxidizing conditions, or, an alkalinity value and values for reducing conditions. If the absolute values of a sample's balance is greater than 5%, the sample analysis is unacceptable.

EXAMPLE

The analysis for GUN-01-010, 84/07/13 will be used.

(1a) The reported alkalinity is 323 mg/l as $CaCO_3$. Bendix reported the following:

Field Analysis of Known Alkalinity Solutions, Gunnison, 6/27/84

Field Value (mg/l as $CaCO_3$)	True Value (mg/l as $CaCO_3$)	Uncertainty (±%)
22.7	21.1	8
362	377	4
914	920	1

The reported alkalinity of 323 mg/l is nearest to the true value of 377 mg/l therefore, an uncertainty of ± 4% will be used. The alkalinities used to calculate the balance will be 310 mg/l as $CaCO_3$ and 336 mg/l as $CaCO_3$.

(1b) Convert alkalinity values to meq/L.

$$\frac{310 \text{ mg } CaCO_3}{L} \times \frac{1\text{mmole}}{100 \text{ mg}} \times \frac{2\text{meq}}{\text{mmole}} = 6.20 \frac{\text{meq}}{L}$$

$$\frac{336 \text{ mg } CaCO_3}{L} \times \frac{1\text{meq}}{50 \text{ mg}} = 6.72 \frac{\text{meq}}{L}$$

(2) The sample's TDS is 2520 mg/l. Only those constituents with reported concentrations greater than 2.52 mg/l will be used to calculate the balance.

CATIONS

Constituent	Concentration (mg/l)	Oxidizing Conditions (meq/l)	Reducing Conditions meq/l)
Ca	595	29.69	29.69
Fe	26.1	1.40	0.93
Mg	44.3	3.65	3.65
Mn	7.01	0.51	0.26
K	6.26	0.16	0.16
Na	19.2	0.84	0.84
		36.25	35.53

ANIONS

Constituent	Concentration (mg/1)	Oxidizing Conditions (meq/1)	Reducing Conditions meq/1)
Cl	19	0.54	0.54
SO_4	1490	31.02	31.02
Alkalinity ($CaCO_3$)	310; 336	* 6.20	6.20
		37.76	37.76

*310 mg/1 was used because it will result in the lowest absolute value in the balance.

(3) The Balance for Oxidizing Conditions is:

$$\left(\frac{36.25-37.76}{36.25+37.76}\right)100 = 2.04\%$$

For Reducing Conditions:

$$\left(\frac{35.53-37.76}{35.53+37.76}\right)100 = 3.04\%$$

The analysis is acceptable under both oxidizing and reducing conditions.

EVALUATION OF PRECISION

The analytical precision of splits will be evaluated to supplement the accuracy and cation-anion balance criteria and aid in identifying analytical problems.

Calculations

Precision will be evaluated using the coefficient of variation of the splits.

The coefficient of variation is:

$$CV = \frac{S}{\bar{X}}$$

$$S = \text{Standard Deviation} = \left[\frac{1}{n-1}\sum_{i=1}^{n}(Xi-X)^2\right]^{1/2}$$

$$X = \text{Arithmetic Mean} = \frac{1}{n}\sum_{i=1}^{n}Xi$$

The following table lists allowable deviations taken from the attached accuracy criteria and maximum coefficients of variation. If these coefficients are exceeded, precision is poor. Notify the water BDA TR.

Allowable Deviation (%)	CV
200	1.38
100	0.84
50	0.45
25	0.23
20	0.18
10	0.09

Example

The laboratory reports the following Mn values for 5 splits 0.03, 0.007, 0.02, 0.03, and 0.009 mg/l.

Average the reported concentrations to determine the allowable deviation. In this case it's 100%.

$$X = 1/5\ (0.03+0.007+0.02+0.03+0.009) = 0.0192$$

$$S = [1/4\ (0.03-0.0192)^2+((0.007-0.0192)^2+(0.02-0.0192)^2$$

$$+(0.03-0.0192)^2+(0.009-0.0192)^2)]^{1/2}$$

$$= 0.011$$

$$CV = \frac{0.011}{0.019} = 0.57$$

The precision of the Mn analyses is considered good.

ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

TO: Distribution

FROM: GRice

DATE: May 9, 1985

SUBJECT: Technical Memo No. 4 Rev. 1
Splits, Blanks, Alkalinity Solutions

SPLITS

At this time, it is not possible for our water sampling teams to collect true splits for analysis of precision. This is because we have been unable to find an acceptable container which can hold five samples at once. Instead of splits, five consecutive replicates will be collected. In most instances, we will be able to treat these replicates as splits. The time at which each replicate was collected will be noted on it's field form.

BLANKS

The following blanks will be submitted to the analyzing laboratory each time a site is sampled or reagents are changed. Blanks are meant to check the purity of preservatives and consist of the preservative alone in deionized water.

PRESERVATIVE	ANALYTE
NaOH Pellets	CN
NaOH Pellets and Zn Acetate Solution	S
H_2SO_4	NO_2, NO_3, NH_4, TOC
HNO_3	METALS
HCl	Mo, Sb, Sn

ALKALINITY SOLUTIONS

Field measurements of alkalinity are critical and we must have a way of checking their accuracy. This will be done as follows.

Each time a site is sampled, Bendix will send three solutions of known alkalinity to the sampling team in the field. The team will measure their alkalinities and send the results to Bendix.

Bendix will submit a report giving the true values along with the team's reported values.

Any inaccuracies in the reported values must be accounted for when computing cation-anion balances.

GR/11

cc: DBetsill DMiller

ALBUQUERQUE OPERATIONS MANUAL	SECTION 16.2.4
	DATE 09/18/90
	EFFECTIVE 09/28/90
	SUPERSEDES
SAMPLING RADON IN WATER	PAGE 1 OF 2

1.0 OBJECTIVE

To establish a procedure for the collection of water samples for the analyses of radon in water.

2.0 REFERENCE

EPA/EERF - Manual-78 Radon in Water Sampling Program.

3.0 APPLICABILITY

Radon content in water analyses will be used in health risk assessment determinations.

4.0 EQUIPMENT

Water collection vials - supplied by laboratory (two 40 ml vials per location ID).

5.0 PROCEDURE

5.1 Samples are to be collected in duplicate.

5.2 If collected at faucet with small screen aerator, remove the aerator before sample collection. Do not collect from faucet with carbon filtration system.

5.3 Run the water for a minimum of two minutes before collecting sample to purge the line. Use cold water.

5.4 Reduce the flow rate to a slow stream, trying to avoid as much agitation and turbulence as possible.

5.5 Place the sample vial under the faucet outlet, as close as possible to the outlet. Direct the water stream down the inside wall of the glass vial and allow it to overflow. After the vial is full (with some overflow) replace the screw cap tightly. Invert the sample vial. If there are any bubbles in the vial discard the sample and collect another sample in the same vial. Repeat this process as many times as needed to obtain a sample without an air bubble.

5.6 Record the collection time and date on the vial label. Also record pertinent information on form 16.2.4A. Note that field parameters are not required for the analysis.

5.7 On the day of collection, or no later than 24 hours after sample collection, return the samples by overnight mail to the laboratory for analysis. Because the laboratories are closed on weekends collect and ship samples only on Mondays, Tuesdays and Wednesdays of each week.

Prepared By: ______________________

Reviewed By: Mark Miller
Task Manager

Reviewed By: Bob R Beaulon 9/25/90
Quality Assurance Manager

Approved By: Steven K. Hein
Project Manager

FORM 16.2.4A

SAMPLING RADON IN WATER

Site Identification: ______

Location Identification: ______

Date of Sample Collection: ______

Time of Sample Collection: ______

Date of Sample Shipped to Lab: ______

Time of Shipment: ______

Method of Shipment: ______

Sample Collected by: ______

Sample collected from: ______

______

______

______

Comments: ______

______

______

______

______

______

JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL	SECTION 16.3.1
	DATE 06/09/89
COMPLETION OF WELL AND SPRING INVENTORY	EFFECTIVE 11/20/89
	SUPERSEDES 05/28/87
	PAGE 1 OF 6

1.0 PURPOSE

These procedures enable the use of a uniform methodology for inventory and documentation of wells and springs located in the vicinity of UMTRA sites.

2.0 SCOPE

These procedures are applicable to members of the TAC or its contractors and subcontractors who have responsibilities and duties for the identification, acquisition, and inventory of descriptive data for each well or spring located within UMTRA Project study areas.

3.0 PROCEDURE: Data Collection Preparation

3.1 The location of each well or spring identified by this well and spring inventory shall be identified by the relevant Site Code and Location ID in accordance with Section 17.4.1 entitled, "Standard Location Identification for Test Borings, Test Pits, and Monitoring Locations".

3.2 Each Site Hydrologist (SH) shall review the computer listing for Borehole Definitions/Test Pit Definitions (BHD/TPD) to obtain previously assigned Location Identification numbers for data collection purposes. For existing and future purposes, a specific location which has been previously assigned a Location Identification number shall permanently retain and use this number, unless this number is changed in accordance with required procedure. Otherwise, a new Location Identification number shall be assigned by the SH in accordance with Section 17.4.1.

3.3 Each SH shall prepare and maintain an updated map of the site vicinity showing all wells and springs located in the course of the well and spring inventory.

3.3.1 Each SH shall incorporate the methodology of this procedure into all well and spring inventories and permit no data gathering efforts that do not include the Standard Location Identification system.

3.3.2 The SH shall review the BHD/TPD computer listing to determine previously assigned Location Identification numbers.

3.4 Record all field data on the attached form entitled "Well and Spring Inventory Field Data" form. See Attachment 10.1.

4.0 PROCEDURE: Determination of Measuring Point Description

Determine the height above or below land surface of the measuring point by use of a pocket steel tape measure graduated in 0.01-foot intervals. Determine the height of the measuring point to the nearest 0.01 foot. Enter this value along with a description of the measuring point on Attachment 10.1 as the "Measuring Point Description" (MPD).

5.0 PROCEDURE: Water Level Measurement of Non-Flowing Wells

5.1 Wetted-tape Method

5.1.1 Prepare the tape for measurement by coating several feet of the lower end of a steel tape with chalk.

5.1.2 Attach lead weights to the lower end of the steel tape to keep it taut.

5.1.3 Lower the tape into the well until a foot or two of the chalked portion is submerged. Alternatively, use tape without weight if the well opening or pump casing clearance is too small and restricts the passage of a weight.

5.1.4 Determine by experimentation the proper length required to lower the tape.

5.1.5 Perform measurement as follows:

A. Lower and hold tape at an even foot mark at the measuring point and record this tape reading.

B. Remove the steel tape from the well. Subtract the wetted length from the even foot mark recorded in A above and record this on Attachment 10.1 as "Static Water Level Depth" (SWLD).

5.2 Electric Sounder Method (M-scope)

An electric sounder consists of a contact electrode that is suspended into a water body by an insulated electric cable from a reel. The sounder has an ammeter, a buzzer, or other closed circuit indicator attached. The indicator shows a closed circuit and flow of current when the electrode touches the water surface. Calibrate the electric sounder(s) used in this survey by measuring each interval and re-marking them where necessary. Measure the water levels with an electric sounder as described below.

5.2.1 Switch on.

5.2.2 Lower the electric cable into the well unit until the ammeter or buzzer indicates a closed circuit. Raise and lower the electric cable slightly until the shortest length of cable that gives the maximum response on the indicator is found.

5.2.3 With the cable in this fixed position, note the length of cable at the measuring point.

5.2.4 Since the electric cable is usually graduated in five-foot intervals, use a pocket steel tape measure, graduated in 0.01-foot intervals, to interpolate between consecutive five-foot marks. Care must be taken that the steel tape measurements are added to the nearest graduated mark footage value when the water level hold point is above the mark. The steel tape measurements are subtracted when below the nearest mark. Determine this total distance to the nearest 0.01 foot and record this value on Attachment 10.1 as the SWLD.

6.0 PROCEDURE: Water Level Measurement of Flowing Wells

6.1 Preferred Method

Measure the water level (piezometric surface) in a flowing well with a manometer or a pressure gauge as described below.

6.1.1 Shut off all flow of the well to any uses (i.e., domestic supply, livestock watering tank, etc.) other than at the well itself. Valves are usually present near the well for this purpose. If it is impossible to shut off the flow of the well other than at the well itself, record this observation on Attachment 10.1 and skip the remaining procedures.

6.1.2 Measure the water level in flowing wells with a manometer. This method is shown schematically in Attachment 10.2.

6.1.3 Record the elevation at the top of the well casing as the "MP Elevation" (MPE).

6.1.4 Attach a vertical section of the flexible transparent plastic tubing to the top of the well casing using various couplings carried into the field for this purpose.

6.1.5 Extend the plastic tubing vertically above the well casing until water ceases to flow from the end of the tubing and stands at a fixed height in the tubing.

6.1.6 Record the height of the water in the plastic tubing above the measuring point as SWLD.

6.1.7 Add SWLD to MPE and record this as a "Static Water Level Elevation" (SWLE).

6.2 Alternative Method

The water level in a flowing well could also be measured by using a pressure gauge as described below.

6.2.1 Record the elevation at the top of the well casing as the "MP Elevation" (MPE).

6.2.2 Attach a pressure gauge to the well casing using the various couplings carried into the field for this purpose.

6.2.3 If the gauge is calibrated to indicate pressure in feet of water, record the gauge readings (to the nearest one-half foot) as SWLD. If the gauge is calibrated in pounds per square inch (psi), multiply the gauge reading by 2.3 to convert it to feet of water, and record this number as SWLD.

6.2.4 Add SWLD to MPE, and record this as a "Static Water Level Elevation" (SWLE).

7.0 PROCEDURE: Water Level Measurement of Springs

The water level of any spring will be identified as that land elevation above mean sea level (MSL). MSL is determined from the inventory location as plotted on the relevant USGS topographic map at the intersection of the spring and the land surface.

8.0 PROCEDURE: Discharge Measurement of Wells

8.1 Determine the discharge from a well in gallons per minute (gpm) by reading a water meter, if the well is so equipped. Alternatively, measure the time required to fill a bucket of known volume.

8.2 Determine the discharge for most wells that are pumping when visited during the field survey by using a bucket or drum and a stopwatch. Fill the bucket or drum of known volume (gallons) with the water that is discharging from the well. Measure the time, t (seconds), required to fill the bucket. This discharge, Q (gpm), is calculated by :

$$Q = 60\ V/t$$

where, Q = discharge in gpm,
V = volume of container in gallons
t = time required to fill the bucket in seconds

The condition of a well at the time the water level is measured must be recorded in the "remarks" column of Attachment 10.1. Such conditions may include:

8.2.1 Well was pumping during water level measurements.

8.2.2 Well was pumping intermittently during water level measurement.

8.2.3 Well was pumping two hours before water level measurements.

8.2.4 Owner reports well has not been pumping for four days, etc.

8.3 If well is pumping at the time of measurement, it will be necessary to record the static water level at a later time. This would be done by taking another measurement after pumping has ceased and sufficient time has been allowed for recovery.

9.0 PROCEDURE: Discharge Measurement of Springs

The natural variability of springs as to location, ease of access, discharge, etc. precludes the establishment of rigid procedures to measure spring discharge. The following list of spring discharge measurement methods are available to the investigator. Based on field conditions, the investigator will determine the method best suited to the characteristics of the spring under investigation.

9.1 Erect a V-notch weir and measure spring discharge. The application of this method is covered in a number of standard references. See Reference 11.1. While this method provides reliable estimates of spring discharge, it is labor intensive, time-consuming, and not suited to all applications.

9.2 Determine the cross-sectional area of the spring discharge outlet. Introduce a floating object into an unobstructed reach of the spring discharge channel and time the object's progress over a fixed distance; this will yield an approximated spring discharge velocity. The product of the cross-sectional area and spring discharge velocity is an approximate measurement of the spring discharge.

9.3 Channel the spring discharge into a container of a known volume and record the time needed to fill the container. This will yield an approximate measurement of spring discharge.

9.4 Make a visual, qualitative estimate of spring discharge. This would include remarks such as very slow, flowing, seepage, moderate, etc. This is possibly the least accurate of the methods discussed.

9.5 Collect well and spring data by completing Attachment 10.1. Record all data information as completely as possible.

10.0 ATTACHMENTS

10.1 Well and Spring Inventory Field Data (WSIFD) Form.

10.2 Figure 1 Schematic Diagram Illustrating Water Level Measurement in a Flowing Well.

11.0 REFERENCES

11.1 <u>National Handbook of Recommended Methods for Water Data Acquisition</u>, 1977. Office of Water Data Coordination, U.S. Geological Survey, MS-417, National Center, Reston, Virginia 22092.

12.0 PROCEDURE REVIEW AND APPROVAL

Prepared By: TAC Representative 10/16/89 Date

Reviewed By: Task Manager 11/9/89 Date

Reviewed By: Quality Assurance Manager 11/16/89 Date

Approved By: Project Manager 11/20/89 Date

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

WELL AND SPRING INVENTORY FIELD DATA FORM (WSIFD)

DATE ____________ FIELD REPRESENTATIVE (S) ____________

SITE CODE ____________

LOCATION ID. ____________ NORTHING ____________ ☐ TOPO MAP

EASTING ____________ ☐ SURVEY

DESCRIPTION OF LOCATION (IF NEEDED) ____________

____

____

☐ WELL DATA METHOD OF LIFT ____________

☐ DISCHARGE WELL DISCHARGE ____________

☐ OBSERVATION WELL HOW DETERMINED ____________

LAND SURFACE DATUM ____________ ☐ TOPO MAP ☐ SURVEY

MEASURING POINT ELEVATION ____________ ☐ TOPO MAP ☐ SURVEY

MP DESCRIPTION ____________

____

STATIC WATER LEVEL DEPTH ____________ ☐ M-SCOPE ☐ WETTED TAPE

PUMPING WATER LEVEL DEPTH ____________ ☐ PRESSURE GAUGE ☐ MANOMETER

STATIC WATER LEVEL ELEVATION ____________

PUMPING WATER LEVEL ELEVATION ____________ ☐ TOPO MAP ☐ SURVEY

WATER LEVEL REMARKS ____________

____

OWNER ____________

ADDRESS ____________

USE OF WELL ☐ HUMAN CONSUMPTION ☐ LIVESTOCK ☐ IRRIGATION

☐ OTHER ____________

NO. OF PEOPLE SERVED ____________

☐ SPRING DATA

DISCHARGE ____________ HOW DETERMINED ____________

WATER LEVEL ELEVATION ____________ ☐ TOPO MAP ☐ SURVEY

REMARKS ____________

____

____

JEG-AL-ENG-25 (6/87)

ATTACHMENT 10.1

ATTACHMENT 10.2

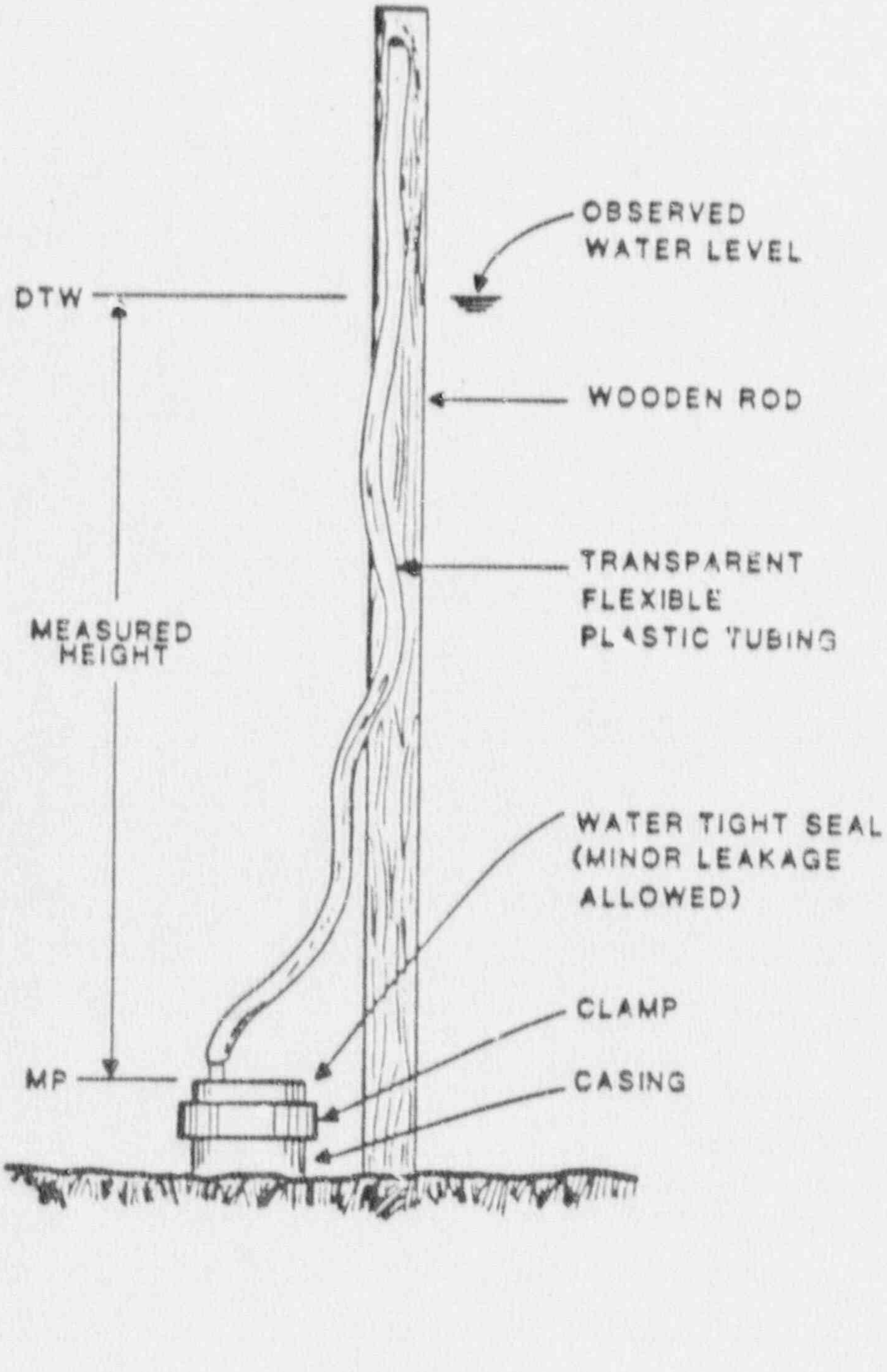


FIGURE 1. Schematic Diagram Illustrating Water Level Measurement in a Flowing Well

JE JACOBS ENGINEERING GROUP INC.

WELL AND SPRING INVENTORY FIELD DATA FORM (WSIFD)

DATE ____________ FIELD REPRESENTATIVE (S) ____________

SITE CODE ____________

LOCATION ID. ____________ NORTHING ____________ EASTING ____________ ☐ TOPO MAP ☐ SURVEY

DESCRIPTION OF LOCATION (IF NEEDED) ____________

☐ WELL DATA

☐ DISCHARGE WELL

☐ OBSERVATION WELL

METHOD OF LIFT ____________

DISCHARGE ____________

HOW DETERMINED ____________

LAND SURFACE DATUM ____________ ☐ TOPO MAP ☐ SURVEY

MEASURING POINT ELEVATION ____________ ☐ TOPO MAP ☐ SURVEY

MP DESCRIPTION ____________

STATIC WATER LEVEL DEPTH ____________

PUMPING WATER LEVEL DEPTH ____________

☐ M-SCOPE ☐ WETTED TAPE ☐ PRESSURE GAUGE ☐ MANOMETER

STATIC WATER LEVEL ELEVATION ____________

PUMPING WATER LEVEL ELEVATION ____________ ☐ TOPO MAP ☐ SURVEY

WATER LEVEL REMARKS ____________

OWNER ____________

ADDRESS ____________

USE OF WELL ☐ HUMAN CONSUMPTION ☐ LIVESTOCK ☐ IRRIGATION ☐ OTHER ____________

NO. OF PEOPLE SERVED ____________

☐ SPRING DATA

DISCHARGE ____________ HOW DETERMINED ____________

WATER LEVEL ELEVATION ____________ ☐ TOPO MAP ☐ SURVEY

REMARKS ____________

JEG-AL-ENG-25 (5/85)

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL

SECTION	17.1.1
DATE	3/30/87
EFFECTIVE	04/29/88
SUPERSEDES	8.3.2 8/8/85
PAGE 1	OF 3

ANALYSIS OF DATA AND COMPILATION OF THE SITE CHARACTERIZATION APPENDIX

1.0 PURPOSE

The purpose of this document is to establish procedures for the analysis and documentation of data on the UMTRA Project.

2.0 SCOPE

In order to prepare remedial action plans (RAP's) for UMTRA Project Sites, data are collected and analyzed. The data as collected, analyzed, and interpreted form the basis for the formulation of the Site Conceptual Designs and the final Site Designs of approved remedial actions. The Processing and Disposal Site data and other pertinent data are formally documented in the Site Characterization Appendix of the draft and final RAP.

This procedure delineates the responsibilities for analyzing data and compiling the Site Characterization Appendix. Also described are the methods of analyzing data, documenting the analyses, and checking, reviewing, and approving data analyses.

3.0 PROCEDURE

3.1 Analysis of data relevant to a particular aspect of the site shall be done by, on behalf of, or under the direction of the discipline site team member responsible for that aspect of the site.

3.2 Analysis of data shall be undertaken at the direction of the Site Manager, who is responsible for the schedule and budgets involved in compiling the site RAP. The Task Manager shall exercise delegated authority to control manhour budgets. In the event that the analyses do not relate to a specific site, the Task Manager of the section responsible for collecting and collating the data shall direct the analysis.

3.3 Data analyses for specific sites shall be done in accordance with the directions and advice of the responsible Task Manager. The Task Manager or his designated representative shall approve all analyses, shall sign the analyses, and shall be responsible for the adequacy and correctness of all data analyses.

3.4 The lead page of a data analysis shall indicate the Project, originator, subject, and date. The Analysis cover sheet to be used is given as Exhibit A.

3.5 Analyses shall be numbered in accordance with the numbering system set out in Exhibit B, or in accordance with a numbering system specifically compiled for a particular site to accord with the particular requirements and facts at that site.

3.6 Calculations undertaken prior to, in conjunction with, or pursuant to data analyses shall be performed and documented as described in Standard Operating Procedure Number 17.1.2.

3.7 Analysis of data shall be done in accordance with the methods and approaches described in the DOE Technical Approach Document (TAD). If an appropriate or applicable method is not given in the TAD, a method that is standard in the relevant technical discipline shall be used.

3.8 Analyses shall be checked by qualified person other than the person who performed the analysis. The Task Manager shall designate the checker, and shall determine the amount of checking necessary. The checker shall evaluate the consistency, applicability, and defensibility of all references, technical concepts, assumptions, calculations, analyses, and conclusions. The Task Manager or his designated representative shall approve the analyses.

3.9 At the direction of the Task Manager or at the specific request of the Site Manager, analyses may be reviewed. A review may be requested or ordered if the analyses involve unusual approaches or methods, or pertain to significant aspects of the work. Reviews will be performed in accordance with the requirements of Standard Operating Procedure Number 9.2.6 and, if applicable, 8.5.2.

3.10 Conflicts between the person compiling the analysis and a reviewer or checker shall be resolved by the Task Manager and, if necessary, by the Project Manager.

3.11 Analyses and documentation of the checking and review process shall be filed with Project Document Control. Documents recording the analyses shall be legible and suitable for reproduction and filing.

3.12 When a computer is used in an analysis, only appropriately verified, validated, and documented programs approved by the TIMS Manger and the Task Manager shall be used.

3.13 As directed by the Site Manager, or advised by the Task Manager, the results of analyses shall be incorporated into or reported and documented in the Site Characterization Appendix of the RAP.

3.14 The format of the Site Characterization Appendix shall be arranged to meet the specific requirements of each site.

Generally, the approach adopted in previous successful Site Characterization Appendices will be adopted and modified as appropriate. The Site Manager, in consultation with Task Managers, may establish the format of the Site Characterization Appendix for reports for which he is responsible.

3.15 As directed by the Site Manager or advised by the Task Managers, the Site Characterization Appendix shall be reviewed by Peer Reviewers at appropriate stages of compilation of the document.

3.16 Information derived from calculations may be incorporated into the Site Characterization Appendix in accordance with the provisions of this Standard Operating Procedure.

Prepared By: JA Caldwell

Reviewed By: JA Caldwell
Task Manager

Reviewed By:
Quality Assurance Manager

Approved By:
Project Manager

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. ____________ DISCIPLINE ____________ NO. OF SHEETS ______

PROJECT:

SITE:

FEATURE:

SOURCES OF DATA:

SOURCES OF FORMULAE & REFERENCES:

PRELIMINARY CALC. ☐ FINAL CALC. ☐ SUPERSEDES CALC. NO. ____________

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE

EXHIBIT A

EXHIBIT B
DESIGN FEATURES

Design Features	Major Design Feature Class No.		Sub-Design Feature No.
Subgrade Limits of Contamination	01	-	01
Subgrade Material Properties		-	02
Subgrade Material Quantities		-	03
Tailings Material Properties	02	-	01
Tailings Material Quantities		-	02
Tailings Long-Term Moisture Content		-	03
Tailings Limits of Contamination		-	04
Embankment Slope Stability	03	-	01
Embankment Liquefaction and Cyclic Mobility		-	02
Embankment Settlement		-	03
Radon Barrier Material Properties	04	-	01
Radon Barrier Material Quantities		-	02
Radon Barrier Long-Term Moisture Content		-	03
Radon Barrier Cover Thickness		-	04
Radon Barrier Diffusion Coefficient		-	05
Erosion Protection for Top and Side Slopes	05	-	01
Erosion Protection for Ditches		-	02
Erosion Protection Due to Off Pile Flooding		-	03
Erosion Protection Rock Durability Properties		-	04
Erosion Protection Quantities			05
Restoration Material Quantities	06	-	01
Restoration Material Properties		-	02
Waste Water Retention Basin & Temporary Utility Ditches	07	-	01
Waste Consumption		-	02
Surface Water Flood Studies PMP Calculations	08	-	-1
Miscellaneous Topics - Subsidence	09	-	01
Pile Configuration Analysis	10	-	01

ALBUQUERQUE OPERATIONS MANUAL	SECTION 17.1.2
	DATE 05/11/90
COMPILATION OF DESIGN CALCULATIONS	EFFECTIVE 06/05/90
	SUPERSEDES 06/20/89
	PAGE 1 OF 3

1.0 PURPOSE

The purpose of this document is to establish procedures to be used to compile Design Calculations for the UMTRA Project.

2.0 SCOPE

Formulation of a design for the UMTRA Project involves analyzing data and completing calculations to assess and support the design. The Calculations are kept on record in Document Control to support design decisions. They are also submitted to review agencies and other affected parties as needed. This procedure describes responsibilities for compiling the Calculations and also sets out the methods and approaches involved in compiling a typical Calculation.

3.0 PROCEDURE

3.1 The Calculations relevant to a particular aspect of the formulation of the design or disposal cell performance shall be compiled by or under the direction of the site team member responsible for that aspect of the design or disposal cell performance.

3.2 Calculations shall be compiled at the direction of the Site Manager, who is responsible for the schedule and budgets involved in compiling the Calculations. The Task Managers, as Work Package Managers in terms of the Cost/Schedule Control System, shall exercise delegated authority over manhour budgets.

3.3 Calculations shall be performed and compiled in accordance with the directions and advice of the responsible Task Manager. The Task Manager shall approve, sign, and is responsible for the adequacy and correctness of the Calculations.

3.4 The lead page of a Calculation shall indicate the Project, originator, subject, and date. The Calculation cover sheet to be used is given as Exhibit A.

3.5 Calculations shall be numbered in accordance with the numbering system set out in Exhibit B, or in accordance with a numbering system specifically compiled for a particular site to accord with the particular requirements and facts at that site.

3.6 Analyses of data undertaken in connection with or in support of Calculations shall be performed and documented as described in Standard Operating Procedure No. 17.1.1.

3.7 Calculations shall be done in accordance with the methods and approaches described in the DOE Technical Approach Document (TAD). If an appropriate or applicable method is not given in the TAD, a method that is standard in the relevant technical discipline shall be used.

3.8 Examples of acceptable Calculations are given in Exhibits D, E, and F.

3.9 Calculations shall be checked by a qualified person other than the person who performed the calculations and analyses. The Task Manager shall designate the checker and shall determine the extent of checking and review that is necessary. The checker shall evaluate the consistency, applicability, and defensibility of all references, technical concepts, assumptions, calculations, and conclusions.

3.10 At the discretion of the Task Manager or at the specific request of the Site Manager, calculations may be reviewed. A review may be ordered or requested if the calculation involves unusual approaches or methods, or results in significant or disputed conclusions. Reviews will be performed in accordance with the requirements of Standard Operating Procedure Number 9.2.6 and, if applicable, 8.5.2.

3.11 Conflicts between the person compiling the Calculations and the reviewer shall be resolved by the Task Manager and, if necessary, by the Project Manager.

3.12 Documents recording Calculations shall be legible and suitable for reproduction and filing. Calculations and documentation of the review process shall be filed with Project Document Control.

3.13 When a computer is used by the compilation of Calculations, only appropriately verified, validated, and documented computer programs approved by the Task Manager shall be used. Reference Standard Operating Procedure Number 8.3.3.

3.14 In compiling Calculations, the methods, approaches, and layout adopted in previously accepted Calculations shall be considered or followed as appropriate.

3.15 In the case of calculations compiled by staff of the Engineering Department, the Site Engineer shall collate all engineering calculations into one or more stand-alone volume(s). The Site Engineer shall be responsible (via delegated authority from the Task Manager) for delivering to Document Control, a copy of the collated Engineering Calculation Volume. Delivery shall be effected by a Document Transmittal Notice.

3.16 In case of calculations compiled by staff of the Hydrological Department, the Site Hydrologist shall collate all Hydrologic calculations into one or more stand-alone volume(s). The Site Hydrologist shall be responsible (via delegated authority from the Task Manager) for delivering to Document Control, a copy of the collated Hydrologic calculation volume. Delivery shall be effected by a Document Transmittal Notice.

Prepared By:

Reviewed By: Task Manager - Engineering

Task Manager - Hydrology

Reviewed By: Bob R Bearden
Quality Assurance Manager

Mark Miller
Task Manager - Rad H&S

Approved By: Project Manager

JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. ____________ DISCIPLINE ____________ NO. OF SHEETS ______

PROJECT:

SITE:

FEATURE:

SOURCES OF DATA:

SOURCES OF FORMULAE & REFERENCES:

PRELIMINARY CALC. ☐ FINAL CALC. ☐ SUPERSEDES CALC. NO. ____________

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE

EXHIBIT A

EXHIBIT 8
DESIGN FEATURES

Design Features	Major Design Feature Class No.	Sub-Design Feature No.
Geotechnical feature		
Subgrade limits of contamination	01	01
Subgrade material properties		02
Subgrade material Quantities		03
Tailings material properties	02	01
Tailings material quantities		02
Tailings long-term moisture content		03
Tailings limits of contamination		04
Off-Pile Ra-226 source term		05
Embankment slope stability	03	01
Embankment liquifaction and cyclic mobility		02
Embankment settlement		03
Radon barrier material properties	04	01
Radon barrier material quantities		02
Radon barrier long term moisture content		03
Radon barrier cover thickness		04
Radon barrier diffusion coefficient		05
Radon barrier sensitivity analysis		06
Erosion protection for top and side slopes	05	01
Erosion protection for ditches		02
Erosion protection due to off pile flooding		03
Erosion protection rock durability properties		04
Erosion protection quantities		05
Restoration material quantities	06	01
Restoration material properties		02
Waste water retention basin & temporary utility ditches	07	01
Waste consumption		02
Surface water flood studies		
PMP calculations	08	01

EXHIBIT B

DESIGN FEATURES

(Continued)

Design Features	Major Design Feature Class No.	Sub-Design Feature No.
Health effects from radon/radon daughter inhalation	09	01
Health effects from gamma radiation exposure		02
Health effects from radioactive particulate inhalation		03
Health effects from radioactive water ingestion		04
Health effects from radioactive food ingestion		05
Miscellaneous topics -		
Subsidence	10	01
Pile configuration analysis	11	01
Disposal Cell Hydrologic and Geochemical Properties	12	
Material properties		01
Relation of hydraulic conductivity to moisture content		02
Hydraulic gradient		03
Seepage flux through the cover		04
Transient tailings drainage		05
Seepage flux from the disposal cell		06
Source Concentration; weighted lysimeter data, back calculated from groundwater beneath tailings, Batch-leach or column extract analyses		07
Geochemical modeling of Speciation and saturation indices of tailings fluids		08
Soil Hydrologic and Geochemical Properties	13	
Material properties		01
Relation of hydraulic conductivity to moisture content		02
Hydraulic gradient		03
Travel time of seepage to groundwater		04
Geochemical modeling; speciation and saturation indices of soil solution, pH buffering or mixing of tailings fluids and soil geochemistry		05

EXHIBIT B
DESIGN FEATURES
(Continued)

Design Features	Major Design Feature Class No.	Sub-Design Feature No.
Geochemical attenuation of contamination by soil		06
Aquifer Hydrologic and Geochemical Properties	14	
Material properties		01
Slug test analysis		02
Pumping test analysis		03
Dispersivity analysis		04
Distribution coefficient analysis		05
Hydraulic gradient		06
Average linear groundwater velocity		07
Potential for vertical flow of groundwater		08
Well yield (Class III groundwater)		09
Statistical analysis of background water quality		10
Statistical analysis of existing groundwater contamination		11
Bivariate analysis of water quality		12
Trilinear or Stiff Diagram analysis of water quality type		13
Geochemical modeling; speciation and saturation indices of groundwater, pH buffering or mixing of tailings fluids with aquifer geochemistry		14
Water Resources Protection Strategy	15	
Identification of hazardous constituents		01
Concentration limits		02
Simulation of concentration of hazardous constituents at POC in uppermost aquifer		03
Simulation of concentration of hazardous constituents at point of exposure		04
Groundwater Restoration	16	
Passive flushing		01
Volume of contaminated groundwater		02

EXHIBIT C - CONTENTS OF A STANDARD CALCULATION

1.0 INTRODUCTION

This exhibit, a part of the Standard Operating Procedure for compilation of Calculations, describes the contents of a standard Calculation. A standard Calculation should contain at least those sections described in this Exhibit. It is recognized that in specific instances some sections may not be incorporated; however, that should be done only for good and sufficient reason. Additional Sections as warranted by the nature of the Calculations being compiled may be used as necessary to compile a complete and comprehensive Calculation.

2.0 CONTENTS OF THE STANDARD CALCULATIONS

2.1 Problem Statement or Purpose of Calculation: This section should describe what design problem is to be addressed, how the calculation fits into the formulation of the SCD, why the calculation is performed, and in what manner the results may be used.

2.2 Overview of the Method and Procedures to be Adopted: This section should describe the methods and procedures, or the models that are to be used in the analyses, evaluations, or calculations. For methods that are described in the Technical Approach Document, reference to that document is sufficient. Methods not included in the Technical Approach Document require a more detailed discussion.

2.3 Assumptions: Provide a series of bullet items listing the assumptions used as input to the models or methods used.

2.4 Material Properties: List all material properties used in the calculations. This section will be necessary for a calculation involving soils, but may not be needed for a calculation involving pile layout or quantities.

2.5 Data Source: List the sources of field, laboratory, or reference data that are to be used in the analyses.

2.6 Solution - Calculations and Analyses: This section should describe and detail the calculations actually performed. Sufficient detail should be given for a checker or reviewer to follow the work done without recourse to the originator.

2.7 Sensitivity Analyses and Parametric Evaluations: If precise parameter values are not known or are likely to vary during the design life of the facility, sensitivity analyses and/or parametric evaluations shall be undertaken. Such analyses and evaluations should consider a feasible range of values for relevant parameters. The range may be derived from statistical analysis of available data or the range may be defined on the basis of judgmental assessment of the likely or feasible range of values. The effect of differing results on the design or performance of the disposal cell shall be considered in deciding on reasonable design details.

2.8 Conclusions and Recommendations: The results of the calculations should be clearly stated. Tables, graphs, or both should be used to summarize the results. If the results are to be used as inputs to another calculation, that fact should be noted, and the results that are to be used should be clearly identified. If the calculation includes a parametric or sensitivity analysis, this should be noted and conclusions stated. The effect that the calculation has on the design layout should be noted. Recommendations for further analyses or design evaluations should be noted.

2.9 Results: This should list the main, relevant results.

2.10 References

2.11 Attachments: Computer program listings or output. Laboratory data.

EXHIBIT D. EXAMPLE CALCULATION
GEOTECHNICAL CALCULATION: SETTLEMENT ANALYSIS

Purpose: This pile settlement calculation evaluates the rate and magnitude of pile settlement that will result when the pile is shaped to promote positive drainage from the top surface. Reshaping will be done by placing windblown soils on the top of the pile. The rate of settlement is required so that the need for pile monitoring following remedial action construction may be evaluated. The magnitude of settlement is required for further assessment of the potential for cracking of the radon barrier or the development of an unacceptable pile top surface profile.

Method Overview: Standard Engineering settlement methods (as incorporated into the "CONSOL" computer program) are used to calculate the rate and magnitude of settlement of the pile for the given loadings. Sensitivity analyses are performed to assess the effect of variations in the design parameters (more specifically, the coefficient of consolidation of the tailings) on the rate and magnitude of settlement. The calculation method adopted models the tailings as a series of layers each with distinct settlement characteristics.

Assumptions: THe main assumption involved in the calculations is that the alluvial soil layer beneath the tailings pile will act as a drainage layer. A second significant assumption is that all the tailings are saturated. Other assumptions are ......

Material Characteristics: This section lists material types and soil properties.

Data Sources: This section notes that the major sources of data about the tailings are the laboratory test results, that specified tailings properties are taken from a listed reference work, and that the layout of the pile as modeled in the analyses is based on maps obtained from the previous owner of the pile.

Solution and Analysis: In this section the detailed calculations are described. All steps are listed. Figures showing the components and layout of the pile and the layers as modeled in the analyses are given. The different cases that are analyzed are tabulated. Details of the computer program and the main equations are listed. Graphs showing the results of the sensitivity analyses are provided.

Discussion: This section discusses the sensitivity analyses and the effect they have on determining whether special design measures are required to deal with settlement of the pile. The discussion focuses on whether the main conclusions would be different if there is a significant difference between actual field tailings properties and those measured in the laboratory.

Conclusions: This section concludes that the rate of settlement is such that all significant settlement will occur while the tailings and other soils that will be used to reshape the pile are being placed. The sensitivity analyses indicate that even if extreme values of the tailings properties are assumed, this conclusion remains valid. It is concluded that the magnitude of settlement is shown to be such that a further assessment of the potential for cover cracking is warranted: The calculation from which this assessment is made is referenced.

EXHIBIT E
EROSION PROTECTION DESIGN

Purpose: The purpose of the calculation is to determine the size of rock required on the top of the pile to prevent erosion of the radon cover in the event of the occurrence of the Probable Maximum Precipitation on the pile.

Design Methods and Procedure: The design method used is the Safety Factor Method as described in the Technical Approach Document and other referenced publications.

Design Discussion and Assumptions: This section references a figure of the layout of the pile and describes the flow directions that will occur in the event of the PMP. The maximum topslope length is given. Note is made that the design of rock is not for flow from flooding around the pile. The assumption that adequate sources of durable rock of the required size will be available is noted.

Material Properties: The angle of friction of the rock as estimated from published data, and the rock specific gravity as assumed are listed and discussed.

Data and Data Sources: The section references the calculation in which the pile area and the site PMP are calculated. Values of these parameters to be used in the calculation are given.

Solution - Calculation and Analysis: This section, which comprises the bulk of the Calculation, describes in detail the application of the method, how the time of concentration is determined, the determination of the volume of flow within the voids of the rock layer, the estimation of the value on Manning's n factor, and a tabulation of the input parameters to the computer program.

Conclusions and Results: This section lists the design flow velocities, the discharge quantities, and the required erosion protection rock sizes and possible gradations. Suitable layer thicknesses are given.

Attachments: The RIPRAP computer program listing, data input, and resultant output printings are given.

EXHIBIT F

EXAMPLE CALCULATION

DISPOSAL CELL GEOCHEMICAL PROPERTIES: SOURCE U CONCENTRATION

Purpose

In absence of lysimeter data, this calculation will be used to provide a conservative estimate of uranium (U) concentration in tailings fluid. This concentration will be used to calculate flux of U below the tailings pile. This flux is used to calculate concentration of U in groundwater of the uppermost aquifer beneath the pile in order to determine if U concentration exceeds the EPA regulated concentration limits.

Overview of Method/Procedure

Using the leachable uranium concentration in tailings and the concentration of fluid in tailings, calculate concentration of uranium in the tailings fluid. This is an alternate way to estimate the source concentration of contaminants when direct data, such as from analysis of lysimeter water samples, are not available. Because the entire amount of leachable constituents is assumed to be concentrated in the pore fluid, this calculation provides a very conservative estimate.

Assumptions

- Chemical conditions in the tailings fluid are similar to those in the leach solution.
- The entire amount of leachable U is present in the tailings fluid.
- Density of the tailings fluid is same as that of the leach water, 1 g/ml.

Material Properties

N/A (Can skip items not applicable)

Data Sources

The leaching and tailings fluid content data are from the reports referenced on the Calculation Cover Sheet.

Calculation

a) Concentration of leachable uranium in tailings = 1.5 g/g.

b) If total mass of tailings is M gram, total amount of leachable uranium = 1.5 M g.

c) Fluid (moisture) content = 10% (wt); therefore, total amount of fluid = 0.1 Mg.

d) Assuming fluid density = 1 g/ml, total volume of fluid = 0.10 M ml.

From b and d above, concentration of U in tailings fluid =

$$\frac{1.5\ M\ g}{0.10\ M\ ml} = 15\ \ g/ml = 15\ mg/l$$

Conclusions and Recommendations

1. Estimated U concentration in the tailings fluid, when the tailings fluid concentration is 10% (wt), is 15 mg/l.

2. This is a highly conservative value since all of leachable U is assumed to be concentrated in 10% pore fluid.

3. This estimate should be substantiated whenever possible, for example, using U concentration in lysimeter samples.

Results

See Calculation above.

References

See source of data.

Attachment

None.

CONCEPTUAL DESIGN

1.0 PURPOSE

The purpose of this document is to describe the Procedures involved in compiling the Site Conceptual Design (SCD) for the UMTRA Project Sites.

2.0 SCOPE

An SCD is prepared for each UMTRA Project site. The SCD is described in a section of the draft Remedial Action Plan that is compiled to describe remedial actions at the site. This Procedure describes the methods and the steps involved in formulating and documenting an SCD. Also described are the responsibilities of the various members of the Site Team involved in formulating and documenting the SCD.

3.0 PROCEDURES

3.1 The Task Managers responsible for the Technical Departments involved in formulating an SCD assign technical staff to the Site Team.

3.2 The Site Manager leads the Site Team and is responsible for organizing and controlling the schedule and budget involved in formulating the SCD. The Task Managers exercise delegated authority over manhour budgets.

3.3 Table 17.2.1 lists the Technical Disciplines normally represented in a Site Team.

3.4 The Site Team, as directed by the Site Manager, meets to consider site characterization data available and makes recommendations for the collection of additional site characterization and other relevant data required to formulate an SCD. Site Characterization and other data are analyzed and documented as described in Standard Operating Procedure Number 17.1.1. As adequate site characterization and other data are obtained and reviewed, the site design team formulates the SCD.

3.5 The Task Managers, at appropriate times during data collection and the formulation of the SCD, consider with their technical staff activities, recommendations, and contributions to the formulation of the SCD.

3.6 The Site Team, as directed by the Site Managers and as advised by the Task Managers, compiles an SCD by: (1) formulating alternative disposal options; (2) evaluating the alternatives; and (3) selecting the alternative option which best meets the design criteria, which is economical, and which is acceptable to the DOE.

3.7 The SCD is documented in the SCD section of the draft Remedial Action Plan. Text and Figures are used as appropriate to describe and document the SCD.

3.8 The site design team members compile design calculations to support the SCD. Design calculation compilation is described in Standard Operating Procedure Number 17.1.2 of the Albuquerque Operations Manual.

3.9 In compiling the SCD, account is taken of: Design Criteria as documented in NRC, EPA, and UMTRA Project related documents; UMTRA Project technical approaches; Project requirements and plans as documented in appropriate Management plan, or procedures; standard practice in the fields of expertise involved in the formulation of the SCD; and approaches and details adopted and successfully implemented on other SCD and final Remedial Action Plans and construction works.

3.10 The format of the SCD section of the draft Remedial Action Plan will be arranged to meet site needs. Generally, the approach adopted in previous, successful draft Remedial Action Plans will be adopted and modified as appropriate. The Site Manager, in consultation with Task Managers, may establish for his site the appropriate format for the draft Remedial Action Plan.

3.11 As directed by the Site Manager or advised by the Task Managers, the SCD will be reviewed by Peer Reviewers (Reference S.O.P. 8.5.2) at appropriate stages of the formulation and documentation of the SCD.

3.12 As directed by the Site Manager, or as advised by the Task Managers, the SCD will be considered in Value Engineering workshops at appropriate stages of the formulation of the Remedial Action Plan and the SCD.

4.0 LIMITATIONS

4.1 Should conflicts exist between the requirements presented herein and those defined in the UMTRA Project Site Management Manual, the requirements of the Site Management Manual shall take precedence.

Prepared By: TA CALDWELL

Reviewed By: ______________
Task Manager

Reviewed By: ______________
Quality Assurance Manager

Approved By: ______________
Project Manager

TABLE 17.2.1 SITE TEAM MEMBERS AND SITE CONCEPTUAL DESIGN RESPONSIBILITIES

Site Managers	Team Leader; organize teams; control budgets and schedules; interact with project management, client, public, and agencies; direct formulation of Site Conceptual Design.
Task Managers	Review Site Conceptual Design; advise on specialist matters; exercise delegated authority for manhour budgets.
Civil Engineering	Specify pile layout, volumes, erosion protection requirements, surface-water control features, construction schedules, and quantity estimates. Compile relevant calculations.
Geotechnical Eng.	Define site soil and rock; tailings geotechnical characteristics; site geology, geomorphology, and seismicity; and pile stability and deformation analyses. Compile relevant calculations.
Genydrology	Characterize ground-water and interconnected surface-water conditions at the site. Define present and potential for contamination of ground water and surface water from pile remedial action. Assess possible design options to maintain or restore ground water quality.
Radiology	Define areal and vertical extent of subpile and off-pile contamination and specific health and safety requirements. Calculate radon source term and thickness of radon barrier.
Cost	Confirm quantities and prepare cost estimates for the site design and alternatives.

ALBUQUERQUE OPERATIONS MANUAL

RADON BARRIER
SITE CONCEPTUAL DESIGN

SECTION 17.2.2
DATE 7/20/87
EFFECTIVE 04/29/88
SUPERSEDES 8.5.2 9/25/86
PAGE 1 OF 2

1.0 PURPOSE

To describe the Radiological Site Conceptual Design Procedures.

2.0 SCOPE

This procedure describes the responsibilities for the data analysis, design calculations, reviews, and other activities required to complete a Site Conceptual Design.

3.0 PROCEDURE

3.1 The Manager of Radiological Services will assign a health physicist to formulate the Site Conceptual Design. Other Radiological Services staff will serve as checkers on any projects to which they have not been assigned.

3.2 The designated health physicist will use the Materials Management computer program to make a preliminary estimate of the volume of contaminated material and the Ra-226 source term. These estimates will be presented to the Manager of Radiological Services and the Site Manager for review. Appropriate changes on the preliminary estimates will be made as directed by the Manager of Radiological Services or his designated representative.

3.3 Upon approval of the volume and source term calculations, the designated health physicist will evaluate the radon diffusion coefficient data, the radon emanating fraction data, and the contaminated material porosity and density data. Modeled or default value of -15 bar long-term moisture content to be provided by Engineering. The data evaluation will provide a determination of the appropriate input parameters for the RAECOM Computer Code. All input parameters will be checked and approved by a checker on the radiological services staff.

3.4 A sensitivity analysis will be performed by the designated health physicist to evaluate the effect of cover long-term moisture, Ra-226 concentration, radon diffusion coefficient, and radon emanating fraction on the proposed cover thickness. The results of the sensitivity analysis will be reviewed by a checker on the radiological services staff.

3.5 The cover thickness estimates generated by the RAECOM and the results of the sensitivity analysis will be approved by the Manager of Radiological Services or his designated representative.

Prepared By: Mark Miller for S. Green

Reviewed By: Mark Miller
Task Manager

Reviewed By: Bob R. Beaulieu
Quality Assurance Manager

Approved By:
Project Manager

SECTION	17.3.1
DATE	3/31/87
EFFECTIVE	04/29/88
SUPERSEDES	8.10.3 8/14/86
PAGE	1 OF 3

PRODUCTION OF DOCUMENTS: TECHNICAL DEPARTMENT PARTICIPATION

1.0 PURPOSE

The purpose of this section is to describe the procedures for the participation by Technical Departments in the production of UMTRA Project documents.

2.0 SCOPE

In order to document the remedial action plans and planning for UMTRA Project sites, the following documents are produced: Discussion Papers, Option Papers, and other similar documents; Environmental Impact Reports - EA and EIS; the Comparative Analysis of Disposal Site Alternatives Report - CADSAR; and the Remedial Action Plan - RAP. The Site Managers are responsible for producing the documents. The Technical Services (Engineering, Hydrological Services, Radiological Services, and Environmental Services) produce appropriate sections that are collated to compile the complete document. This procedure describes the participation by and input from the technical staff (Site Team members and Task Managers) to the documents. It does not cover the procedures adopted by Site Managers in compiling documents.

3.0 PROCEDURES: THE CADSAR

3.1 The Site Manager is responsible for compiling and writing the CADSAR.

3.2 Site team members shall assist the Site Manager in writing the CADSAR by providing information, data, advice, text of appropriate sections, figures or diagrams as requested by the Site Manager and directed by the Task Manager.

3.3 Site team members may, as requested by the Site Manager, and as directed by the Task Manager, write Appendices for the CADSAR. Such Appendices shall be written in a format similar to the format of the corresponding Appendix or Section of the RAP.

3.4 Site team members shall input to and contribute information and data to the CADSAR either by oral discussions or the transmission of white papers, figures, diagrams, tables, analyses, calculations, or appendices.

3.5 Site team members and Task Managers shall review the CADSAR, in accordance with the requirements of Standard Operating Procedure Number 9.2.6, prior to issue for technical acceptability, correctness, and reasonability.

3.6 The Site Manager is responsible for ascertaining and confirming that Task Manager approval of all information, etc., provided by Site Team members has been obtained.

3.7 It is not necessary to compile calculations or analyses to support data and designs incorporated into the CADSAR.

3.8 The provisions of this section shall apply also to the compilation of Discussion Papers, Option Papers, and other similar documents.

4.0 PROCEDURES: EA AND EIS

4.1 The Site Manager and Task Manager, Environmental Services (EV) are responsible for compiling the site EA or EIS.

4.2 Site team members shall contribute text, tables, figures, diagrams, and information to the documents as requested by the responsible Site and Task Manager.

4.3 Information provided to the EV Specialist compiling the EA or EIS shall be reviewed by the responsible Task Manager as soon as practical after compilation of the first draft. This may be before or after submission of the information to the EV Specialist.

4.4 The EA or EIS shall be reviewed and approved by the Task Managers in accordance with the applicable Standard Operating Procedures: Peer Review 8.5.2 or Request for Review 9.2.6.

4.5 Responses to comments on the EA or EIS shall be compiled by site team members as requested by the Site Manager and as directed by the Task Manager. Responses to comments shall be reviewed and approved by Task Managers if possible before submission to the Site Managers, and at any rate before issue to DOE.

5.0 PROCEDURES: RAP (Draft and Final)

5.1 The Site Manager is responsible for compiling and collating the RAP, and he shall do this in accordance with the provisions of the UMTRA Project Site Management Manual, UMTRA-DOE/AL 40005.0000.

5.2 Technical Departments are responsible for compiling sections of the RAP that relate to their specific disciplines. Technical contributions to the RAP are made by way of written text and associated figures and tables.

5.3 Site team members shall compile the written sections of the RAP text for which they are responsible at the direction of the Site Manager and in accordance with the concurrence and knowledge of the responsible Task Manager.

5.4 Before submitting sections of the RAP to the Site Manager for incorporation into the RAP, site team members shall have that text checked and approved by the responsible Task Manager. The Site Manager is responsible for confirming that Task Manager concurrence has been obtained.

5.5 The RAP shall be checked and approved by the site team members and the Task Managers before publication or issue of the RAP. This shall be done in accordance with Standard Operating Procedure 9.2.6.

5.6 Updates or revisions to the RAP shall be made by the site team members as requested by the Site Manager and as directed by the Task Manager.

5.7 Responses to comments on the RAP shall be compiled by the site team members as requested by the Site Manager and as directed by the Task Manager. Responses to comments shall be checked and approved by Task Managers if possible before submission to the Site Managers, and at any rate before issue to DOE.

6.0 LIMITATIONS

6.1 Should conflicts exist between the requirements presented herein and those defined in the UMTRA Project Site Management Manual, the requirements of the Site Management Manual shall take precedence.

Prepared By: T.A. CALDWELL

Reviewed By: TA Caldwell
Task Manager

Reviewed By:
Quality Assurance Manager

Approved By:
Project Manager

ALBUQUERQUE OPERATIONS MANUAL

SECTION	17.3.2
DATE	1/14/88
EFFECTIVE	04/29/88
SUPERSEDES	
PAGE 1	OF 2

TECHNICAL APPROACH DOCUMENT (TAD)
CHECKLIST FOR REVIEW OF UMTRA
RAP REQUIREMENTS

1.0 PURPOSE

The purpose of this procedure is to provide guidance and direction to UMTRA personnel and minimum requirements for verification that draft and final Remedial Action Plans are reviewed and completed; containing all required material and data as prescribed by the UMTRA Project Technical Approach Document (TAD).

2.0 SCOPE

The scope of this procedure will encompass personnel responsibilities and requirements for performing reviews of UMTRA Project RAPs to minimum requirements listed on the attached checklist.

3.0 PROCEDURE

3.1 UMTRA Project site manager or task managers will assign technical staff to review RAPs for evaluation of technical content, conclusion, and completeness.

3.2 Technical staff personnel shall review all assigned UMTRA RAPs and verify that said documents contain, at a minimum, all items identified in the Technical Approach Document (TAD) checklist for document review (Attachment 1).

3.3 As each TAD checklist item is verified as being contained in, or absent from, the reviewed document, and that the item(s) is determined either complete or lacking data, the reviewer will check the appropriate corresponding space for yes or no. "Yes" will indicate the item(s) is incorporated into the document and that the data and information contained within the document is complete and accurate. If, however, the document does not contain the required item(s) or the data or information is determined to be incomplete, the checklist item should be marked "No." All "No" responses should be accompanied by a brief statement in the "Remarks" space explaining the negative response. If the item(s) does not apply to the document under review, check "No" and write "N/A" under remarks.

3.4 Upon completion of review, completed checklists will be returned to the responsible task manager.

3.5 The task manager shall review all returned TAD checklists. Task managers shall take appropriate action as indicated below.

3.5.1 If the document is determined to be complete, with all minimum characteristics satisfactorily addressed, it will be approved by the task manager and forwarded for final review as directed in 3.6.

3.5.2 If comments on the checklist indicate that an item(s) is not incorporated, or data or information is determined to be incomplete, the document and a copy of the checklist will be returned to the appropriate technical personnel for rewrite or data incorporation and completion, as necessary.

3.6 Upon task manager approval, the document and TAD checklist will be routed for final review and approval and/or comment to the appropriate site manager, quality assurance, and project manager.

3.7 After the document has completed the final review cycle, it shall be returned to the task manager for incorporation of comments and final processing. Final document final processing shall be in accordance with AOM, Section 17.3.1.

Prepared By: ______________________________

Reviewed By: ______________________________
Task Manager

Reviewed By: ______________________________
Quality Assurance Manager

Approved By: ______________________________
Project Manager

TECHNICAL APPROACH DOCUMENT
CHECKLIST FOR RAP DOCUMENTS

SITE: ______________________ REVIEWER: ______________________

TASK MANAGER: ______________ DATE: ______________________

CONCURRENCE: __ ____________ __

ITEM	COVERAGE		
	YES	NO	REMARKS
I. BACKGROUND WATER QUALITY			
A. Literature review			
B. Well and spring inventory for two-mile radius			
C. Background monitor wells			
1. Uppermost aquifer			
i. Three or more monitor wells			
2. Lower aquifer			
i. Three or more monitor wells			
3. Sampled at least twice			
i. Six or more sample analyses			
4. Well logs			
D. Surface waters (pile side of stream or river)			
1. Low flow			
i. Upstream			
ii. Intermediate			
iii. Downstream			
2. High flow			
i. Upstream			
ii. Intermediate			
iii. Downstream			

ITEM	COVERAGE		
	YES	NO	REMARKS
II. PRESENCE AND MOVEMENT OF CONTAMINANT PLUMES IN GROUNDWATER AND DISCHARGE TO SURFACE WATERS			
A. Contaminants identified			
1. Source term			
2. Groundwater			
i. Vertical extent			
ii. Lateral extent			
iii. Constituents above standards			
3. Location of groundwater discharge to surface			
B. Flow directions and aquifer properties			
1. Vertical gradients			
2. Lateral gradients			
3. Average flow velocities			
4. Travel times to background concentration or surface water discharge			
5. Piezometric surface map			
III. PREDICTION OF EFFECTS OF REMEDIAL ACTION ON GROUNDWATER			
A. Flux calculations for saturated zone			
B. Infiltration through pile			
C. Estimate dispersion/attenuation of contaminants			
D. Geochemical controls on contaminant movement, geochemical modeling, precipitation/dissolution, speciation adsorption, other water-rock interactions, leaching studies on site specific materials, mineralogical analyses influencing geochemical processes			
E. Predicted future concentrations			

ITEM	COVERAGE		
	YES	NO	REMARKS
IV. IMPACTS ON BENEFICIAL USE OF GROUNDWATER			
A. Present value of affected resource			
B. Potential for human exposure			
V. CONTROL ALTERNATIVES FOR GROUNDWATER			
A. Aquifer restoration			
1. Potential restoration alternatives			
i. Technical feasibility			
ii. Estimated cost			
iii. Impacts on other users			
B. Alternate water supplies			
C. Institutional controls			
VI. RADIOLOGICAL SITE CHARACTERIZATION			
A. Appropriately spaces grid points			
B. Borehole drilling/logging/sampling for deep contamination			
C. Gamma exposure rate measurements			
D. Soil sampling/delta measurements for shallow contamination			
E. Soil sampling below tailings for thorium and heavy metals			
F. Building surveys for salvageable buildings			
G. Volume calculations based on reasonable, conservative assumptions			
H. Off pile Ra-226 source			
I. Tailings pile Ra-226 source			

ITEM	COVERAGE		
	YES	NO	REMARKS
VII. RADON BARRIER DESIGN			
A. RAECOM			
B. Geotechnical data - bulk density, porosity, long-term moisture, provided by site hydrologist			
C. Radon emanation - show insignificant dependence on moisture, Ra-226 contents			
D. Radon diffusion coefficients			
1. Measurements for all materials and justification			
2. Least squares fitting (LSDFIT) of results			
E. Radium content - layer average and values calculated for each RAECOM layer			
F. Ambient radon - background site radon levels			
G. Sensitivity Analysis			
1. Pile Ra-226 content			
2. Radon emanating fraction			
3. Cover diffusion coefficient			
4. Cover moisture content			
5. Tailings diffusion coefficient			
6. Worst case			
VIII. SURFACE WATER HYDROLOGY			
A. Consider effect on pile of runoff from: direct precipitation; upland watershed; large streams			
B. Collect available data			
C. Do flood studies			
D. Assess effect of geomorphology on pile			
E. Review dam failure impact (if any)			

ITEM	COVERAGE		
	YES	NO	REMARKS
F. Determine PMP and PMF			
G. Provide diversion facilities to direct off pile flow			
H. Provide erosion protection in and around pile for design events.			
IX. EROSION PROTECTION			
A. Select appropriate design methodology			
B. Identify source of rock			
C. Size rock			
D. Size bedding			
E. Check adequacy of protection for ditches, aprons			
F. Confirm rock durability, check laboratory test list and conformance with NUREG requirements			
G. Check compatibility of filter and erosion barrier			
X. GEOTECHNICAL			
A. Review previous work			
B. Characterize region and site geology			
C. Define site geomorphology; gullies, mass movement, slope erosion, techtonism, base level/ change			
D. Define subsurface conditions: archived data, field boreholes, test pits, laboratory test			
E. Borrow pit definition - material characteristics			
F. Tailings characteristics			
G. Construction material characteristics			
H. Field seismicity: surface and bedrock acceleration; seismic magnitude and intensity; fault locations			

ITEM	COVERAGE		
	YES	NO	REMARKS
I. Slope stability: static and seismic; factors of safety adequacy			
J. Pile settlement: settlement defined, potential effect on pile integrity considered			
K. Liquefaction potential: adequate soil strength soil moisture adequacy, compaction of tailings			
XI. NON-RADIOLOGICAL CONTAMINANTS			
A. Review of existing soil and tailings data			
B. Inventory of potentially hazardous materials			
C. Data gaps (additional sampling)			
D. Correlation between non-radiological constituents and Ra-226			

JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL	
	SECTION 17.4.1
	DATE 6/12/87
LOCATION IDENTIFICATION FOR TEST BORINGS, TEST PITS, AND MONITORING LOCATIONS	EFFECTIVE 04/29/88
	SUPERSEDES 8.2.13 7/4/86
	PAGE 1 OF 2

1.0 PURPOSE

This operating procedure establishes a uniform test boring, test pit, and monitoring location identification system for use on UMTRA site investigations.

2.0 POLICY

All test borings, test pits, monitoring locations, and observation wells where physical, chemical, biological, or radiological measurements are made will be designated using the standard identification system described herein. This procedure includes all existing locations that are or will be used by the TAC for the completion of the site characterization tasks. Note, however, that excluded from this standard procedure are the thousands of surface locations scanned or sampled for the purpose of site characterization requiring no specific identifier. These surface locations (where the elevation (Z) is implied to be the topographic surface) will be simply referred to by a north coordinate (Y) and an east coordinate (X).

3.0 PROCEDURE

Each location defined above shall be identified by a Site Code and a Location ID. The site code will consist of the standard 3-character designation as listed in Section 8.3.5 of the AOM plus an additional two-digit number further describing a specific aspect of the site defined categorically by the site type. This two-digit number is assigned by the Data Administrator after concurrence with the Site Manager and maintained in the General Site Information (GSI) Master File.

The Location ID will consist of a 3-digit designation with a range per site as follows:

001 through 999

This three-digit number is assigned and maintained in a log by the Data Administrator.

Thus, the identification will take the form,

SSSNN-NNN

where:

SSSNN is the site code
NNN is the Location ID per site.

EXAMPLES

CAN01-001	Canonsburg Processing Site - Borehole Number 001
SLC02-345	Salt Lake City (Clive) Disposal Site - Test Pit Number 345

No designation in this procedure provides for distinguishing the log type, e.g., radiological, geological, hydrological, etc. As a result, any location may be logged for multiple data types without restriction noted in the identification. Other characteristics associated with each defined location will have independent descriptions. Included are items such as: north coordinate, east coordinate, elevation, log type, log date, previous identification, etc. All of these descriptions may be used as additional identification for test borings, test pits, etc., as necessary.

4.0 RESPONSIBILITY

Each Site Manager and responsible technical personnel shall incorporate this identification system into all field investigation activities and permit no data gathering efforts that do not include the standard identification system. The Data Administrator will be responsible for maintaining the sequential numbering system and dispensing these numbers as necessary. Any existing location used in site characterization will be redesignated by technical personnel and approved by the Data Administrator to conform to the standard identification system described above.

Prepared By: ______________________

Reviewed By: Linda [illegible]
Task Manager

Reviewed By: ______________________
Quality Assurance Manager

Approved By: ______________________
Project Manager

UMTRA PROJECT
TAC HYDROLOGICAL STANDARD OPERATING PROCEDURES

16.0 Hydrological Standard Operating Procedures

16.1 Field Operations

16.1.1 Monitor Well Installation
16.1.2 Well Development
16.1.3 Slug Testing
16.1.4 Packer Testing
16.1.5 Aquifer Pump Testing
16.1.6 Soil Water Sampler Installation and Use
16.1.7 Installation and Servicing of Tensiometers
16.1.8 Batch and Column Leach Testing

16.2 Water Sampling

16.2.1 Water Sampling, Preserving, Shipping, and Testing
16.2.2 Water Sampling for Tritium Analysis
16.2.3 Evaluation of Chemical Analysis of Water Samples

16.3 Data Control

16.3.1 Completion of Well and Spring Inventory

continued

UMTRA PROJECT
TAC TECHNICAL STANDARD OPERATING PROCEDURES

17.0 Technical Standard Operating Procedures - Office

- 17.1 Analysis and Calculations
  - 17.1.1 Analysis of Data
  - 17.1.2 Compilation of Design Calculations
- 17.2 Design
  - 17.2.1 Conceptual Design
  - 17.2.2 Radon Barrier Site Conceptual Design
- 17.3 Documents
  - 17.3.1 Production of Documents: Technical Division Participation
  - 17.3.2 Technical Approach Document (TAD) Checklist for Review of UMTRA RAP Documents
- 17.4 Data Control
  - 17.4.1 Location ID for Test Borings, Test Pits, and Monitoring Locations

JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL	SECTION 16.1.1
	DATE 10/02/90
MONITOR WELL INSTALLATION	EFFECTIVE 11/15/90
	SUPERSEDES 02/25/87
	PAGE 1 OF 8

1.0 PURPOSE

To provide quality control for monitor well installation that will enable successful completion of field drilling investigation(s) oriented toward obtaining representative geohydrological quality information, and to provide regulatory compliance for monitor well construction, modification, repair and abandonment activities.

2.0 SCOPE

This procedure is applicable to members of the TAC and its contractors and subcontractors with responsibilities and duties for the installation of monitor well(s), well development, well testing, and collection of water samples for water quality determinations.

3.0 PROCEDURES

3.1 All field measurements and comments shall be recorded on Attachment 5.1 or 5.2 pursuant to TAC data reporting formats and protocols. See 4.0.

3.2 All lines on the forms shall be completed. The letter designation "NA" (Not Applicable) or "NK" (Not Known) shall be used in all blank spaces.

3.3 If some steps or procedures were not performed as described, the reason must be stated on Attachment 5.1 or 5.2 or submitted as an attachment to the data sheet.

3.4 When granular backfill is used as part of a well installation, at least one-half to one pint of sample shall be taken from each shipment of granular material, stored with the soil samples, and recorded on the sketch of each installation for which that material was used.

3.5 The contractor shall submit the specifications of the proposed sand pack material to the TAC Field Technical Representative (FTR) for approval prior to use. Describe each sample in terms of lithology, grain size distribution, and source. Record both the company from whom the material was purchased and the pit or quarry of origin. This material shall be clean, inert, and siliceous. Use typically well-sorted (poorly graded) sand such as No. 8-12 or similar material with less than ten percent (10%) passing through the design slot size for medium to course grain aquifer materials and No. 10-20 with less than ten percent (10%) passing through the design slot size for fine to medium grain aquifer materials.

3.6 Sketch the well installation on Attachment 5.1 and show, by depth from surface grade, the bottom of the boring, sump, screen location, coupling design and location, granular backfill, seals, grout, cave-in centralizers, and height of riser above ground surface. Record the actual composition of the grout, seals, and granular backfill on each Attachment 5.1. Also include the screen slot size (in inches), slot configuration, total open area per foot of screen, and screen manufacturer.

Note: Any use of PVC solvents, glues, soap, or cleaners is prohibited below grade unless otherwise stated in the specifications. Where such material is used, it shall be recorded and described on Attachment 5.1 and shall include manufacturer and type (specification).

3.7 Use, whenever applicable, PVC centralizers to assure the uniform and complete annular filling by granular backfill, seal, and grout materials. Fasten centralizers to the well casing with mechanical fasteners. The centralizers shall be radially spaced about the casing at 120° or 90° intervals. On Attachment 5.2, provide a description and location(s) of the fastening device and centralizer.

3.8 Attachment 5.3 and 5.4 depict typical well construction. However, specific contract requirements may alter some of the components and/or values shown. Furthermore, when installed as a piezometer or well point (for water levels only), the well configuration may significantly vary from these figures. After development is complete,, indicate the static water level in the well on the well construction diagram.

3.9 Well sketches shall include the protective casing detail.

3.10 Install protective casing around all monitor wells. The TAC shall determine exceptions on a case-by-case basis. Minimum elements in the protection design include:

3.10.1 A five-foot minimum length of black iron pipe or galvanized pipe extending about 1.5 to three feet above the ground surface and set in cement grout. See Attachments 5.3, 5.4, and 5.5.

3.10.2 The pipe diameter shall be eight inches (8" i.d.) for four-inch wells and six inches (6" i.d.) for two-inch wells (depending on approved borehole size). A 0.5-inch drain hole near ground level is permitted.

3.10.3 Install a protective steel cap (as in Attachment 5.3 and 5.4) and secure the cap to the top of each protective casing by the use of a steel pin which penetrates the casing and cap. Paint the location identification on the inside and outside of the cover with enamel type paint. The Site Manager shall designate location identification which shall conform with TAC format.

3.10.4 The well cover must keep precipitation out of the protective casing and shall be secured to the casing by means of padlocks.

3.10.5 It is desirable that all padlocks at a given site be opened by the same key. The numbers on the locks shall be noted and then rubbed off the back of the lock.

3.10.6 (Optional) Paint the protective casing with aluminum colored paint.

3.10.7 As shown in Attachment 5.5, secure those wells which are not protected by the steel surface casing with an enclosure of three (3) fenced wood or steel posts. Cement each post in place. NOTE: The installation of the posts is recommended in addition to the protective casing in areas where vehicle traffic might pose a hazard.

1) The wood posts should be 4" x 4" x ~6', the steel posts should be 3" diameter (o.d.) x ~6', and the T-bar driven steel posts should be 6' long.

2) Place each of the posts radially and about four feet (4") from the well, placed two feet (2') below ground surface, and have four feet (4') minimally above ground surface.

3) If high vegetation exists around the well site, flag the posts with brightly-colored plastic ribbon-like material or its equivalent.

3.10.8 Optional. Use three-strand barbed wire strung on four (4) posts as shown in Attachment 5.5, as livestock guards in grazing areas. For post dimensions see 3.10.7.

3.11 Emplace a filter pack (granular backfill; sand pack) in the annulus adjacent to the well screen in all monitor wells as follows:

3.11.1 Fill the annulus between the well screen and borehole wall with approved silica sand.

When neither of the two proposed generic filter sand/screen-slot sizes are used, it will be required that representative aquifer material be collected and sieved to determine grain size distribution.

3.11.2 The average grain-size of the filter sand shall be based on expected grain-size distributions in the screened formation and on the size of predesigned well-screened openings. Ideally, the filter pack will pass only the smallest of the grain size (40%) found within the formation. The sand shall have a gradation which will allow not more than ten percent (10%) of pack material to pass through the screen slots. Refer to Figures 16.1 1-5, 16.1 1-6, 16.1 1-7, for selecting filter pack material size and well screen slot size.

3.11.3 For wells deeper than 75 feet, or as determined by the FTR, emplace the sand pack with a tremie pipe. Gravity feed the sand through the tremie pipe into the annulus throughout the entire screened interval and a minimum of three feet over the top of the screen.

3.11.4 As a last resort, clean water should only be added when no other practicable method exists for proper filter pack emplacement. In such a case it is necessary to pump sufficient sand slurry through the tremie pipe to cover the screen after the sand pack has densified and settled. As a general rule-of-thumb, apply at least a seven-foot (7′) thick layer of sand slurry over the top of a 15 foot-long screen. Increase the sand-pack thickness by two feet (2′) for each additional five feet (5′) of screen. Thus, the top of a 30-foot long screen would be 13 feet deeper than the top of the sand pack after emplacement.

3.11.5 Using the tremie pipe, ascertain the depth of the top of the sand and verify the thickness of the sand pack. Additional sand shall be added to bring the top of the sand pack to the proper elevation, if necessary.

3.11.6 Under no circumstances shall the sand pack extend into any aquifer other than the one to be monitored. In most cases, the well design can be modified to allow for a sufficient sand pack without threat of cross-flow between producing zones through the sand pack.

3.11.7 The Site Hydrologist and FTR are the only individuals authorized to modify an existing well design.

The filter pack shall consist of clean silica sand and ensure continuous flow capability from the natural formation to the well bore.

3.12 Emplace a bentonite seal between all contacts of sand pack and grout to prevent infiltration of cement into the well. In special circumstances, where an open borehole has been drilled to a depth below that at which the screen will be set and if grout is used to seal off a lower aquifer or as backfill up to the proper level, emplace a bentonite seal above the grout before casing, screen, and sand pack are introduced. Allow the grout to set up prior to placing the seal. Place any bentonite seal in the monitor well as follows:

3.12.1 Fill the annulus between water-tight well casing and borehole (and in the interval between the sand pack and the grout seal) with a bentonite seal at least five-feet thick (vertically). The annulus must be filled with a bentonite seal to a level above the highest seasonal groundwater fluctuation.

3.12.2 Emplace the seal material as bentonite pellets or graded bentonite chip. The bentonite shall have a minimum purity of 90% montmorillonite clay and a minimum dry bulk density of 75 lb/ft^3 for 1/2-inch pellets, as provided by American Colloid, or its equal and 50.0 lb/ft^3 for 3/4" graded chip. The pellets and graded chip should be screened prior to placement in order to separate the fines from the unbroken - intact seal material. The fines are discarded. Place a cap over the top of the casing and pour a five (5) gallon bucket of bentonite directly down the annulus. Note: Care must be taken to avoid introducing pellets into the well bore. Pour the pellets from different points around the casing to ensure even application. Use a tremie pipe to redistribute and level out the top of the seal.

3.12.3 For wells deeper than 75 feet, pour the bentonite as pellets, or if necessary, introduce the bentonite as a slurry. The TAC FTR shall determine the method of emplacement after evaluating the condition of the well and borehole wall.

1) If there are no centralizers in the upper portions of the casing, manipulate the casing to prevent pellets from hanging up in the narrow annulus and to allow them to settle as rapidly as possible to the bottom.

3.12.4 If a slurry of bentonite is used as an annular seal, prepare the slurry by mixing powdered bentonite with potable water. The slurry must be of sufficiently high specific gravity and viscosity to prevent its displacement by the grout that will be emplaced above. As a precaution, regardless of depth and depending on fluid visocity, emplace a few handfuls of bentonite pellets in to solidify the surface of the bentonite slurry.

3.12.5 Before pumping the seal, make sure that the sand pack has ceased settling by measuring the depth of the top of the sand with the tremie pipe. The sand pack must provide an adequate cover over the screen as discussed in 3.8.

3.12.6 Visually check the condition of the slurry by pumping into a bucket or onto the ground. Retract the tremie pipe three feet and commence pumping.

3.12.7 In all situations, emplace a bentonite seal a minimum thickness of five feet. The top of the seal shall be tagged by tremie pipe to verify that the proper thickness of seal has been placed in the annulus.

3.12.8 Repeat application and verification as necessary until the specified quantity of bentonite has been placed in the well annulus.

3.13 Use only Type I or Type II cement without accelerator additives. Allow 20 minutes for bentonite slurry or bentonite pellets to set before grouting commences. Place grout in the monitor well as follows:

3.13.1 Fill the annulus between the well casing and borehole wall with grout.

3.13.2 Place the grout with a grout tremie-pipe located just over the top of the seal.

3.13.3 The tremie pipe should normally consist of 1.25-inch PVC or steel pipe. One-inch rolled thin-walled poly pipe has been used with success in some cases.

3.13.4 Pump the grout through this pipe to the bottom of the open annulus until undiluted grout flows from the annulus at the ground surface.

3.13.5 The grout shall consist of a neat cement mix with four pounds of commercial bentonite and approximately 7.5 gallons of water added per 94-pound bag of cement. Use only grout mixed with TAC-approved water.

3.13.6 Any drill casing or hollow-stem auger shall be left in the hole during grouting to the extent practical.

3.13.7 During grouting, the drill casing or hollow-stem auger may be removed as the grout level rises above the contact.

3.13.8 While the grout is still green (per 3.13.5 above), add additional grout to compensate for the removed casing or auger and tremie pipe and to ensure that the top of the grout is at or above ground surface. Construct a grout apron at the base of the protective casing to facilitate surface water runoff.

3.13.9 Install the protective casing.

3.13.10 After the grout has set for 48 hours or more, fill any depression in the grout due to settlement with a grout similar to that described in 3.13.5.

3.14 Clean up equipment and work area.

4.0 MONITOR WELL REGULATORY COMPLIANCE

4.1 It shall be the responsibility of the UMTRA site hydrologist, site manager, or other project personnel designated by the site manager proposing to construct,, modify, repair, or abandon an UMTRA monitor well to notify in writing the regulatory compliance staff, within Environmental Services, of the proposed action. This shall be done at the same time as the scope of work is developed for the proposed action.

4.1.1 The notification to Environmental Services shall be recorded on Part I of the Regulatory Compliance Data Sheet, Attachment 5.8.

4.2 It shall be the responsibility of the regulatory compliance staff, upon being notified that a proposed monitor well action is pending, to initiate the regulatory compliance and clearance process, and update the central Monitor Well Inventory database.

4.2.1 With this information, the regulatory compliance staff will open a record or modify existing records in the Monitor Well Inventory database (available via the DART) providing a tracking system of the regulatory, maintenance, and access status of all UMTRA monitor wells.

4.2.2 Environmental Services will obtain necessary regulatory permits or clearances from the appropriate state, tribal, or Federal permitting agencies and provide copies to the FTR before drilling can commence.

4.3 In the case of new monitor wells or those wells requiring repairs, the site hydrologist/FTR must provide a status report to Environmental Services on the proposed activity within 30 days of the initial notification.

4.3.1 For those states where licensed drillers are required to file completion reports, the site hydrologist/FTR must provide verification of filing, including a copy of the completion report, to the regulatory compliance specialist.

4.3.2 For those states where the well owner files compliance documentation, the site hydrologist/FTR must provide copies of the completion report to the regulatory compliance staff within one week of the completion of drilling.

5.0 ATTACHMENT(S): Supporting Document(s)

5.1 Figure 16.1.1-1; Well Completion Record [JEG-AL-ENG-3(6/87)].

5.2 Figure 16.1.1-2; Borehole/Well Construction Log [JEG-AL-ENG-1(6/87)].

5.3 Figure 16.1.1-3a; Typical Construction of Alluvial Well.

5.4 Figure 16.1.1-3b; Typical Construction of Bedrock Well.

5.5 Figure 16.1.1-4a; Post Placement Around Well.

5.6 Figure 16.1.1-4b; Post Placement Around Well

5.7 Figure 16.1.1-5; Sieve Retention Graph

5.8 Figure 16.1.1-6; Sieve Retention Graph

5.9 Figure 16.1.1-7; Correlation Chart of Screen Openings and Sieve Sizes

5.10 Figure 16.1.1-8; Regulatory Compliance Data Sheet

Prepared By: Don Metzler
TAC Technical Representative

Reviewed By:
Task Manager

Reviewed By: Bob R Bearden 11/15/90
Quality Control Manager

Approved By:
Project Manager

FIGURE 16.1.1-1

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

WELL COMPLETION RECORD

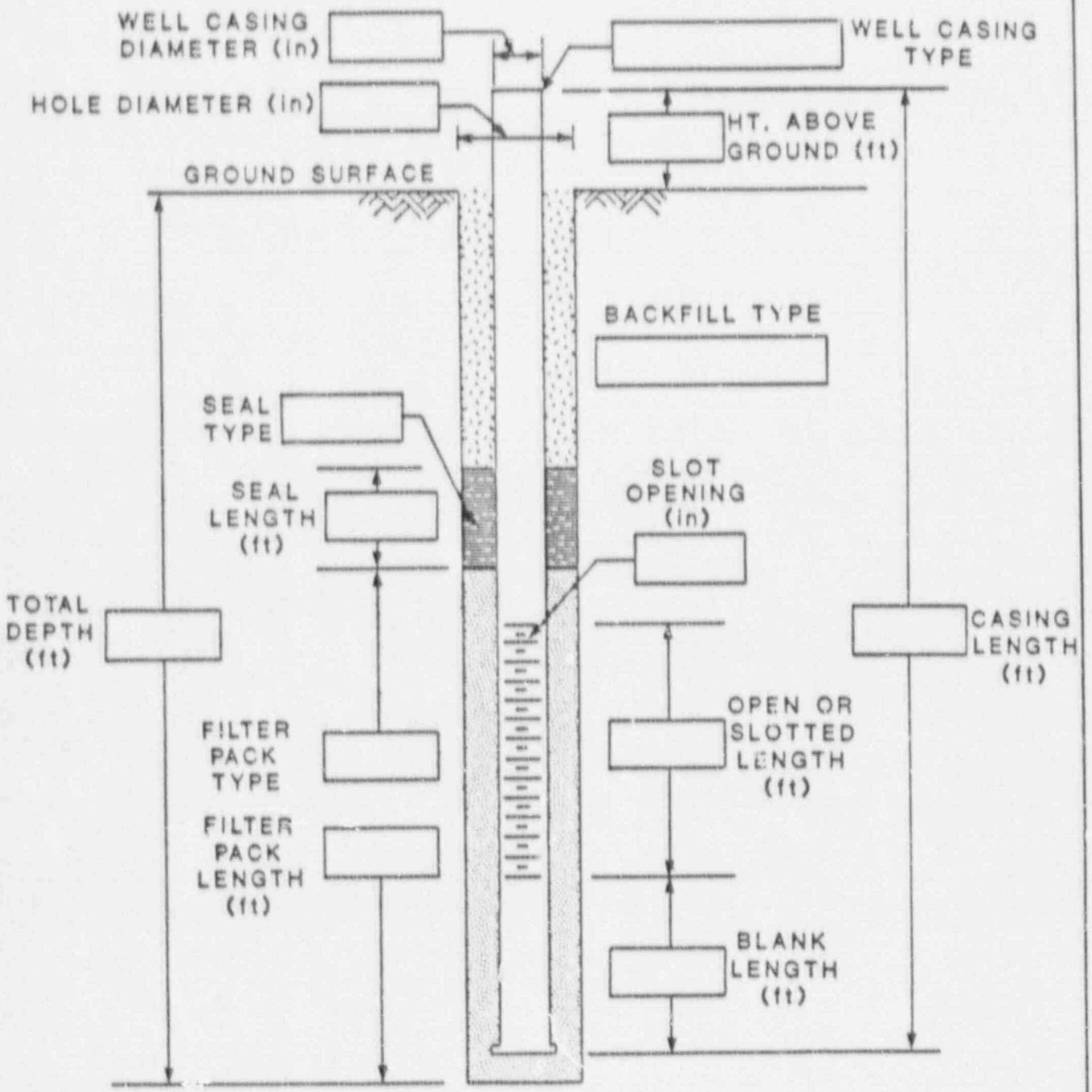
SITE ID: ____________ LOCATION ID: ____________ DATE INSTALLED: ____________

APPROX. SITE COORDINATES:(FT.) N ______________ E ______________

OPEN AREA PER LINEAL FT. (IN^2/FT.) ______________________________

FORMATION OF COMPLETION: ______________________________

FIELD REP.: ______________________ DRILLER: ______________________



COMMENTS: ______________________________

____

JEG-AL-ENG-3 (6/87)

FIGURE 16.1.1-2

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: ____________ LOCATION ID: ____________ FIELD REP: ____________

APPROX. SITE COORDINATES (FT.): N ____________ E ____________

GROUND ELEVATION (FT. MSL): ____________ COMPLETION DATE: ____________

BOREHOLE SUMMARY

DRILLER: ____________

RIG TYPE: ____________

BIT TYPE	HOLE DIA. (in.)	END ● DEPTH (ft.)	FLUID TYPE

CASING SUMMARY

CASING TYPE*	DESCRIPTION	DIA. (in.)	END ◆ DEPTH (ft.)

* P-Protective S-Screen B-Blank O-Open N-None

◆ Depth from Top of Casing

WELL CONSTRUCTION

TYPE CODE*	DESCRIPTION	END ● DEPTH (ft.)

* B - Backfill S - Seal F - Filter Pack

● Depth from Ground Surface

CONSTRUCTION TIME LOG

ACTIVITY	START		END TIME
	DATE	TIME	
DRILLING			
CASING			
FILTER PACK			
SEAL			
BACKFILL			
DEVELOPMENT			
OTHER			

WELL DEVELOPMENT

COMMENTS: ____________

JEG-AL-ENG-1 (6/87)

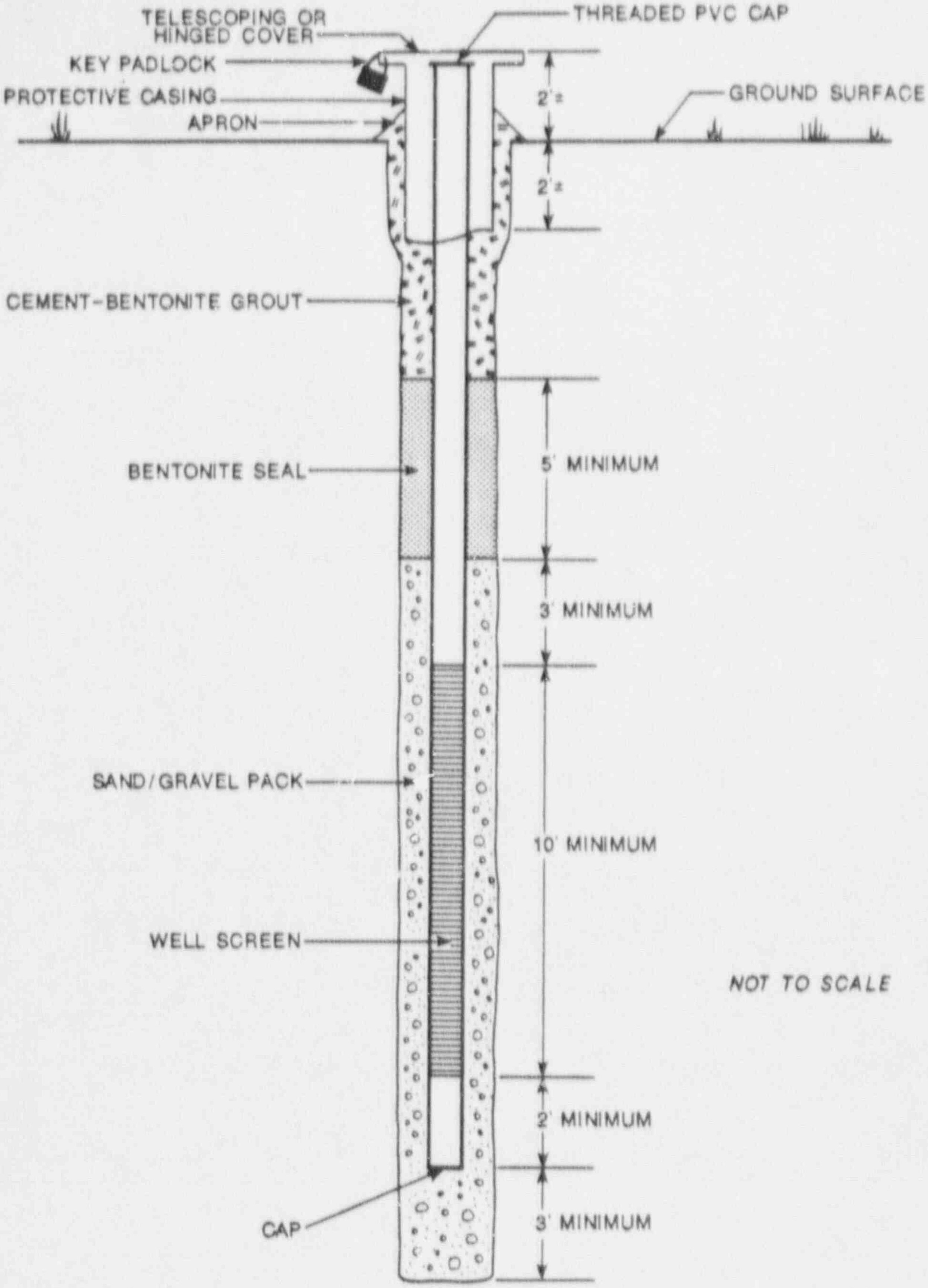


FIGURE 16.1.1-3A
TYPICAL CONSTRUCTION OF ALLUVIAL WELL

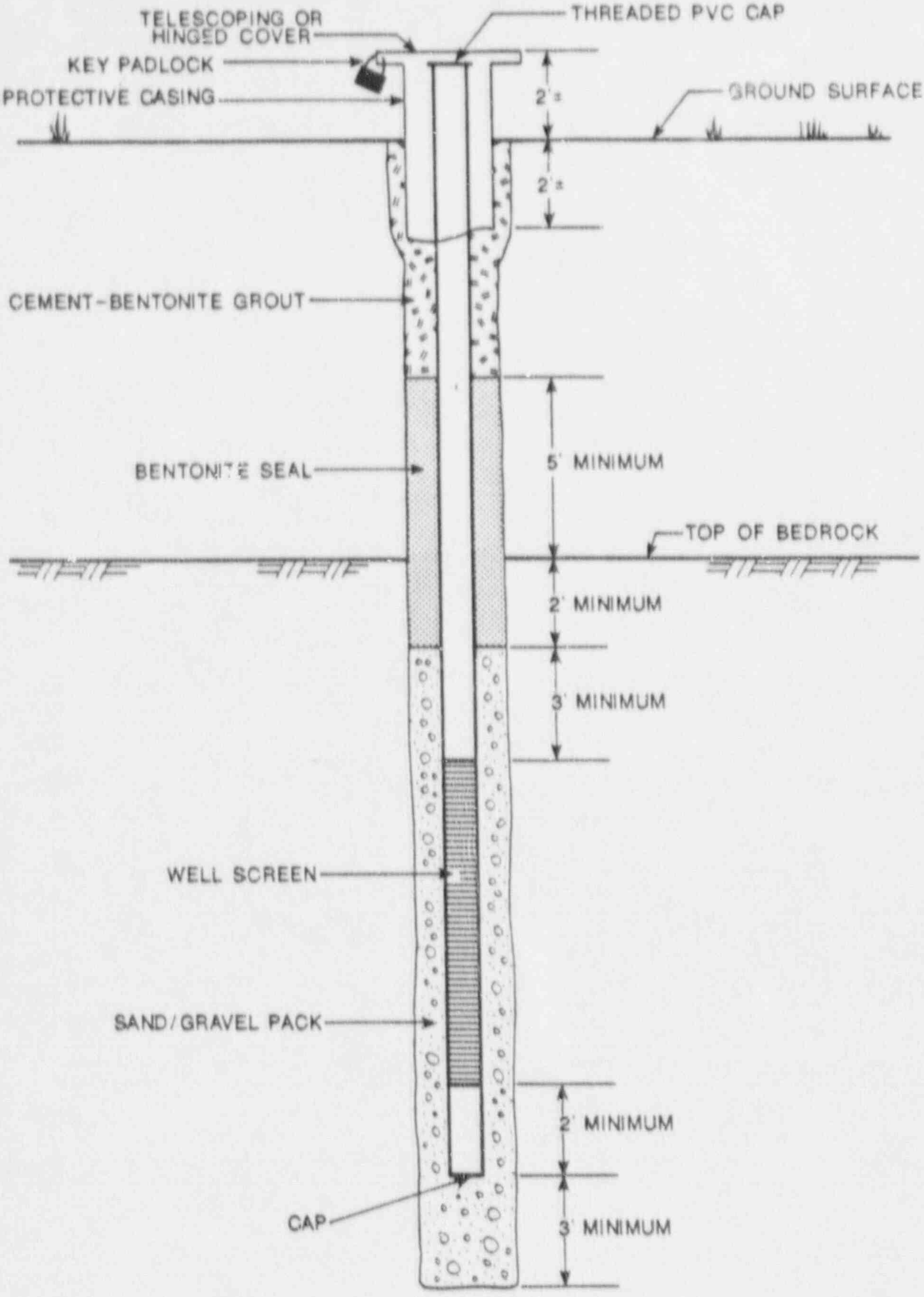


FIGURE 16.1.1-3B
TYPICAL CONSTRUCTION OF BEDROCK WELL

FIGURE 16.1.1-4

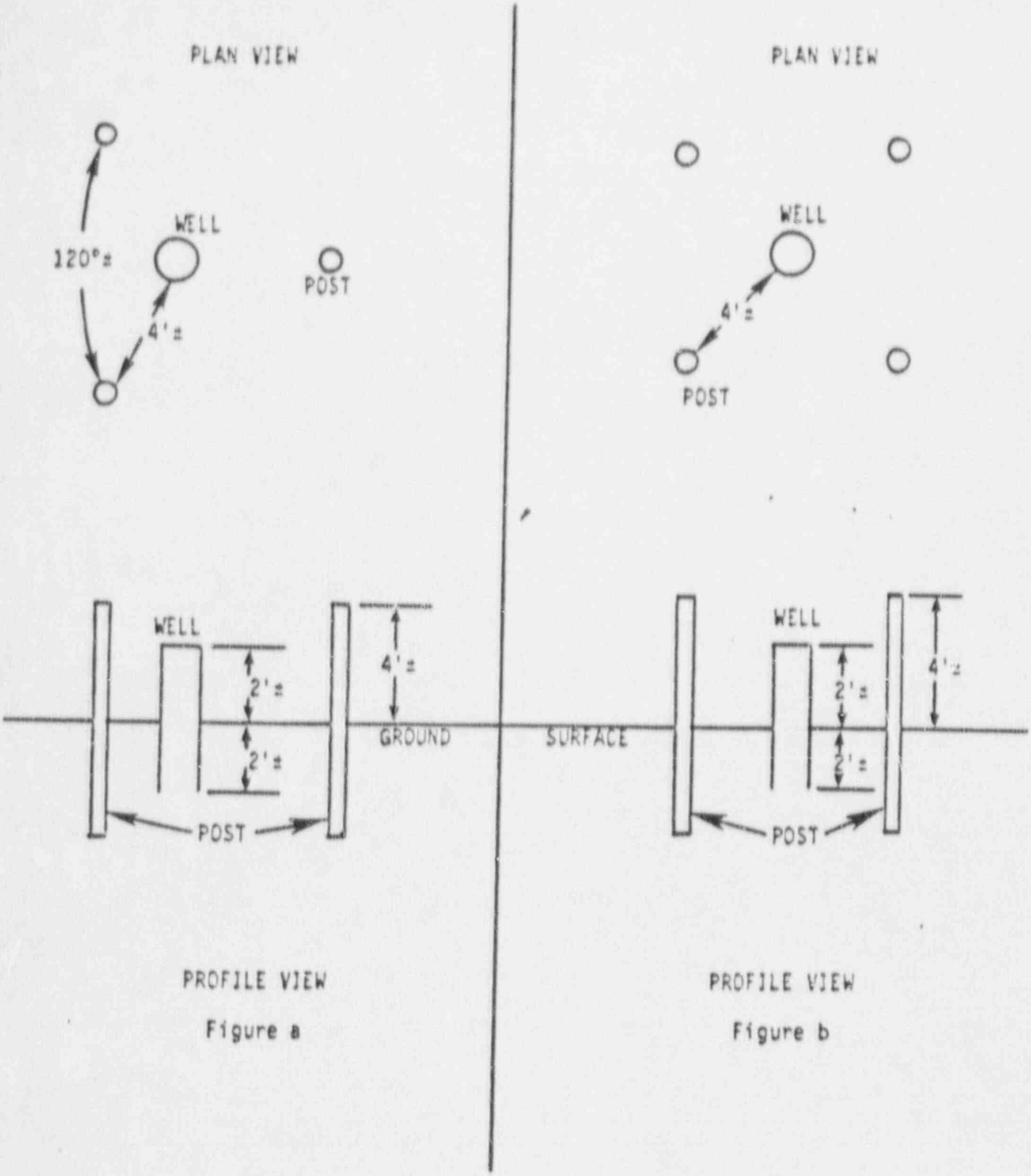


Figure a

Figure b

POST PLACEMENT AROUND WELL

FIGURE 16.1.1-5

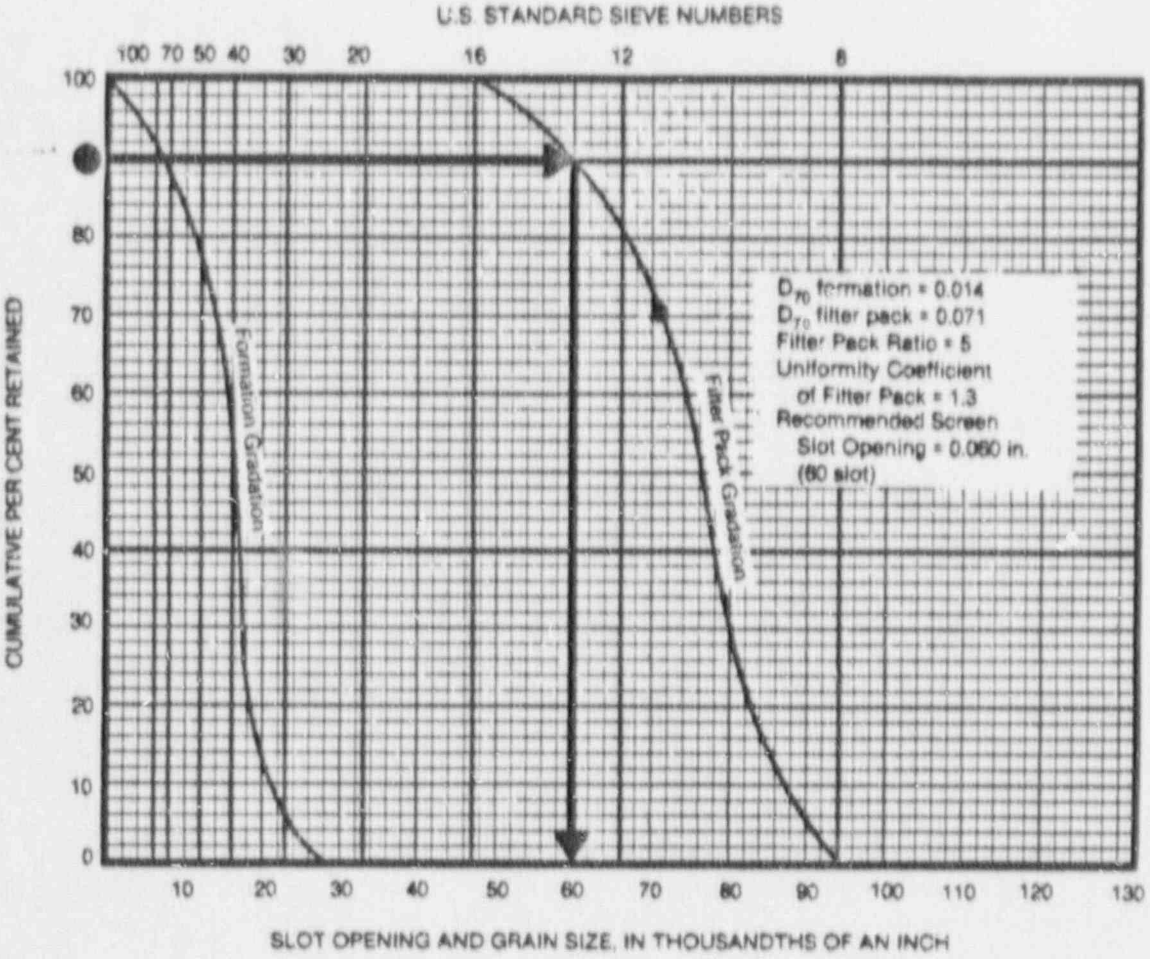


FIGURE 16.1.1-6

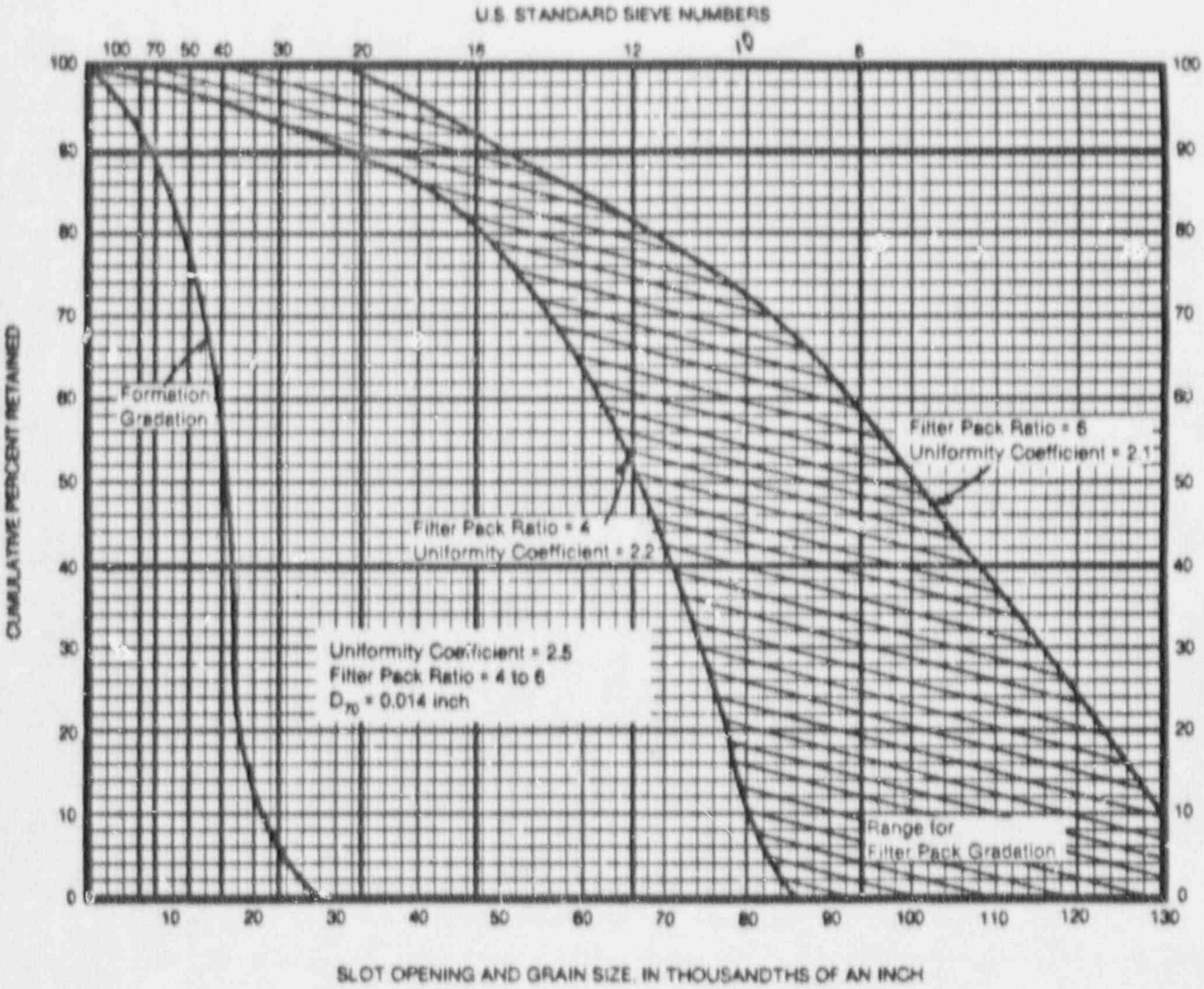


FIGURE 16.1.1-7

Correlation Chart of Screen Openings and Sieve Sizes

Geologic Material Grain-size Range	Johnson Slot No.	Gauze No.	Tyler			U.S. Standard		
			Sieve No.	Size of Openings Inches	Size of Openings mm	Sieve No.	Size of Openings Inches	
clay & silt		—	400	0.0015	0.038	400	0.0015	
	—	—	325	0.0017	0.043	325	0.0017	
	—	—	270	0.0021	0.053	270	0.0021	
	—	—	250	0.0024	0.061	230	0.0024	
	—	—	200	0.0029	0.074	200	0.0029	
fine sand	—	—	170	0.0035	0.088	170	0.0035	
	—	—	150	0.0041	0.104	140	0.0041	
	—	—	115	0.0049	0.124	120	0.0049	
	6	90	100	0.0058	0.147	100	0.0059	
	7	80	80	0.0069	0.175	80	0.0070	
	8	70	65	0.0082	0.208	70	0.0083	
	10	60	60	0.0097	0.246	60	0.0098	
medium sand	12	50	48	0.0116	0.295	50	0.0117	
	14	—	42	0.0138	0.351	45	0.0138	
	16		35	0.0164	0.417	40	0.0165 (1/64)	
	18	40	—	0.0180	0.457	—	0.0180	
	20		32	0.0195	0.495	35	0.0197	
	23		28	0.0232	0.589	30	0.0232	
coarse sand	25	30	—	0.0250	0.635	—	0.0250	
	28		24	0.0276	0.701	25	0.0280	
	31		—	0.0310	0.788	—	0.0310 (1/32)	(a)
	33		20	0.0328	0.833	20	0.0331	
	35	20	—	0.035	0.889	—	0.0350	
	39		16	0.039	0.991	18	0.0394	
very coarse sand	47		14	0.046	1.168	16	0.0469	(b)
	56		12	0.055	1.397	14	0.0555	
	62		—	0.062	1.590	—	0.062 (1/16)	
	66		10	0.065	1.651	12	0.0661	
	79		9	0.078	1.981	10	0.0787	
very fine gravel	93		8	0.093	2.362	8	0.0931	
	94		—	0.094	2.390	—	0.094 (3/32)	
	111		7	0.110	2.794	7	0.111	
	125		—	0.125	3.180	—	0.125 (1/8)	
	132		6	0.131	3.327	6	0.132	
fine gravel	157		5	0.156	3.962	5	0.157	
	187		4	0.185	4.699	4	0.187 (3/16)	
	223		3½	0.221	5.613	3½	0.223	
	250		—	0.250	6.350	¼	0.250 (¼)	
	263		3	0.263	6.680	—	0.263	
	312		2½	0.312	7.925	5/16	0.312 (5/16)	
	375		0.371	0.371	9.423	⅜	0.375 (⅜)	
	438		0.441	0.441	11.20	7/16	0.438 (7/16)	
	500		0.525	0.525	13.33	½	0.500 (½)	

a) UMTRA specifications suggest 10-20 silica sand with 0.030 slotted screen for fine to medium grain aquifers.

b) UMTRA specifications suggest 8-12 silica sand with 0.050 slotted screen for medium to course grain aquifers.

FIGURE 16.1.1-8

REGULATORY COMPLIANCE DATA SHEET

PART I (To Completed by Site Hydrologist/FTR)

Submit to Regulatory Compliance Specialist, Environmental Services, concurrent with initiation of the scope of work. Locate wells by township, range, and section (See back of sheet) and attach map ________.

Site Hydrologist/FTR ____

Site ID Code: ____________ Location ID Code: _______________

Action to be taken: ☐ Drill Wells ☐ Repair Wells ☐ Abandon Wells

No. of wells: Monitor Wells______ Bore Holes_______ Test Pits________

Driller (name/address): ____

State License #: ____

Land Owner (name/address): ____

Proposed Construction Start Date: ___________

Proposed Construction Completion Date: ___________

Drill Rig/Construction Type: ____

PART II (To be completed by Regulatory Compliance Staff)

Permit/Clearance Date: ______________

Access Agreement #: __________________ Date: ______________

Open record in Monitor Well Inventory ☐ Yes ☐ No Date: ______________

PART III (To be completed by Regulatory Compliance Staff)

Actual Construction Start Date: ________ Actual Completion Date: _________

Well Completion Report filed: Driller ☐ Jacobs ☐ Date: ____________

Records in files: ☐ Yes ☐ No

Update Monitor Well Inventory: Date_____________

1. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

2. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

3. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

4. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

5. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

6. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

7. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

8. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

9. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

10. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

11. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

12. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

13. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

14. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

15. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

16. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

17. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

18. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

19. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

20. N/S_____ FT. & E/W_____ FT. FRM ___COR. or ___1/4 of SEC.___ T ___ N/S
R___E/W SLBM/USM. DEPTH _______FT. DIAMETER _________IN.

FIGURE 16.1.1-8

JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL

SECTION 16.1.2
DATE 5/27/87
EFFECTIVE 08/18/88
SUPERSEDES 8.2.8 6/6/86
PAGE 1 OF 3

WELL DEVELOPMENT

1.0 PURPOSE

To define the procedures to be followed while developing a well in order to obtain water samples for future water-quality testing.

2.0 SCOPE

The following procedures shall be implemented after the installation of an observation monitoring well.

As attachments to this section are the applicable TAC forms:

Figure 1, Borehole/Well Construction Log JEG-AL-ENG-1 (3/84).

All field measurements and comments shall be recorded on the appropriate TAC forms as per TAC data reporting formats and protocols. All lines on the forms shall be completed. The letter designation "NA" for not applicable or "NK" for not known shall be used in all blank spaces. If some steps or procedures were not performed as described, the reason must be stated as is practicable on the appropriate form or submitted as an attachment thereto.

3.0 PROCEDURES

3.1 The development shall be performed as soon as practical after well installation, but no sooner than 48 hours after grouting is completed.

3.2 Development shall be accomplished by airlift pumping and/or bottom discharge bailer until the well water is clear and sediment within the well is removed to the fullest extent practical.

a) For those wells where the boring was made without the use of drilling fluid (mud, and/or water), remove approximately five (5) times the standing water volume in the well (well screen and casing plus saturated annulus). Should recharge be so slow that five volumes could not be removed in one day, or the water remain discolored or contain greater than one percent particulates after this five-volume removal, the TAC Office shall direct an alternate procedure based on the subjective judgment of the lead geotechnical engineer or hydrologist.

b) For those wells where the boring was made or enlarged with the use of drilling fluid (mud, and/or water), remove approximately five times the measured amount of total fluids lost while drilling plus five times the standing water volume as above (in paragraph a.). The same procedure also applies here as above for cases of slow recharge, discolored, or particulate-laden water.

3.3 No dispersing agents, acids, or disinfectants shall be used to enhance development of the well.

3.4 No water shall be added to the well to assist development without prior TAC/TR approval. If a well cannot be cleaned of mud using airlift to produce formation water because the aquifer yields insufficient water (e.g., one gallon per minute or less), small amounts of potable water may be injected to clean up this poorly yielding well. This may be done by dumping in buckets of water or by pumping it through the air line intermittently. When most of the bentonite is out, continue development with formation water only. It is essential that at least five times the amount of water injected must be produced back from the well in order to assure that all injected water is removed from the formation. When most of the bentonite is out, continue development with formation water only, as described in Section 3.2.b.

3.5 During development, the effort shall be made to remove the standing water from points near the bottom of the well screen as well as from the top of the water column. Moreover, the airlift outlet should be placed at several depths along the screened interval to ensure complete development through the sand pack. Since casing consists primarily of PVC material, the control of air-blast within the screen section is essential to avoid rupturing the screen.

To evaluate initial water quality, the FTR shall conduct pH and specific conductivity tests during development. The detection of abnormal readings should be relayed to the TAC/TR prior to completion of development.

3.6 If problems are encountered during development, the TAC project team shall be notified by telephone within one working day after problem detection.

3.7 The following data shall be recorded on the Borehole/Well Construction Log or an attachment thereof as part of development.

a) Well designation (location ID).

b) Date(s) of well installation.

c) Date(s) and time of well development.

d) Static water level before and after development.

e) Quantity of water removed and time of removal.

f) Depth of open hole inside well before and after development.

g) Physical character of removed water, to include changes during development in clarity, color, particulates, and odor.

h) Physical character of removed sediments, to include lithology and grain size.

i) Type and size/capacity of pump and/or bailer used.

j) Description of surge techniques, if used.

Prepared By: Gerald Lindsay

Reviewed By: ______________________
Task Manager

Reviewed By: ______________________
Quality Assurance Manager

Approved By: ______________________
Project Manager

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: ____________ LOCATION ID: ____________ FIELD REP: ____________

APPROX. SITE COORDINATES (FT.): N ____________ E ____________

GROUND ELEVATION (FT. MSL): ____________ COMPLETION DATE: ____________

BOREHOLE SUMMARY

DRILLER: ____________

RIG TYPE: ____________

BIT TYPE	HOLE DIA. (in.)	END DEPTH ● (ft.)	FLUID TYPE

CASING SUMMARY

CASING TYPE *	DESCRIPTION	DIA. (in.)	END ✚ DEPTH (ft.)

* P-Protective S-Screen B-Blank O-Open N-None

✚ Depth from Top of Casing

CONSTRUCTION TIME LOG

ACTIVITY	START		END TIME
	DATE	TIME	
DRILLING			
CASING			
FILTER PACK			
SEAL			
BACKFILL			
DEVELOPMENT			
OTHER			

WELL CONSTRUCTION

TYPE CODE*	DESCRIPTION	END ● DEPTH (ft.)

* B - Backfill S - Seal F - Filter Pack

● Depth from Ground Surface

WELL DEVELOPMENT

COMMENTS: ____________

JEG-AL-ENG-1 (6/87)

FIGURE 1

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL	SECTION 16.1.3
	DATE 5/27/87
SLUG TESTING	EFFECTIVE 08/18/88
	SUPERSEDES 8.2.10 1/30/86
	PAGE 1 OF 2

1.0 PURPOSE

To define the methodology to be followed in conducting slug tests of hydrogeologic units. A slug test is used to determine saturated hydraulic conductivity with rapid withdrawal or injection of a solid slug or slug of water from a well.

2.0 SCOPE

The following format will be used for the conducting, reporting, and analysis of all slug tests, whether conducted by JEG representatives or subcontractors.

3.0 PROCEDURE

3.1 All data generated in performing slug tests will be entered on a JEG Slug Test Data form JEG-AL-ENG-8 (3/84).

3.2 All spaces on the form shall be completed excepting: "open interval," "total depth of well," "well diameter," "residual ddn," "1/tm," and "H-h/H-Ho." The first 3 quantities are a part of the historic data base and may be completed prior to going to the field if it is desired to analyze the slug test in the field. The last three quantities may be computed from the slug test data.

3.3 The depth to static water shall be measured and recorded prior to emplacement of the slug or bailer. The datum shall be the top of the well casing or, for uncased holes, the ground surface.

3.4 Either slug-withdrawal or slug-injection tests will be performed. The type of test performed will be noted on the Slug Test Data Form.

3.5 Prior to the start of the test, the slug or bailer shall be placed in the well or borehole so that the top of the slug or bailer is below the level of the static water level.

3.6 After the slug has been emplaced, the test observers shall allow the water level to equilibrate as nearly as possible to the static water level. When in the judgment of the test observers the water level has been allowed to equilibrate as near as is practicable to the static water level, the water level will be recorded (to ± .01 foot) on the form as the initial water level using the datum as the top of casing or, for uncased holes, the ground surface. The initial water level will also be recorded as the first entry in groundwater depth measurements.

3.7 The test will start upon removal or addition of the slug from the water, and that moment will be designated as "t_0". The elapsed time will be measured from that moment using a stop watch or other accurate and precise timing device.

3.8 Periodically, after the removal of the slug, the depth to water will be measured and recorded on the form. The datum will be the top of casing, or, for uncased holes, the ground surface. The depth will be recorded in feet to an accuracy of ± .01 foot. The corresponding elapsed time will be recorded as elapsed time in minutes and seconds. The initial frequency of measurement shall be approximately every 30 seconds. After about 5 minutes, the frequency of measurement shall be approximately every minute. Measurement frequency will depend upon the rate of recharge in each individual well. After about 20 minutes, the observers shall make further measurements at their convenience. The test shall be conducted for at least 20 minutes or until the water level recovers to within 0.10 foot of the initial water level. If pressure transducers are used as the primary water-level measurement device, the values should be checked and calibrated with a sounder or tape, approximately every 20 minutes.

3.9 Tests shall be conducted on relatively undisturbed wells. If a test is conducted on a well that has recently been pumped for water sampling purposes, the measured water level must be within 0.10 foot of the water level prior to sampling. At least one week should elapse between the drilling of a well and the performance of a slug test.

3.10 Upon completion of the slug test, the completed form shall be checked by the Site Hydrologist. Upon acceptance as being complete and accurate, the data shall be stored in the technical data base as described in Section 8.3.1.

Prepared By: ____________________
TAC Hydrologist

Reviewed By: ____________________
Task Manager

Reviewed By: ____________________
Quality Assurance Manager

Approved By: ____________________
Project Manager

JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL	SECTION 16.1.4
	DATE 11-2-89
PACKER (PERMEABILITY) TESTING	EFFECTIVE 12-08-89
	SUPERSEDES 05/27/87
	PAGE 1 OF 5

1.0 PURPOSE

1.1 To provide procedures, equipment requirements, and test methods for conducting packer tests and analyzing data.

2.0 SCOPE

2.1 This procedure is applicable to members of TAC and its contractors and its subcontractors who have responsibilities and duties for the installation of well(s), well development, packer testing, data analyses, and collection of water samples for water quality determinations.

3.0 EQUIPMENT

3.1 Packer unit(s)

3.2 Extra glands

3.3 Strapping Tool

3.4 Electric Tape: several rolls to seal "A" rod joints

3.5 Top of "A" rod connector with pressure gauge

3.6 Three (3) sections of water hose

3.7 In-line straight pipe sections near flowmeter

3.8 Two (2) flowmeters: 1-50 gpm, 50-350 gpm

3.9 By-pass "T"

3.10 Stopwatch

3.11 Air line

3.12 CO_2 tank

3.13 CO_2 regulator

3.14 Air line couplings

3.15 Thermometer

3.16 Water supply tank

3.17 Pump

3.18 Packer (Permeability) Test Forms

4.0 PROCEDURE

4.1 Record all information and data from a test on a Packer (Permeability) Test Form (Figure 4.1) pursuant to TAC data reporting formats and protocols.

4.2 Perform pre-test preparation. Before introducing the test equipment into the borehole, flush the boring extensively with clean potable water to rid hole of all drilling fluids and cuttings. This is best accomplished at the end of last core run, while the tool string is still in the boring. If possible, avoid the use of revert or bentonite while drilling the hole. If drilling mud must be used, use revert and do not packer test the boring for 72 hours after drilling.

4.3 Set up the equipment in accordance with Figure 4.2. Introduce the packer unit, "A" rod string, and air line into the borehole. All connections should be kept as short and straight as possible with a minimum number of changes in the diameter of hose, pipe, etc. Measure the height of the water pressure gauge above ground level, the depth to the top of the test interval, and the length of the test interval. Record the data to the nearest 0.1 foot or 0.01 foot on the test form. NOTE: DO NOT USE INCHES.

The length of the test section is governed by the character of the rock, but should be between 10 and 20 feet in length. Except under the most adverse conditions, the use of test sections greater than 20 feet in length is not recommended. Longer test sections may not permit sufficient localization of permeable zones and may complicate calculations.

The test should be performed using centrifugal pumps having sufficient capacity to develop back pressure. Multiple cylinder pumps should be avoided due to the fluctuating pressures which create difficulty in making accurate readings because the high and low readings must be averaged to determine the approximate true effective pressure. A pump with a capacity of up to 250 gpm against a total head of 160 feet is adequate for most tests.

4.4 Before inflating the packer, circulate clean potable water through the system using low flow and, if possible, establish a head at the top of the hole. This helps to check the packer seal. During this procedure check the flowmeter performance to assure reliability. Have two flowmeters available to cover a range of flow from less than [illegible] gpm to 400 gpm.

4.5 Stop the water flow and inflate the packer unit(s). The pressure is a function of the depth to the test interval and rock conditions. Experience has shown that 35 to 45 psi is usually sufficient. Higher pressure can be used; however, problems with leakage may be more pronounced. During this procedure check for possible leaks (i.e., air bubbles in borehole head, leakage at tank, etc.).

4.6 Commence water flow to the test interval using only clean potable water. Regulate the water pressure using the by-pass valve (Figure 4.2). Avoid exceeding a maximum water pressure of 25 psi. Record the water temperature on the packer test form. In tests above the water table, pump water at the desired pressure into the test section for about 10 minutes in coarse materials or 20 minutes in fine-grained materials before making measurements. Check for poor packer seal by checking whether water is rising in the borehole.

4.7 Commence the actual test holding the water pressure as constant as possible. Record the water flow rate and water pressure, the air pressure of the packer, and the elapsed time, e.g., 0.0 minutes, 0.5 minutes, 1.0 minutes, 1.5 minutes, etc. Record every 30 seconds for at least 10 minutes. Test should be run until stabilization occurs; that is, until three or more readings of flow rate and pressure are essentially equal. The test can be cut short if flows are too high to establish pressure. However, a constant inflow value should be established. If there is no flow, check all the joints, connections, and hoses to make sure they are tight so no water loss occurs and check the lines for blockage.

4.8 When test is complete depressurize the packer and allow a minimum of seven (7) minutes for packer deflation before withdrawing equipment from borehole.

4.9 Attachments

4.9.1 Figure 4.1 Packer (Permeability) Test Form

4.9.2 Figure 4.2 Schematic Diagram of Packer System Set-Up

5.0 TEST METHODS

5.1 The two methods presented are described in detail in the U.S. Bureau of Reclamation (USBR) Ground Water Manual (1977). All figures and examples are from this reference. A schematic drawing of the two methods is shown in Figure 5.1.

The Ground Water Manual (1977) and the USBR Earth Manual (1974) provide additional packer (permeability) test methods for various conditions in individual drill holes in unsaturated and saturated material. These two references are readily available and provide access to other sources of literature on packer test methods which can be used to analyze test data. Values for head loss in pipes due to friction are available from Driscoll (1986). Also, other standard references are available on head loss in pipes and may be used in the computation of permeability.

5.2 Method 1: Involves the use of a single packer in consolidated rock. The hole may be cased down to the test interval or uncased depending on material stability. The hole is drilled to a given distance, the tools removed, and a packer is seated at a prescribed distance above the bottom of the hole. Water is pumped into the test section under pressure and readings are recorded. For additional tests deeper in the boring, the equipment is removed and the hole is drilled deeper. The packer is inserted again to isolate the newly drilled hole, and the test is repeated.

5.3 Method 2: Involves the use of two packers in consolidated rock. The material must be stable and not require casing above the test interval. The hole is drilled to the final depth and cleaned prior to testing. Two packers are spaced to isolate a desired test interval starting at the bottom of the hole and, after the test, lifted a prescribed distance to test the next section. This procedure is repeated until the entire hole is tested.

5.4 Examples: The equations presented in Figure 5.1 are based on the percent of unsaturated material. Three examples are provided addressing the three different zones of saturation. Figure 5.2 is to be used in delineating between Zone 1 and Zone 2. Figures 5.3 and 5.4 are to be used to determine the respective conductivity coefficients (Cu and Cs) for the equations provided in Figure 5.1.

5.5 Attachments

5.5.1 Figure 5.1 Permeability test for use in saturated or unsaturated consolidated rock.

5.5.2 Figure 5.2 Location of Zone 1 lower boundary, for use in unsaturated materials.

5.5.3 Figure 5.3 Conductivity coefficients for permeability determination in unsaturated materials with partially penetrating cylindrical test wells.

5.5.4 Figure 5.4 Conductivity coefficients for semispherical flow in saturated materials through partially penetrating cylindrical test wells.

5.5.5 Examples 1, 2, and 3.

6.0 REFERENCES

Driscoll, F. G., 1986. Groundwater and Wells, second edition, Johnson Division, St. Paul, Minnesota, 1088 pp.

U.S. Bureau of Reclamation, 1974. Earth Manual, second edition, U.S. Government Printing Office, Washington, D.C., 810 pp.

U.S. Bureau of Reclamation, 1977. Ground Water Manual, first edition, U.S. Government Printing Office, Washington, D.C., 480 pp.

Prepared By: KH-

Reviewed By: Kent Bostick
Task Manager

Reviewed By: Bob
Quality Assurance Manager

Approved By: Steven R.
Project Manager

FIGURE 4.1

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

PACKER (PERMEABILITY) TEST FORM

Page____ of _____

SITE ID_______________ LOCATION ID___________ LOG DATE__________

LOGGING COMPANY____________________ FIELD REP.____________________

BOREHOLE RADIUS (FT)_______________ ___ PACKER TYPE: SINGLE/DOUBLE TEST

TOP PACKER LENGTH (FT)___________ BOTTOM PACKER LENGTH (FT)___________

BOREHOLE DEPTH (FT BELOW DATUM)____________________

BOTTOM PACKER DEPTH/BOTTOM OF HOLE (FT BELOW DATUM)____________________

TEST INTERVAL LENGTH (FT)____________________

HEIGHT OF PRESSURE GAUGE ABOVE DATUM (FT)____________________

DIAMETER (IN)___________ LENGTH (FT)_______________ OF INTAKE PIPE

STATIC GROUNDWATER DEPTH BELOW DATUM (FT)____________________

NOTE: DATUM = GROUND SURFACE

EQUIPMENT DESCRIPTION____

ELAPSED TIME (MINUTES)	VOLUME (GALS)	WATER PRESSURE (PSI)	PACKER PRESSURE (S) (PSI)

COMMENTS: ____

DAVEPPTF.DRW

JEG-AL-ENG-62 (10/89)

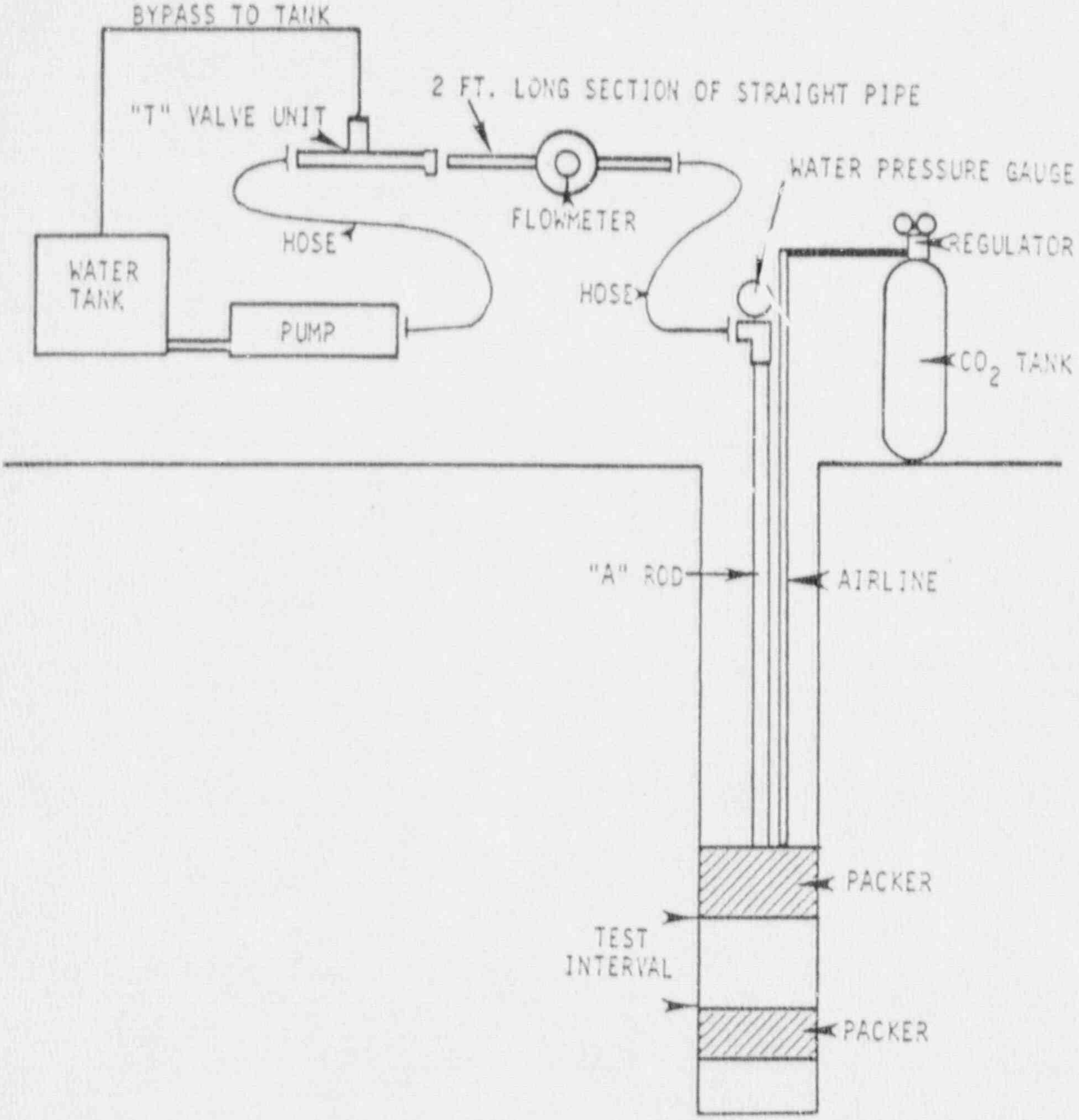
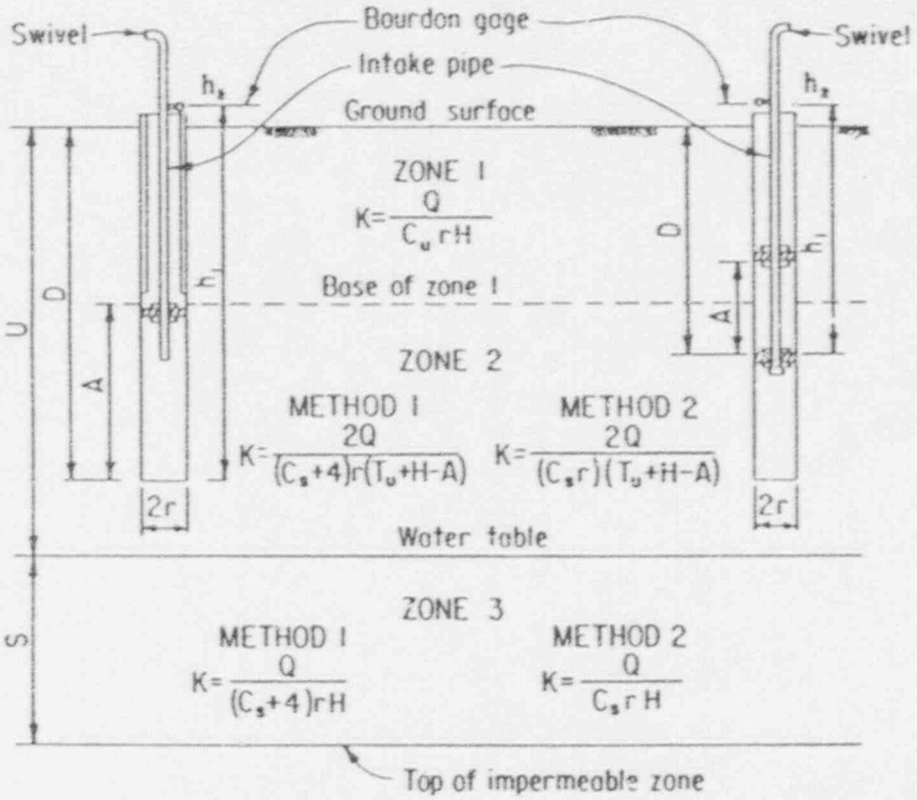


FIGURE 4.2
SCHEMATIC DIAGRAM OF PACKER SYSTEM SETUP



K = coefficient of permeability, feet per second under a unit gradient

Q = steady flow into well, ft³/s

$H = h_1 + h_2 - L$ = effective head, ft

h_1 (above water table) = distance between Bourdon gage and bottom of hole for method 1 or distance between gage and upper surface of lower packer for method 2, ft

h_1 (below water table) = distance between gage and water table, ft

h_2 = applied pressure at gage, 1 lb/in² = 2.307 ft of water

L = head loss in pipe due to friction, ft; ignore head loss for $Q<4$ gal/min in 1¼-inch pipe; use length of pipe between gage and top of test section for computations

$X = \frac{H}{T_u}(100)$ = percent of unsaturated stratum

A = length of test section, ft

r = radius of test hole, ft

C_u = conductivity coefficient for unsaturated materials with partially penetrating cylindrical test wells

C_s = conductivity coefficient for semi-spherical flow in saturated materials through partially penetrating cylindrical test wells

U = thickness of unsaturated material, ft

S = thickness of saturated material, ft

$T_u = U - D + H$ = distance from water surface in well to water table, ft

D = distance from ground surface to bottom of test section, ft

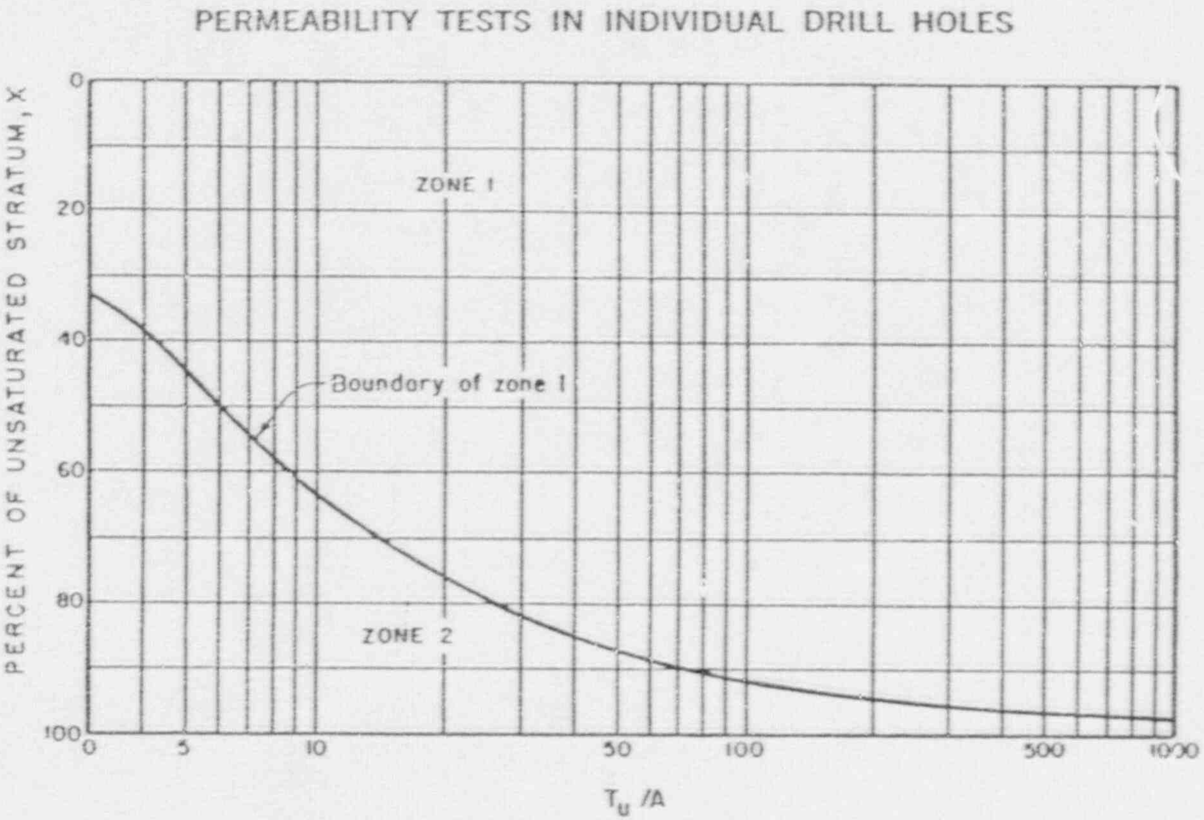
a = surface area of test section, ft²; area of wall plus area of bottom for method 1; area of wall for method 2

Limitations:

$Q/a \leq 0.10$, $S \geq 5A$, $A \geq 10r$, thickness of each packer must be $\geq 10r$ in method 2

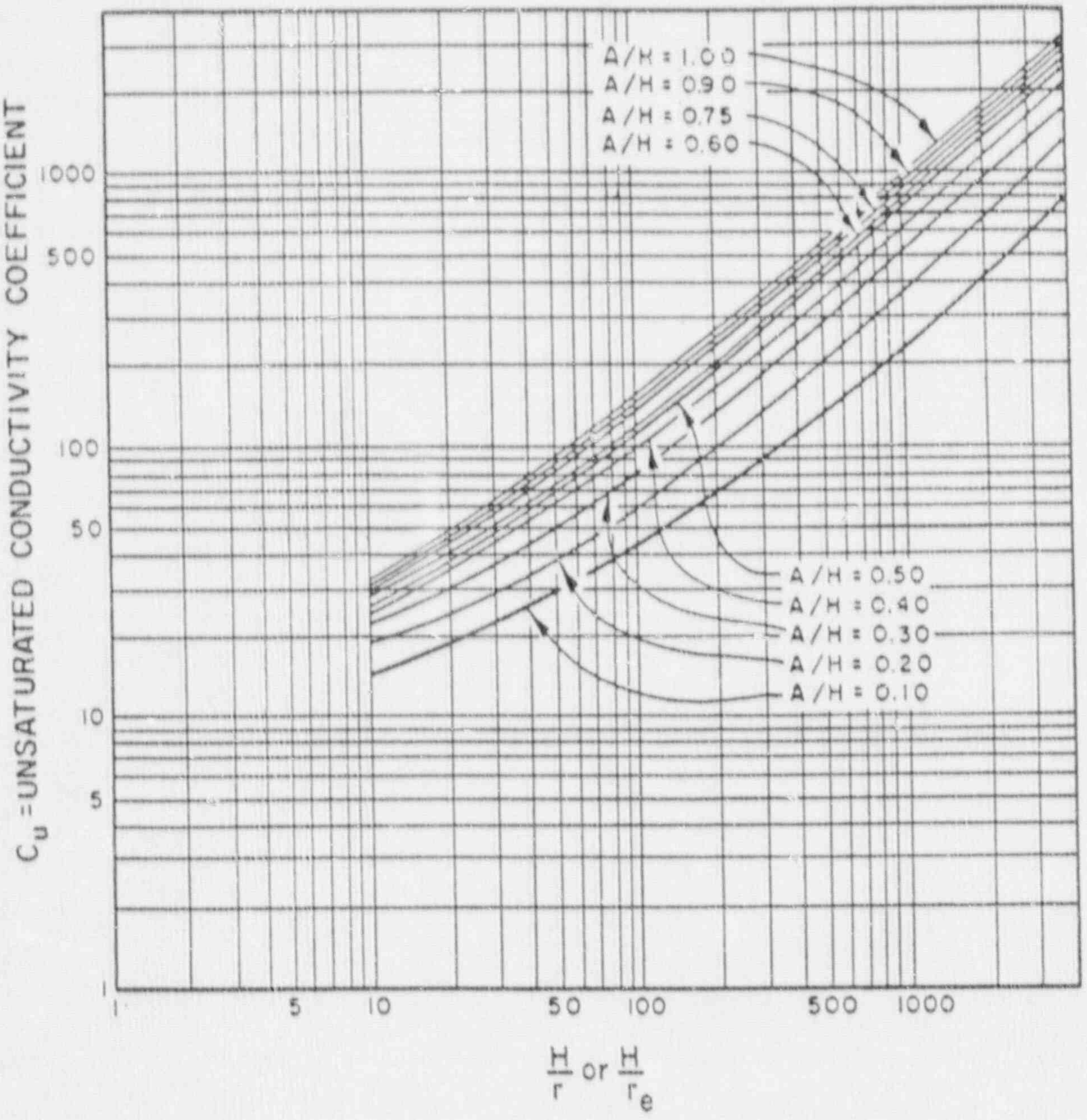
REF: U.S. BUREAU OF RECLAMATION (1977)

FIGURE 5.1
PERMEABILITY TEST FOR USE IN SATURATED OR UNSATURATED CONSOLIDATED ROCK



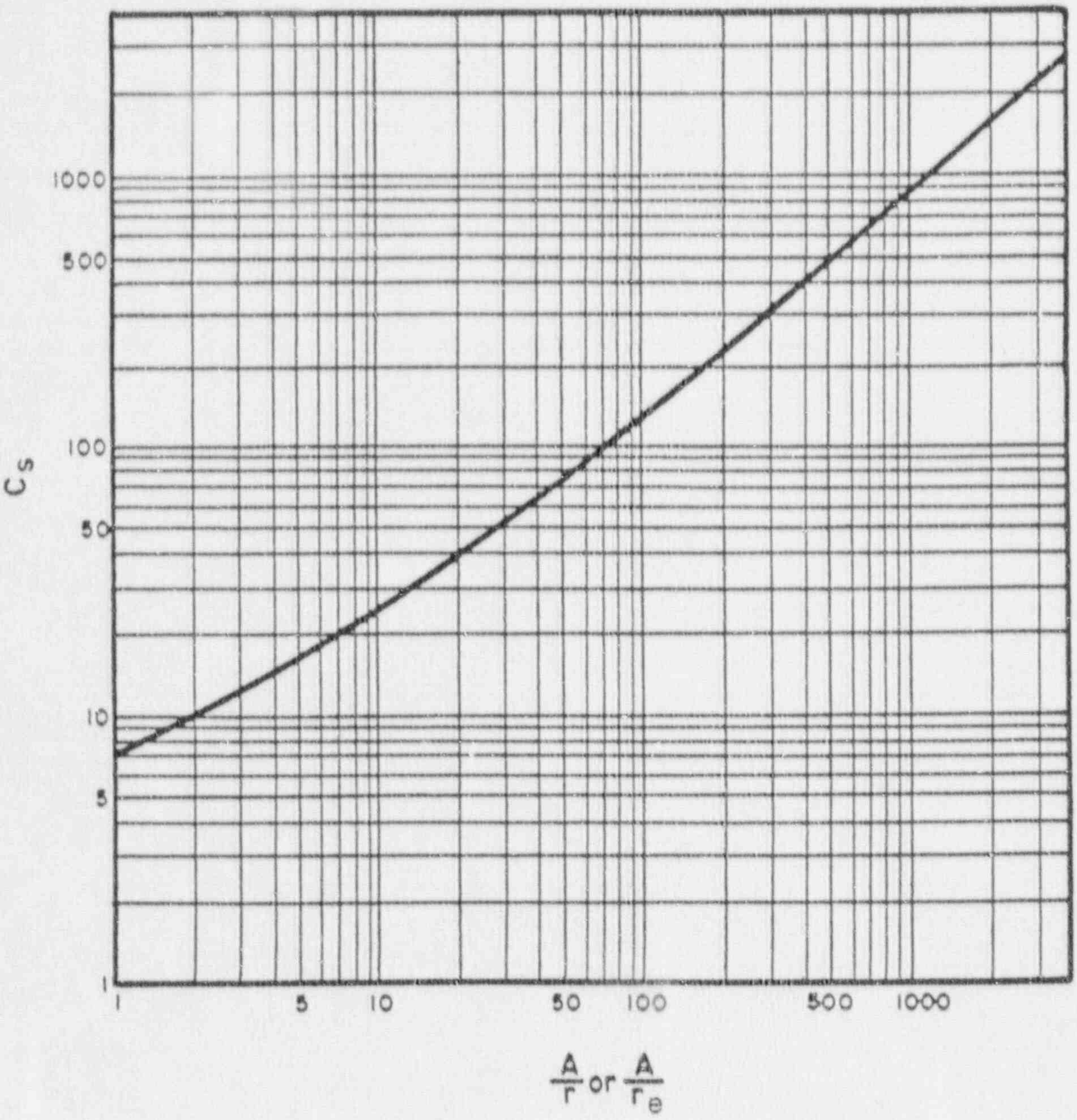
REF: U.S. BUREAU OF RECLAMATION (1977)

FIGURE 5.2
LOCATION OF ZONE 1 LOWER BOUNDARY, FOR
USE IN UNSATURATED MATERIALS



REF: U.S. BUREAU OF RECLAMATION (1977)

FIGURE 5.3
CONDUCTIVITY COEFFICIENTS FOR PERMEABILITY DETERMINATION
IN UNSATURATED MATERIALS WITH PARTIALLY
PENETRATING CYLINDRICAL TEST WELLS



REF: U.S. BUREAU OF RECLAMATION (1977)

FIGURE 5.4
CONDUCTIVITY COEFFICIENTS FOR SEMISPHERICAL FLOW IN SATURATED MATERIALS THROUGH PARTIALLY PENETRATING CYLINDRICAL TEST WELLS

Example 1:

Zone 1—*Method* 1

Given: $U=75$ ft, $D=25$ ft, $A=10$ ft, $r=0.5$ ft,
$h_1=32$ ft, $h_2=25$ lb/in^2$=57.8$ ft, and
$Q=20$ gal/min$=0.045$ ft^3/s.

Head loss L for a 1¼-inch pipe at 20 gal/min is 0.76 foot per 10-foot section. If the distance from the Bourdon gage to the bottom of the pipe is 22 ft, the total L is $(2.2)(0.76)=1.7$ ft.

$H=h_1+h_2-L=32+57.8-1.7=88.1$ ft of effective head.
$T_u=U-D+H=75-25+88.1=138.1$ ft

$$X=\frac{H}{T_u}(100)=\frac{88.1}{138.1}(100)=63.8 \text{ percent}$$

$$\frac{T_u}{A}=\frac{138.1}{10}=13.8$$

The values for X and $\frac{T_u}{A}$ lie in zone 1 (fig. 5.2). To determine the conductivity coefficient C_u from figure 5.3 :

$$\frac{H}{r}=\frac{88.1}{0.5}=176.2$$

$$\frac{A}{H}=\frac{10}{88.1}=0.11 \text{ and } C_u=62$$

Then,

$$K=\frac{Q}{C_u rH}=\frac{0.045}{(62)(0.5)(88.1)}=0.000016 \text{ ft/s}$$

REF: U.S. BUREAU OF RECLAMATION (1977)

FIGURE 5.5
PRESSURE PERMEABILITY TESTS EXAMPLES OF
METHODS 1 AND 2

Example 2:

Zone 2

Given: U, A, r, h_2, Q, and L are as given in example 1.
$D=65$ ft, and $h_1=72$ ft.

If the distance from the Bourdon gage to the bottom of the intake pipe is 62 ft, the total L is $(6.2)(0.76)=4.7$ ft.

$H=72+57.8-4.7=125.1$ ft
$T_u=75-65+125.1=135.1$ ft

$$X=\frac{125.1}{135.1}(100)=92.6 \text{ percent and } \frac{T_u}{A}=\frac{135.1}{10}=13.5$$

The test section is in zone 2 (fig. 5.2). To determine the conductivity coefficient C_s from figure 5.4 :

$$\frac{A}{r}=\frac{10}{0.5}=20 \text{ and } C_s=39.5$$

Method 1

$$K=\frac{2Q}{(C_s+4)r(T_u+H-A)}=\frac{(2)(0.045)}{(39.5+4)(0.5)(135.1+125.1-10)}$$

$$=0.000016 \text{ ft/s}$$

Method 2

$$K=\frac{2Q}{(C_sr)(T_u+H-A)}=\frac{(2)(0.045)}{(39.5)(0.5)(135.1+125.1-10)}=0.000018 \text{ ft/s}$$

Example 3:

Zone 3

Given: U, A, r, h_2, Q, and L are as given in example 1.
$D=100$ ft, $h_1=82$ ft, and $S=60$ ft.

If the distance from the Bourdon gage to the bottom of the intake pipe is 97 ft, the total L is $(9.7)(0.76)=7.4$ ft.

$H=82+57.8-7.4=132.4$ ft

$$\frac{A}{r}=\frac{10}{0.5}=20 \text{ and } C_s=39.5 \text{ from figure 5.4}$$

Method 1

$$K=\frac{Q}{(C_s+4)rH}=\frac{0.045}{(39.5+4)\ (0.5)\ (132.4)}=0.000016 \text{ ft/s}$$

Method 2

$$K=\frac{Q}{C_srH}=\frac{0.045}{(39.5)\ (0.5)\ (132.4)}=0.000017 \text{ ft/s}$$

REF: U.S. BUREAU OF RECLAMATION (1977)

FIGURE 5.5
PRESSURE PERMEABILITY TESTS EXAMPLES
OF METHODS 1 AND 2 (CONCLUDED)

ALBUQUERQUE OPERATIONS MANUAL	SECTION 16.1.5
	DATE 5/27/87
	EFFECTIVE 08/18/88
AQUIFER PUMP TESTING	SUPERSEDES 8.2.12 4/8/85
	PAGE 1 OF 3

1.0 PURPOSE

To define the procedures to be followed by TAC hydrologists in conducting pumping tests of aquifers for characterization of hydrogeologic units on the UMTRA Project.

2.0 SCOPE

The pumping test will be performed to estimate the hydrologic characteristics of the hydrogeologic interval. The equipment used in the test will depend on the rate of flow of fluid encountered and drill hole stability conditions. Because of the great variety of hydrogeologic conditions that are likely to be encountered during drilling and testing, several different test tool arrangements are planned in order to be able to perform the pumping test.

3.0 PROCEDURE

3.1 The test methods used will follow the guidelines for well testing in Technical Memorandum No. 1 (April 9, 1985) which is provided as Attachment #2. The data obtained during the test, regardless of method or equipment, shall include:

a) Static water level.
b) Water discharge rate.
c) Pressure versus time data for each gauge.
d) Water temperature and specific conductivity.
e) Depth of water intake.
f) Whether or not a flowmeter/trace ejector survey was performed.

3.2 An aquifer test data form (Attachment 1) shall be completed for each test in order to document the test results. This form shall be the lead page of the data records of the test. The complete, original test data records shall be sent to the Albuquerque Office, to the attention of the site hydrologist, after each test, and filed in the Project Document Control Center files. Additionally, a copy of these records shall be retained by the field representative in charge of the test.

3.3 A diagram of the equipment actually used in each pumping test shall be prepared by the TAC site hydrologist or received from the subcontractor responsible for the testing. The diagram will show the tubing dimensions, the depth of water intake, and the location of gauges and packers. This diagram shall become part of the data records of each test.

3.4 All gauges and flowmeters used in the pumping test procedures shall be calibrated before arrival on site. Copies of the documentation of instrument calibration shall be obtained from the instrument or testing service company by the TAC site hydrologist. The calibration records shall consist of laboratory measurements and, if performed, any on-site zero adjustment and/or calibration.

3.5 Water pumped from the well during the pumping test shall be disposed of in such a manner so that no adverse impacts are created on surface water quality or on the quality of the drawdown data from observation wells.

3.6 In cases where a weir or an orifice are used to measure flow volumes or rates, these devices will be checked on-site, using a bucket of known volume and stopwatch, and their accuracy will be documented before testing proceeds.

3.7 All equipment shall be installed, and it shall be demonstrated to the technical representative that the system is in proper working order and performing to specifications at least 24 hours before the proposed start of the pumping test.

3.8 For air-lift pumping tests, water samples will be collected by wireline sampler which shall be put down the hole after the pumping has stopped. The actual depth of the interval which is producing the fluid and the depth at which the sample was collected shall be recorded.

3.9 For pumping tests which employ mechanical pumps, samples will be collected above ground level from the discharge line.

3.10 After collection, the water sample will be treated in accordance with Water Sampling/Preserving/Shipping and Testing Standard Operating Procedure 16.2.1, and will be analyzed by a geochemical laboratory in accordance with Standard Operating Procedure 16.2.3.

4.0 REFERENCES

Thackston, J., 1985, Technical Memorandum No. 1, "Bore Hole Hydraulic Testing for Aquifer Characterization."

Prepared By: John R. Dempsey

Reviewed By: ______________________
Task Manager

Reviewed By: ______________________
Quality Assurance Manager

Approved By: ______________________
Project Manager

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TECHNICAL MEMORANDUM NO. 1
BORE HOLE HYDRAULIC TESTING FOR AQUIFER CHARACTERIZATION

1.0 INTRODUCTION

This technical memorandum provides guidelines and procedures for determining the hydraulic parameters of aquifers using slug tests and pumping tests. The hydraulic conductivity (K) of an aquifer is a measure of the aquifer's ability to conduct water. The greater the value of hydraulic conductivity, the more readily the aquifer conducts water. Figure 1 illustrates the typical range of hydraulic conductivity values associated with a variety of earth materials. The transmissivity (T) of an aquifer is defined as the ability of the aquifer to transmit water through its entire thickness and is equal to the hydraulic conductivity (K) times the saturated thickness of the aquifer (b); this can be stated as $T = Kb$, for cases in which K is constant with depth. Otherwise, transmissivity is equal to the integration of hydraulic conductivity over depth, which can be stated as $T = K(Z)dz$.

The specific yield of an aquifer is the ratio of the volume of water drained by gravity from a unit volume of aquifer material. The storage coefficient of an aquifer is the volume of water in storage released from a column of aquifer with unit cross section under a unit decline of head.

1.1 SLUG TEST

1.1.1 PURPOSE

The purpose of this section is to outline procedures for the conduction and evaluation of slug tests, which are a quick and inexpensive method of estimating the hydraulic conductivity or transmissivity of many aquifer systems.

A slug test will generally work in aquifers where the hydraulic conductivity is less than or equal to 10^{-2} cm/sec. In aquifers of greater hydraulic conductivity the water level may return to static level before a sufficient number of water level readings can be made. In aquifers of low hydraulic conductivities (10^{-4} to 10^{-7} cm/sec), slug tests are generally a reliable field method of determining hydraulic conductivity or transmissivity near the screened zone of the well.

The advantages of using slug tests to estimate hydraulic conductivities are:

- Estimates can be made in situ and errors incurred in laboratory testing of disturbed samples are avoided.

- Tests can be performed quickly at relatively low cost, because a pumping well and observation wells are not required.

- The hydraulic conductivity of small discrete portions of an aquifer can be made, such as sand layers in a clay.

There are disadvantages in using slug tests which must be evaluated before the test is conducted. These include:

- Only the hydraulic conductivity of the area immediately surrounding the well is estimated. These results may not be representative of the average hydraulic conductivity of the area.

- Often only a range of hydraulic conductivity values rather than an average value can be deduced from test results.

- Certain assumptions are made in the analysis process. If the assumptions made are inappropriate for the geologic conditions at the site, the results may be erroneous.

- The storage coefficient (S) usually cannot be determined.

- Data sufficient for analysis may not be collected if the hydraulic conductivity is relatively high.

This technical memorandum explains procedures and equipment commonly used in conducting most slug tests, and a list of analysis techniques used under different geologic conditions and for different bore hole or well systems. Also included are example calculations of typical slug tests (Appendices 1-1 and 1-2).

1.1.2 DESIGN, DRILLING AND CONSTRUCTION OF SLUG TEST WELL

Several factors enter into the design of a well for the performance of slug testing. These include depth and diameter of the test well, length of screened interval and size of screen openings. Some of these factors can be chosen as drilling proceeds or be predetermined from previous borings. Well design is generally determined from an evaluation of drill cuttings, corings, and geophysical logging.

The depth and screened interval of the hole are determined by the location of the zone of interest. The diameter of the hole and casing to be inserted in the hole should be large enough in order that the volume of the slug does not overflow the top of casing. This may be a problem when the water level in the bore hole is relatively close to the ground surface. The screened interval should consist of screen with a percentage of open intervals large enough so as not to excessively restrict water flowing from the bore hole to the subsurface materials tested. Wells with screened intervals which require a gravel pack should be packed with material of a grain size distribution that would result in approximately an order of magnitude of higher hydraulic conductivity than the subsurface materials being tested.

A variety of drilling techniques can be used in completing the test well. These may include mud-rotary, air-rotary, coring and auger techniques. The type of drilling method used depends on the behavior of the material being drilled and the specific objectives of the project. Drilling without drilling fluids is preferred because this prevents further contamination of the subsurface. Mud-rotary techniques are sometimes required in order to lubricate the bit and hold up the bore hole walls when relatively thick, coarse, unconsolidated materials are encountered. Augering is normally performed without the use of drilling fluids and used in the drilling of shallow holes with relatively cohesive materials.

The construction of the test well is relatively simple and involves the assembly of the appropriate diameter casing (usually PVC because of lower cost) for insertion into the bore hole. A pre-slotted screened section is prepared and attached to the casing string, normally with a cap on the bottom (to prevent material from entering the bottom of the screen), and the whole assembly is lowered into the hole. If a gravel pack is necessary as a filter due to the aquifer containing very fine unconsolidated sand, then it should be placed opposite the screened interval using a tremie pipe. The annulus is then grouted from the top of the gravel pack up to the ground surface in order to allow hydraulic connection only between the test well and the zone to be tested. The hole should be flushed or bailed before grouting if drilling fluid remains in the hole. If the ground water in the hole is highly contaminated, special safety precautions should be taken to control the discharge water before test well development.

1.1.3 EQUIPMENT

Equipment necessary to conduct a slug test includes:

- Well or bore hole
- Water level measuring device
- Known solid volume of particular shape (slug) that will easily fit into the well or bore hole or container to add or remove a known volume of water
- Watch with second hand
- Semi-log graph paper
- Indelible pen or pencil and paper

A number of water level measuring devices can be used for measuring the depth to water in a well. An excellent device for measuring the depth to water during a slug test is the pressure transducer. An example strip chart data record is shown in Appendix 1-2. Accurate readings may also be obtained with electric water level indicators or weighted tapes with ploppers. Water level measurement by the wetted-tape method should be avoided as it may be difficult to obtain a sufficient number of readings for analysis of the test if the water level recovers in a short amount of time.

1.1.4 PROCEDURE

Before beginning the slug test, the following information should be recorded:

- Site ID and well or bore hole location
- Location and elevation of reference point from which water depth measurements are made
- Elevation of ground water with respect to the reference point
- Date and time of test
- Well depth, screen length and depth, riser pipe radius, well screen radius, and radius of the gravel pack, plus the bore hole depth and radius
- Aquifer or ground water zone being tested
- Volume of water added or withdrawn or volume of solid cylinder (slug)
- Type of measuring device used
- Names of personnel conducting test

The following procedures will apply to most slug tests. The field procedures required for a particular slug test may be slightly different, however, and the procedures should be modified to that test as necessary.

- Determine the static water level in the well by measuring the depth to water periodically for several minutes and taking the average of the readings.
- "Instantaneously" introduce or remove a known volume of water to the well. Another method is to introduce a solid cylinder of known volume to displace and raise the water level, allow the water level to restabilize and remove the cylinder. It is important to remove or add the volumes as quickly as possible because the analysis assumes an "instantaneous" change in volume is created in the well.
- With the moment of volume addition or removal assigned time zero, measure and record the depth to water and the time at each reading. Depths should be measured to the nearest 0.01 foot. The number of depth-time measurements necessary to complete the test are variable. It is critical to make as many measurements as possible in the early part of the test.

- Continue measuring and recording depth-time measurements until the water level returns to equilibrium conditions or a sufficient number of readings have been made to clearly show a trend on a semi-log plot of time versus depth.

The time required for a slug test to be completed is a function of the volume of the "slug", the hydraulic conductivity of the formation and the type of well completion. The slug volume should be large enough that a sufficient number of water level measurements can be made before the water level returns to equilibrium conditions. The length of the test may range from less than a minute to several hours.

If the well is to be used as a monitoring well, precautions should be taken that the well is not contaminated by introduced material. If water is added to the monitoring well, it should be from an uncontaminated source and transported in a clean container. Bailers or measuring devices should be cleaned prior to the test. If tests are performed on more than one monitoring well, care must be taken to avoid cross contamination of the wells.

1.1.5 DATA ANALYSIS

The analysis of slug test data is based on the modification of well-known ground water flow equations (either the Theim equation, the Theis equation, or subsequent modification). Several authors have presented analytical solutions for the analysis of slug test data. Most solutions require a semi-logarithmic plot of the data collected: dimensionless head (logarithmic scale) or residual head (logarithmic scale) versus time (arithmetic scale).

Hvorslev (1951) was one of the first researchers to publish techniques of analysis of either constant or slug (falling head) tests in near-surface saturated soils. His analysis for slug tests involves a semi-logarithmic plot of the falling head (or water level) divided by the initial head against time. Basic algebraic equations are presented for different configurations of the soil relative to the test hole. In general, the permeability is proportional to a "shape factor" and inversely proportional to a "time lag". The "shape factor" is determined from the test well characteristics or dimensions. "Time lag" is determined from the semi-logarithmic plot.

Cooper et al (1967) and Papadopulos et al (1973) developed a set of type curves for analyzing slug test data, particularly for tests run in materials which are confined (under artesian pressure). The field data are plotted as dimensionless head (arithmetic scale) versus time (logarithmic scale) and matched to a set of type curves. The match point values are substituted into simple algebraic formulated to obtain a value for K (Appendix 1-1).

Bouwer and Rice (1976) and Bouwer (1978) developed a technique for analyzing slug test data collected from completely or partially penetrating wells in unconfined aquifers. Their analysis involves a plot of residual head (logarithmic scale) versus time (arithmetic scale). A straight line is applied to the early-time data and used to calculate a value for K. An example of the use of this technique is presented in Appendix 1-2. A plot of the data and calculations are included.

Pressurized slug test methods have been developed for testing extremely low conductivity materials (10^{-8} cm/sec or lower) (Bredehoeft and Papadopulos, 1980). Basically, the pressurized slug technique is a modification of the conventional slug test discussed previously. The advantage of the pressurized slug technique is the reduction of time required to perform a test in tight formations. This method involves creating an instantaneous surcharge on drawdown in the test zone, then closing a valve to shut in the well. Based on the rate of decay of the pressure slug and the geometry of the test zone, the transmissivity, hydraulic conductivity, and storativity may be calculated.

1.2 AQUIFER PUMPING TEST

1.2.1 PURPOSE

The purpose of this section is to briefly describe the use of aquifer pumping tests to evaluate aquifer characteristics. Aquifer pumping tests, commonly referred to as pump tests, are used to determine hydraulic characteristics and properties of water-bearing zones. Pumping tests provide results that are often more representative of the aquifer's characteristics than do slug tests.

Aquifer characteristics which may be obtained from pumping tests include hydraulic conductivity (K), transmissivity (T), and specific yield (S_y) for unconfined aquifers and storage coefficient (S) for confined aquifers.

Equipment, personnel and time commitments needed to conduct pumping tests are greater than those required for slug tests. Briefly, a pumping test consists of pumping one well and recording the drawdown in the pumping well and in other nearby observation wells.

There are advantages and disadvantages of pumping tests. Some of these are listed below.

Advantages of pumping test:

- o A greater portion of the aquifer is tested and the results obtained may be more reliable and representative of the aquifer characteristics.
- o Coefficient of storage and specific yield values can be determined.

Disadvantages of pumping test:

- o In low permeability aquifers long-term pumping may be required to complete the test and obtain reliable aquifer characteristics.
- o Disposal of discharged water may require special provisions if the ground water is contaminated.
- o Test may be very expensive when compared to slug tests.

There are several types of pumping tests. The most common type is the constant rate discharge test (Todd, 1980). Variable rate tests are also employed under some conditions. Although the analysis is more complicated, any sort of temporal variations in flow rate can be accounted for by assuming the law of superimpositions holds. Usually this is a good assumption. The most widely used variable rate tests are the step-drawdown test, the constant head test, and the air-lift pump test (Kruseman and DeRidder, 1976).

Another useful technique is injection testing. Injection tests, both constant rate and variable rate, are analytically identical to pumping tests except for considering the flow rate a surcharge on the aquifer rather than a withdrawal. The data quality is also similar. Although injection tests are commonly used in the petroleum industry (Earlougher, 1977), numerous applications exist in hazardous waste practice. Obviously, water sampling for hydrochemical characterization of the aquifer must be conducted prior to injection in application of this technique. The injection fluid should be free of suspended solids and should be of equal or higher quality than the ground water at the test site.

One major advantage of this type of test is that contaminated ground water is not removed from the formation and, thus, is not a disposal problem. A potential disadvantage of the injection test is that in certain cases the injection well would have to be able to withstand some induced hydraulic pressure. Cases where the injection rate is large enough to elevate the water level above the well casing would require a sealed well head configuration and proper well construction so that there would be no leakage of injected fluid on to the ground surface. These requirements may be relatively expensive and difficult to operate in the field without the necessary precautions. Once an injection system is working at a constant rate of flow, the data collected are analyzed in much the same way as those from an aquifer pumping test, except that the water level buildup is used in the analysis instead of drawdown.

1.2.2 PUMP WELL DESIGN

Design of the pump well is an important consideration in aquifer testing. In some cases an existing well will be used for pumping. When sufficient funds and conditions permit, a pumping well can be designed and constructed specifically for the test. The pumping well should be screened throughout the thickness of the aquifer to be tested with standard well screen. The well should be gravel packed, if necessary, to minimize sand production in unconsolidated fine-grained aquifers. Standard well construction techniques are discussed in Johnson (1986). The well should be correctly sealed from overlying and underlying units that are not to be directly pumped, and so that leakage down the well annulus cannot occur which may interfere with the interpretation of the test. The completed pumping well should be developed by the appropriate methods to remove drilling fluid from the well, and to wash and grade the grain sizes of the gravel pack and surrounding aquifer materials. Proper development of the well may prevent an unexpected variation in the pumping rate during the constant discharge test, which could lead to inconsistent drawdown data from the pumping well.

1.2.3 EQUIPMENT

The amount of equipment necessary to perform a constant-rate pumping test is greater than that used in a slug test. This is part of the reason why the aquifer pumping test is considerably more expensive. Equipment needed for a pumping test includes:

- o Pumping well and pump. Pumps are commonly of the submersible or turbine type. The pumping well should be properly developed prior to testing.
- o One or more observation wells hydraulically connected to the pumped aquifer and completed to the proper specifications for the particular test.
- o An orifice, weir, flow meter, container or other type of water measuring device to accurately measure and monitor the discharge from the pumping well.
- o Sufficient pipe to transport the discharge from the pumping well away from the area to prevent infiltration in the area of influence of the pumped zone.
- o Gate valve on the discharge pipe to control the pumping rate.
- o Outlet near well head for water quality determination and sampling.
- o Depth-to-water measuring devices for each observation well and the pumping well (these may include steel tapes, electric sounding probes, Stevens Recorders, or pressure transducers).
- o A thermometer and other water quality equipment necessary.
- o Watches capable of reading to the nearest second for all observers, or a stopwatch.
- o 3-cycle by 5-cycle log and 5-cycle semi-log graph paper.

- Indelible pens or pencils, and forms for recording times and drawdown measurements at each well.
- Appropriate references, and calculator for determinations in the field.
- A barometer or recording barograph (for tests conducted in confined aquifers).

1.2.4 OBSERVATION WELL SITING

The location and number of observation wells depends on several factors:

- Whether the aquifer tested is confined or unconfined
- The thickness of the aquifer
- The anistropy of the aquifer
- Location of the screened interval of the pumping well relative to the total aquifer thickness
- Location of aquifer boundaries, whether positive (lake or stream) or negative (impermeable boundaries)
- Practical and economic considerations

Any number of observation wells may be considered. Often, four wells are desirable, three on a line passing through the center of the pumped well and one on a line normal to that line and also passing through the pumping well. A number of guidelines for location of observation wells are presented in the Ground Water Manual (prepared by the U.S. Department of Interior), and Kruseman and DeRidder (1976).

As a general rule for tests performed in both confined and unconfined aquifers, the observation wells should be screened or completed in a substantial portion of the aquifer thickness in approximately the median depth of the test zone. In some cases, special tests require that observation wells be selectively completed in several depth zones in order to accurately determine aquifer characteristics such as anisotropy and vertical hydraulic conductivity.

The location of observation wells, relative to the pumping well, generally depends on four aquifer conditions:

- Most aquifers with fully penetrating pumping wells: observation wells should be located at a distance estimated by using the Theis formulation (Theis, 1935). Use of this formulation is described by Walton (1970). Assumed aquifer parameters are used to determine a location which will give the amount of drawdown required for proper analysis.
- Thin aquifers with fully penetrating pumping wells: for confined aquifers the nearest observation well should be located at least 25

feet from the pumping well. For unconfined aquifers, observation wells should generally be located 15 to 100 feet from the pumping well.

- Thick, isotropic aquifers with a partially penetrating pumping well: observation wells should be located one and one-half to two times the aquifer thickness from the pumping well.
- Thick, anisotropic aquifers with partially penetrating pumping well: observation wells should be located at a minimum distance from the pumping well equal to twice the thickness of the aquifer times the square root of the ratio of the horizontal to the vertical hydraulic conductivity.

1.2.5 PROCEDURES

The field procedures to conduct pumping tests are similar to field procedures to conduct slug tests. The basic procedure consists of monitoring the water level over time in the pumping well and each observation well as the pumping well is discharged at a constant rate.

The following data must be recorded accurately at the time the test is performed:

- Well identification number or location of pumping well and each observation well
- Location of each well
- Location and elevation of reference point from which water depth measurements are made, and elevation of ground with respect to the reference point
- Date and time of test
- Well depth, pump depth, screen length, well radius and radius of gravel pack plus well screen for each well

All gauges, transducers, flow meters,etc. used in conducting pumping tests shall be calibrated before use at the site. Copies of the documentation of instrumentation calibration should be obtained by the TAC hydrogeologist and later filed with the test data records. The calibration records will consist of laboratory measurements and, if performed, any on-site zero adjustment and/or calibration. In cases where a weir or an orifice is used to measure flow rates, the device will be checked on site using a container of measured volume and a stopwatch. Accuracy of the meters must be verified before testing proceeds.

If funds are available, it is normally advised to monitor pre-test water levels at the test site for about one week prior to performance of the test. This can be accomplished by using a continuous-recording device such as a Stevens Recorder. This information allows the determination of the barometric efficiency of the aquifer when barometric records are available. It also helps determine if the aquifer is experiencing an increase or decrease in head with time due to recharge or pumping in the nearby area, or diurnal effects of evaportranspiration. Changes in barometric pressure are recorded during the test (preferably with an on-site barograph) in order to correct water levels for any possible fluctuations which may occur due to changing atmospheric conditions. Pre-test water level trends are projected for the duration of the test. These trends and/or barometric changes are used to "correct" water levels during the test so that they are representative of the hydraulic response of the aquifer due to pumping of the test well.

During an aquifer test, water levels should be measured to give at least ten observations of drawdown within each log cycle of time. During the early part of the test, sufficient personnel should be available to have at least one person at each observation well and at the pumping well. After the first two hours, two people are usually sufficient to continue the test. It is not necessary that readings at the wells be taken simultaneously. It is very important that depth to water readings be measured accurately and readings recorded at the exact time measured. A typical aquifer pump test data form is shown as Attachment 1.

The duration of the test is determined by the needs of the project and the aquifer properties. One simple test for determining adequacy of data is when the log-time versus drawdown for the most distant observation well begins to plot as a straight line on the semi-log graph paper. There are several exceptions to this simple rule of thumb; therefore, it should be considered a minimum criteria. Different hydrogeologic conditions can produce straight line trends on long-time versus drawdown plots. In general, longer tests produce more definitive results. If budget permits, a duration of one to several days is desirable, followed by a similar period of monitoring the recovery of the water level. Unconfined aquifers and partially penetrating wells may have shorter test durations. A knowledge of the local hydrogeology, combined with a clear understanding of the overall objectives of the project, is necessary in interpreting just how long the test should be conducted. There is no need to continue the test if the water level becomes constant with time. This normally indicates that a hydrogeologic source has been intercepted and that additional useful information will not be collected by continuing the pumping portion of the test.

Measurement of recovering water levels after pumping is concluded is often done to verify results obtained from the pumping portion of the test. The recovering water levels in the pumping well and the observation wells are measured for a period immediately following cessation of pumping. Monitoring of the recovery period should, by rule of thumb, be at least one-half the length of the pumping portion of the aquifer test. This length of time usually allows the collection of useful data for additional analysis.

1.2.6 DATA ANALYSIS

Numerous techniques of analysis have been developed by researchers to evaluate water level data collected from constant discharge aquifer pumping tests. Many of the analyses use the graphical "curve matching" technique which involves the matching of theoretical "type" curves to plots of log-drawdown versus log-time from the observation wells. Other analyses rely on other graphical techniques such as application of a straight line to plots of drawdown versus log-time.

Theis (1935) developed a theoretical formulation which analyzed the lowering of the potentiometric level in an aquifer due to the constant withdrawal of water from the aquifer. This classic formulation has been widely used to predict water level response in aquifers due to specified pumping stresses. Several authors have described the use of this formulation in estimating transmissivity and storativity from aquifer test data Lohman (1972), Walton (1970), Todd (1980), and Freeze and Cherry (1979). In brief, the method involves superimposing the Theis solution (or "type" curve) on a log-log plot of drawdown versus time data from a test well. The coordinate axes of the type curve must be kept parallel to the field data plot axes. Data from the "match point" is used to solve two algebraic equations which give the value of transmissivity (T) and storativity (S) (or storage coefficient). Hydraulic conductivity (K) may be computed by dividing T by the aquifer thickness (b). An example of the application of this technique is presented in Appendix 1-3.

The same aquifer parameters can also be determined from a semi-log plot of drawdown versus time for either the pumping well or observation wells. Cooper and Jacob (1946) showed that after a relatively short time after pumping begins an analysis of the data, plotted as described above, provided essentially the same T, S, and K values as the Theis technique.

Hydrogeologic judgment should be used in applying straight line (Cooper-Jacob method) fits to these plots because different hydrogeologic conditions can produce similar trends in the data plot. For example, bounded aquifers produce straight line trends that may yield apparent transmissivity values that are too low. Knowledge of the hydrogeology of the area and the type of aquifer conditions is essential for correct analysis of test data.

Since the development of the Theis equation, several other formulations have been published which attempt to describe the response of certain aquifers to a constant pumping stress. Hantush (1955, 1956) developed formulations and a corresponding set of type curves for an aquifer which is overlain and/or underlain by a confining bed which has significant storage and experiences vertical flow when the adjacent aquifer is pumped. The same curve matching procedure is used here as with the Theis type curve except that several type curves are available for matching to the data depending on the degree of leakage into the pumped aquifer. Hydraulic characteristics of the confining unit can be calculated using the set of Hantush type curves.

Another commonly used set of "type" curves was developed by Boulton (1954, 1963) and is used when the aquifer tested is unconfined and may exhibit a phenomenon known as delayed yield. Delayed yield is a result of retardation of drainage due to such a force as capillary tension. Boulton's type curves include a set of early-time type curves and late-time type curves. The early-time data and late-time data are respectively matched to the early-time and late-time type curves to give values for transmissivity, storage coefficient, and specific yield. The particular curve used in the set of "type" curves yields additional information concerning how the unconfined aquifer responds to pumping. Neuman (1972, 1974, 1975) also developed a set of type curves for the response of unconfined aquifers to pumping but used different assumptions concerning the physical processes in effect. In practice, Neuman and Boulton curves have been shown to give similar results.

Other less common analytical techniques have been described in detail by the authors mentioned above. A publication by Kruseman and DeRidder (1976) is one of the most complete works on the analysis and evaluation of pumping test data. Methods described (with practical examples) include treatment of aquifers from confined to unconfined under both non-steady and steady-state pumping conditions. Methods of correcting drawdown data from tests in which partially penetrating wells exist are also discussed by Kruseman and DeRidder (1976). In addition, the analyses of data from aquifers which have a non-ideal shape or are bounded in some fashion by different hydrogeologic units are presented. Techniques for analysis of recovery data collected after the completion of pumping are presented. Analyses for various types of variable discharge rate tests, such as the Aron-Scott method, are also presented in Kruseman and DeRidder (1976).

This memo has briefly described equipment, procedures, and other factors which must be considered for constant-rate pumping tests. References which provide additional information are presented in the list of references. Ground Water and Wells (Johnson, 1986) is a field guide with many suggestions on how to perform the tests. Ground Water Hydrology (Todd, 1980) and other references, such as Kruseman and DeRidder (1976), provide analytical techniques and example problems of pumping tests conducted under different geologic conditions.

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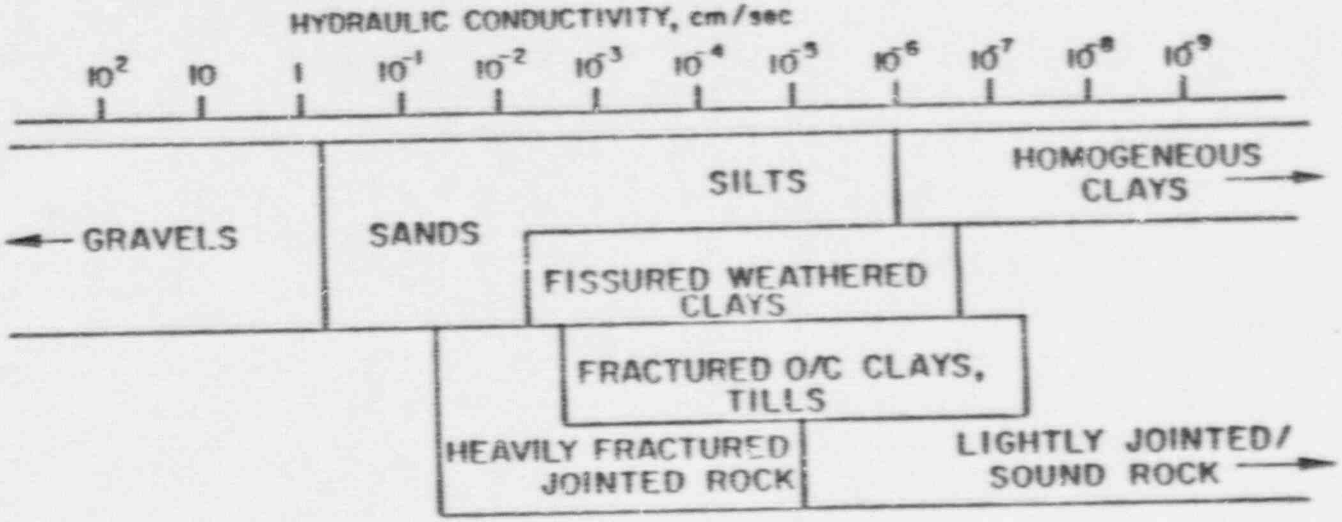


RANGE OF HYDRAULIC CONDUCTIVITY VALUES

FIGURE 1-1

APPENDIX 1-1

EXAMPLE OF ANALYSIS OF SLUG TEST

APPENDIX 1-1

EXAMPLE OF ANALYSIS OF SLUG TEST
AFTER COOPER, BREDEHOEFT AND PAPADOPULOS (1967)

SLUG TEST MW-20

From Recorder Chart

Time (sec)	mv x 0.556 =	Head (ft)	H/Ho
30	2.7	1.50	0.94
60	2.5	1.39	0.87
120	2.2	1.22	0.76
180	1.9	1.06	0.66
330	1.4	0.78	0.49
480	1.0	0.56	0.35
630	0.7	0.39	0.24

From 2-Cycle Semi-Log Plot

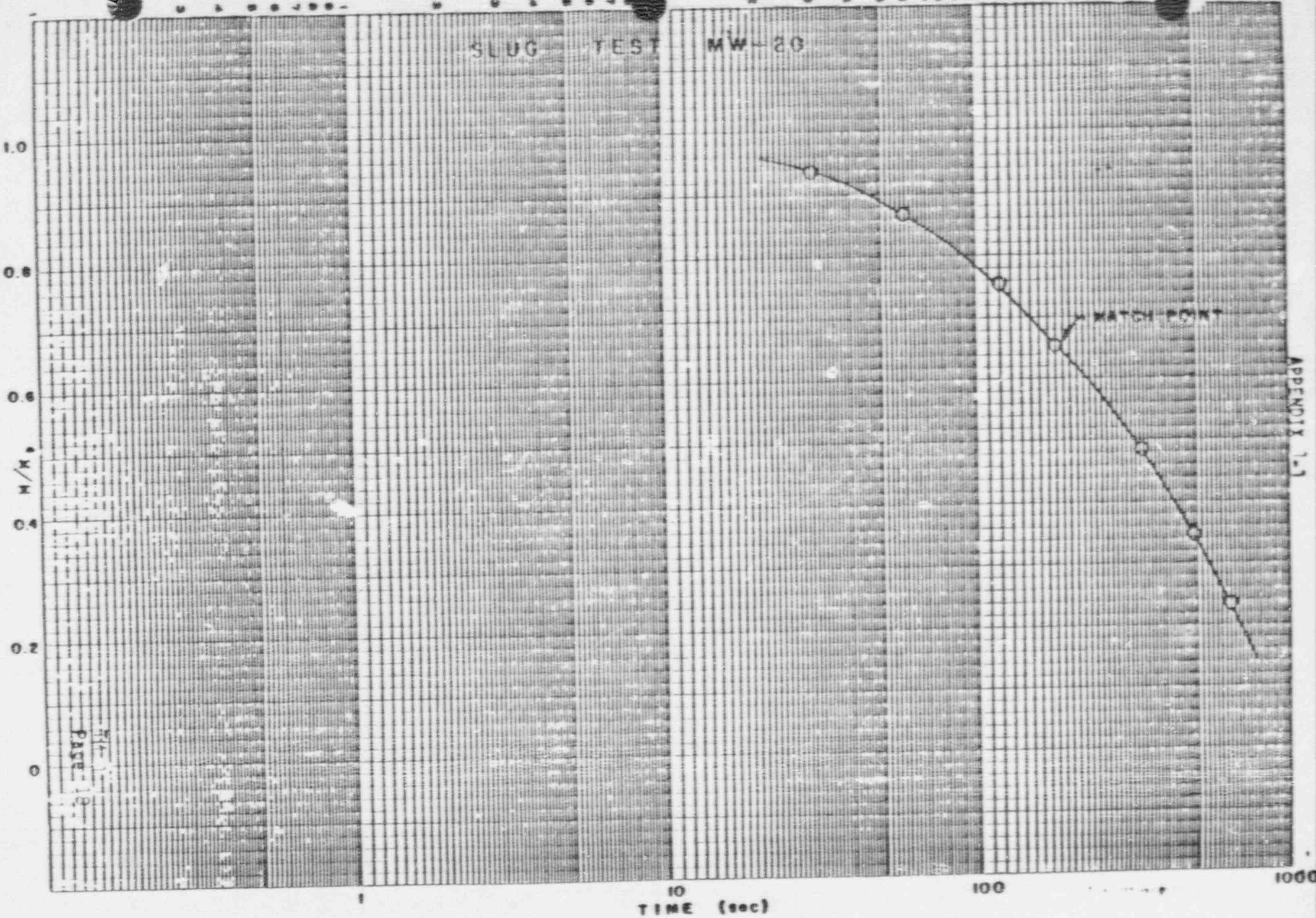
$H_o = 1.60$ ft

From 4-Cycle Semi-Log Plot at Match Point ($\alpha = 10^{-5}$ Curve)

$\frac{Tt}{r_c^2} = 1.23 \quad H/H_o = 0.66 \quad t = 180$ sec

$$T = \frac{1.23(0.125)^2}{180} = 1.07 \times 10^{-4} \text{ ft}^2/\text{sec}$$

$$K = \frac{T}{4.00}(30.48) = 8.14 \times 10^{-4} \text{cm/sec}$$ (using screen length)



APPENDIX 1-1

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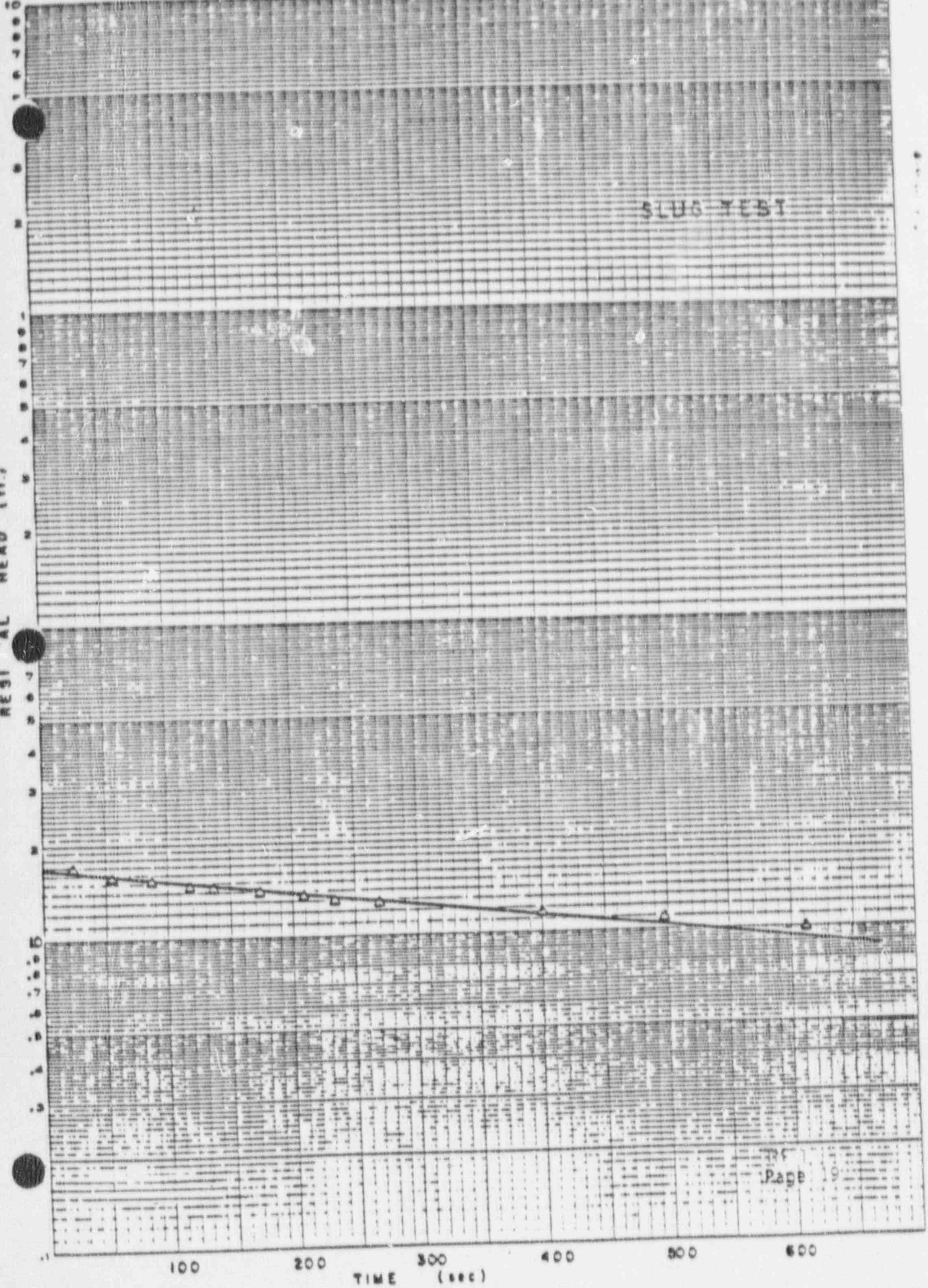
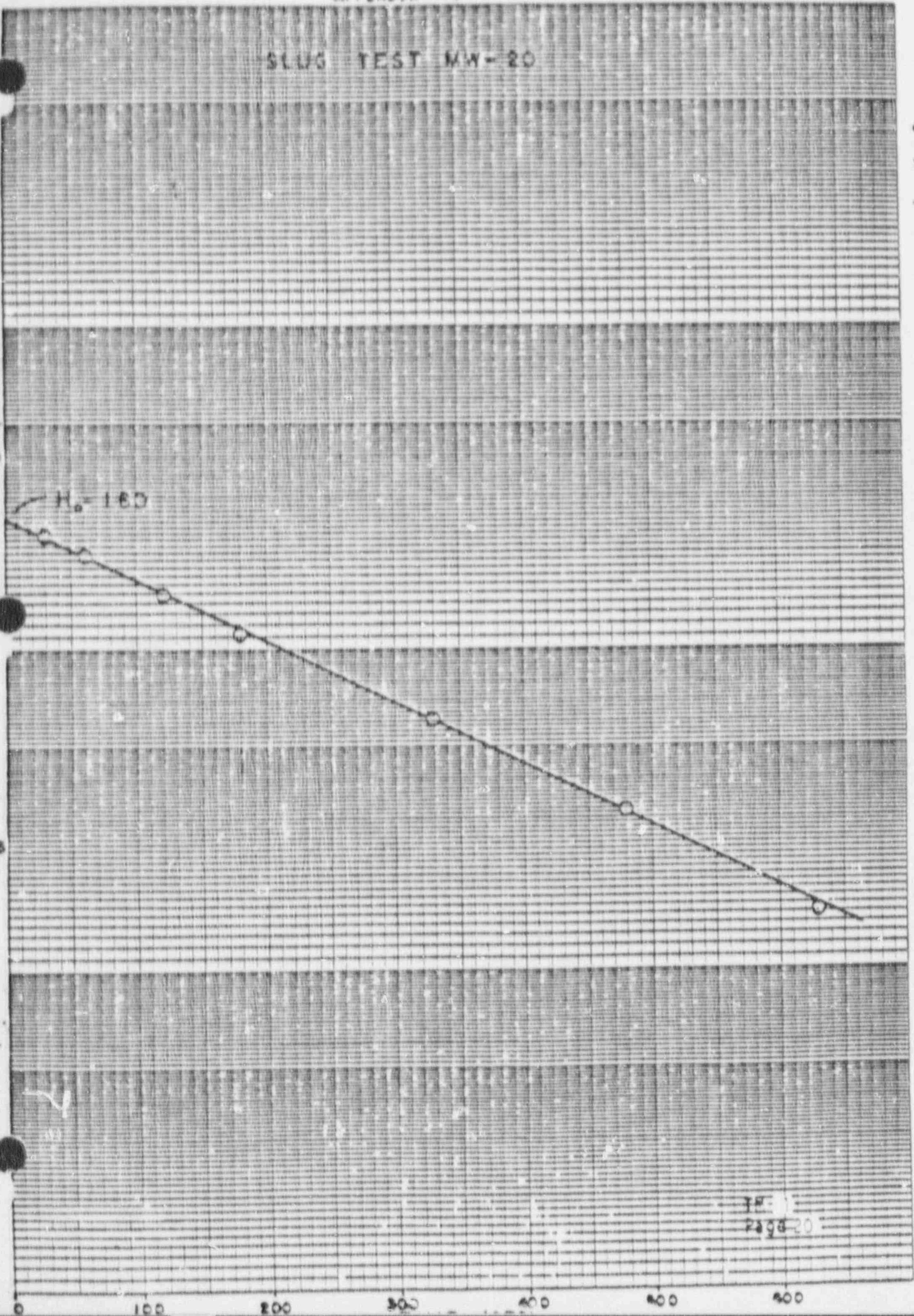
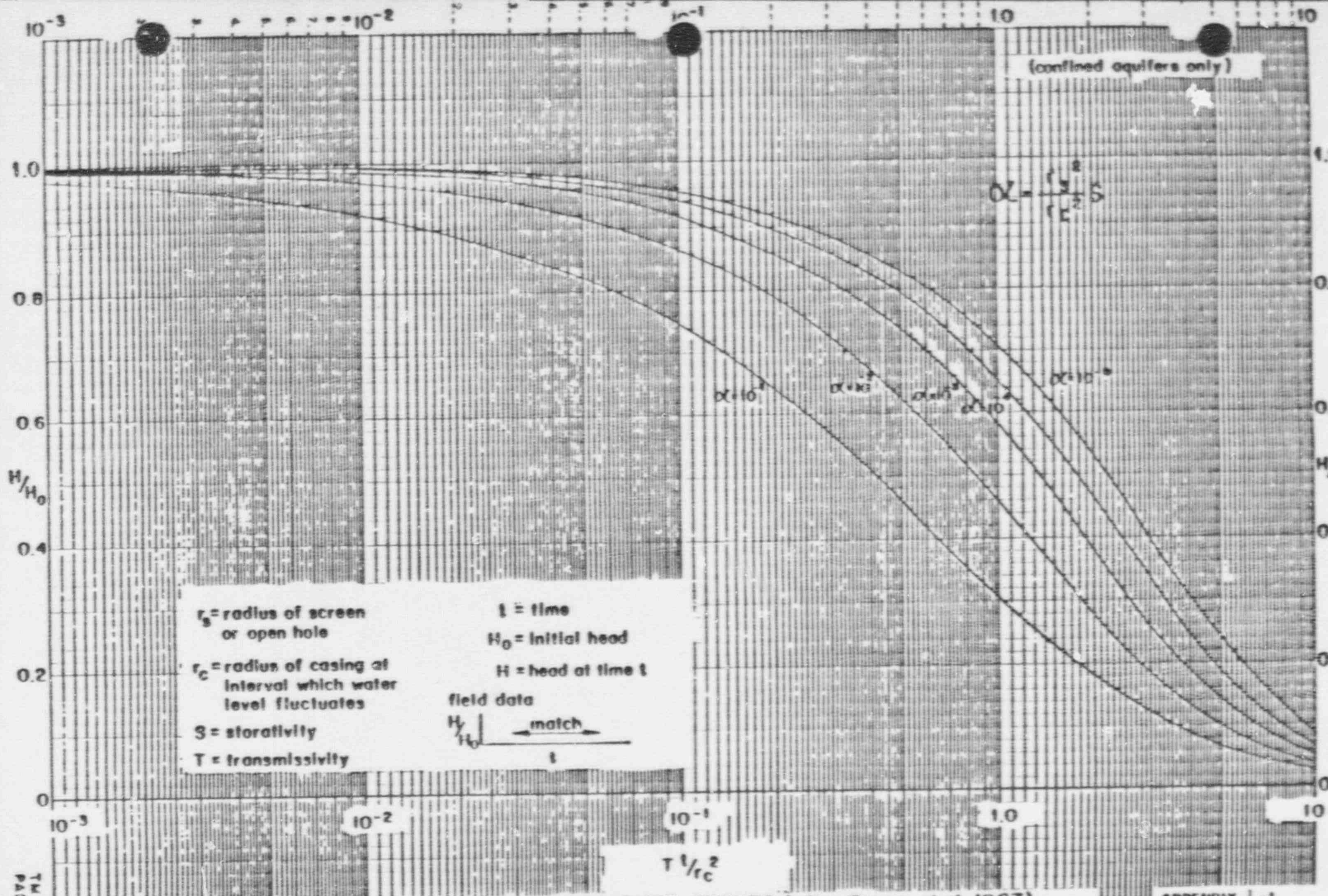

SLUG TEST
RESIDUAL HEAD (ft.)
TIME (sec)
.1
100
200
300
400
500
600
.3
.4
.5
.6
.7
.8
.9
1.0

APPENDIX 1-1



TE-
Page 20

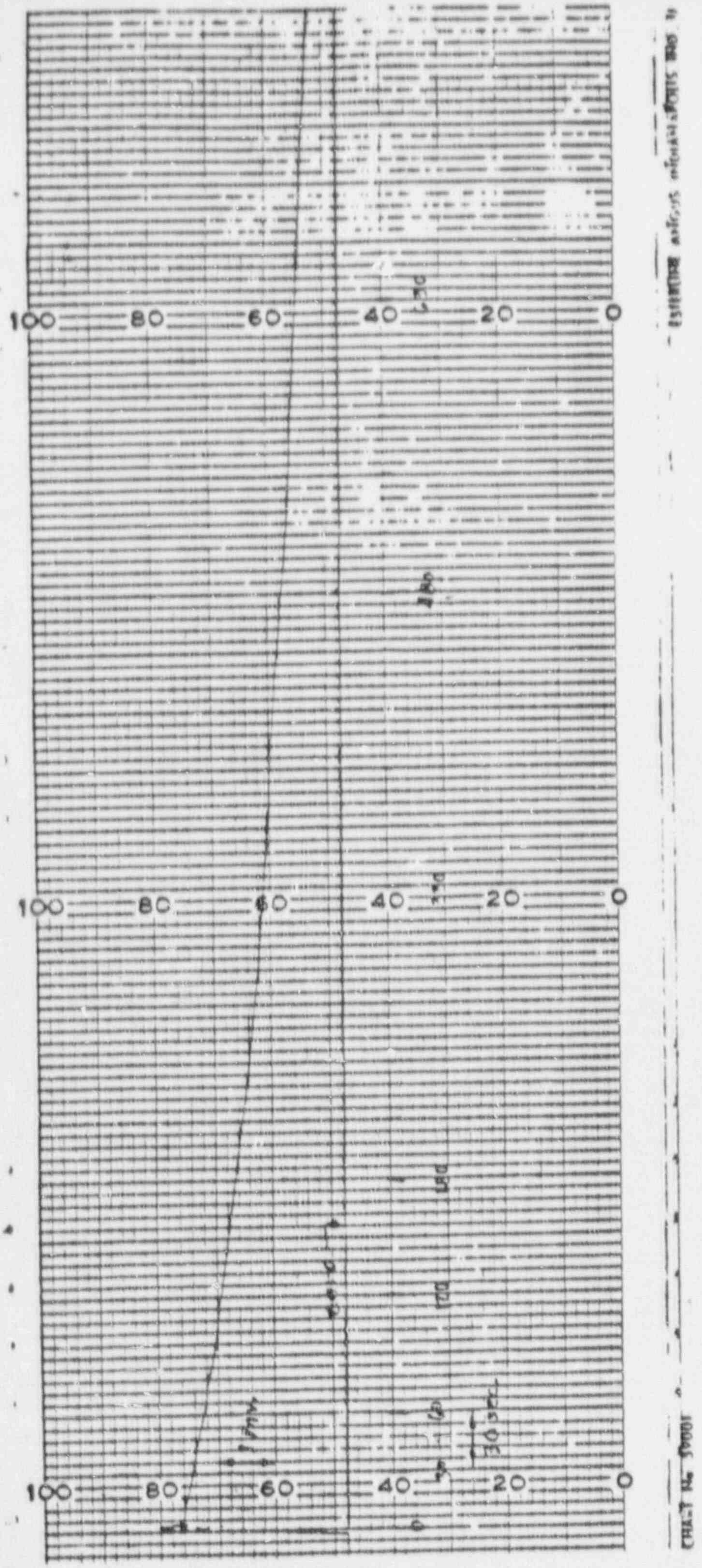


SLUG TEST TYPE CURVES (after Cooper et al, 1967)

APPENDIX 1-2

EXAMPLE OF PRESSURE TRANSDUCER CHART AND ANALYSIS OF SLUG TEST

APPENDIX 1-2



PRESSURE TRANSDUCER DATA, SLUG TEST

APPENDIX 1-2

EXAMPLE OF ANALYSIS OF SLUG TEST DATA ANALYSIS FOR AN UNCONFINED AQUIFER

After Bouwer and Rice (1976)

1) Slug Test Data for Example Well

r_w = 0.333 ft
r_c = 0.167 ft
L = 10.0 ft
D = 27.8 ft
H = 11.8 ft

y_t = 1.21 ft at t = 300 sec
y_0 = 1.67 feet

2) Evaluate Coefficients A and B or C as required (Figure 3 of Bouwer and Rice, 1976)

$$L/r_w = \frac{10 \text{ ft}}{.333 \text{ ft}} = 30.03$$

A = 2.5   B = 0.38   C = ____ (C is not determined because $D \neq H$)

3) Evaluate $\ln(R_e/r_w)$ where R_e is the effective radius over which the heads are dissipated.

$$\ln[(D-H/r_w] = 3.84: \left(\text{if } \ln\frac{[D-H]}{r_w} > 6, \text{ then } = 6\right)$$

$$\ln\left(\frac{R_e}{r_w}\right) = \left[\frac{1.1}{\ln(H/r_w)} + \frac{A + B\ln[(D-H)/r_w]}{(L/r_w)}\right]^{-1} \text{ (where } D \neq H)$$

Or,

$$\ln\left(\frac{R_e}{r_w}\right) = \left[\frac{1.1}{\ln(H/r_w)} + \frac{C}{(L/r_w)}\right]^{-1} \text{ (where } D = H)$$

Using the slug test data,

$$\ln\left(\frac{R_e}{r_w}\right) = \left[\frac{1.1}{\ln\left(\frac{11.8}{.333}\right)} + \frac{2.5 + (0.38 \times 3.87)}{30.03}\right]^{-1}$$

$$= 2.27$$

APPENDIX 1-2 (continued)

EXAMPLE OF ANALYSIS OF SLUG TEST DATA ANALYSIS FOR AN UNCONFINED AQUIFER
After Bouwer and Rice (1976)

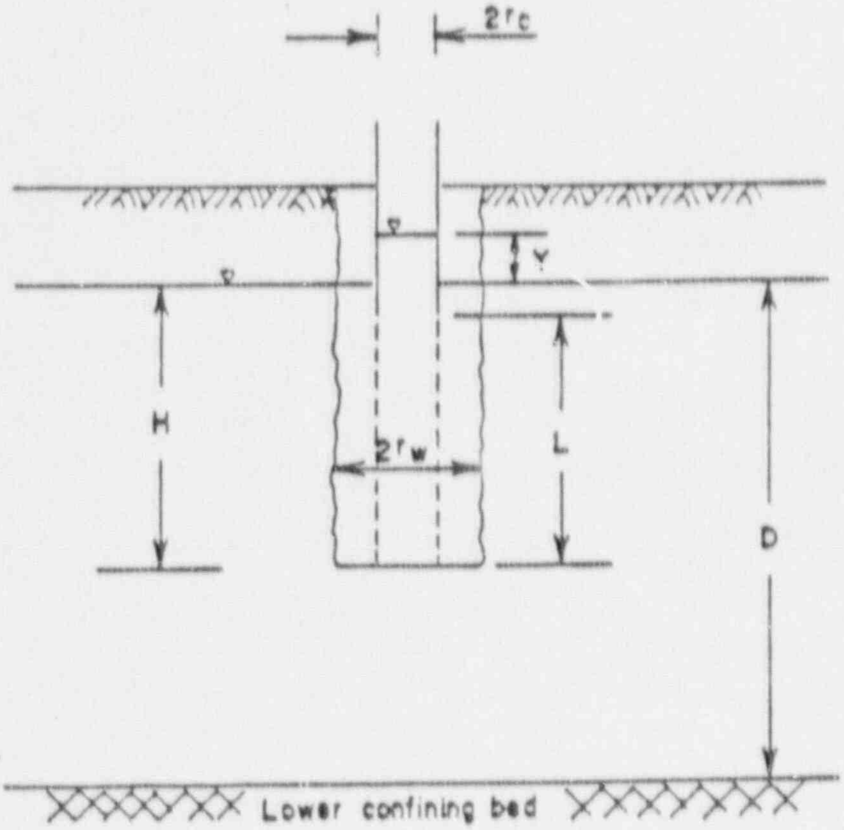
4) Evaluate the Hydraulic Conductivity, K

$$K = \frac{r_c^2 \ln\left(\frac{r_e}{r_w}\right)}{2\,Lt} \ln \frac{y_o}{y_t}$$

$= 3.4 \times 10^{-6}$ ft/sec $= 1.0 \times 10^{-4}$ cm/sec $= 2.2$ gpd/ft^2

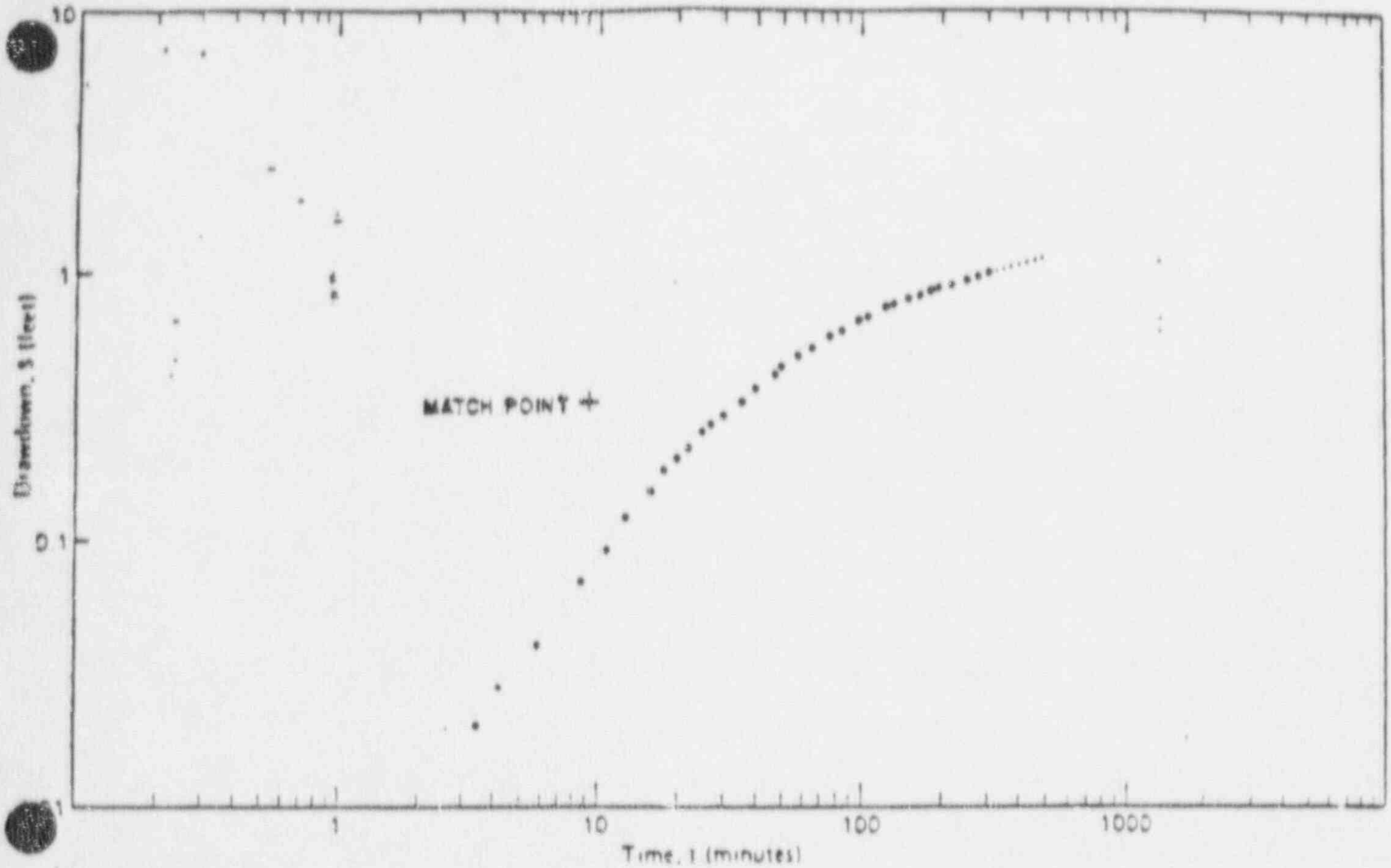
5) Evaluate the Transmissivity, T

T = KxD = 61 gpd/ft



APPENDIX 1-3

EXAMPLE OF ANALYSIS OF AQUIFER TEST DATA



$$T = \frac{114.6Q}{s} W(u)$$

$$= \frac{114.6\,(21.6)}{0.345}\,(1)$$

$$T = 7200 \text{ gpd/ft}$$

$$S = \frac{Tut}{1.87\, r^2}$$

$$= \frac{(7200)\,(1)\,(6.8 \times 10^{-3})}{1.87\,(60.4)^2}$$

$$S = 0.007$$

$Q = 21.6$ gpm
$r = 60.4$ ft
$b = 53$ ft

$$K = \frac{T}{b} = \frac{7200}{53} = 140 \text{ gpd/ft}^2$$

Theis Match Point

$$\left.\begin{array}{c} W(u) = 1 \\ u = 1 \\ s = 0.345 \text{ ft} \\ t = 9.8 \text{ min} \end{array}\right\} \Rightarrow$$

APPENDIX 1-3: EXAMPLE OF ANALYSIS OF AQUIFER TEST DATA

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ALBUQUERQUE OPERATIONS

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AQUIFER TEST

SITE ID: ____________________ LOCATION ID: ____________________
START TEST: DATE ____________________ END TEST: DATE ____________________
TIME ____________________ TIME ____________________
DATUM ELEV. (FT. MSL): ____________________ AVG. PUMPING RATE (GAL/MIN): ____________________
STATIC WATER LEVEL (FT. MSL): MEASUREMENT METHOD: ____________________
INITIAL (AT t_0) ____________________ WELL DEPTH (FT.): ____________________
FINAL ____________________ CASING DIAMETER (IN.): ____________________

WATER LEVEL MEASUREMENT METHOD: ____________________
DISTANCE FROM PUMPED WELL, r (FT.): ____________________
DATA ADJUSTED FOR REGIONAL WATER LEVEL CHANGES? ____________________
FIELD REP(S): ____________________
COMMENTS: ____________________

PUMP TEST			RECOVERY TEST	
ELAPSED TIME (MIN.)	DEPTH TO WATER * (FT.)	PUMPING RATE (GAL/MIN)	ELAPSED TIME (MIN.)	DEPTH TO WATER * (FT.)

* BELOW DATUM

JEG-AL-ENG-5 (6/87)

AQUIFER TEST

Page __ of __

PUMP TEST			RECOVERY TEST	
ELAPSED TIME (MIN.)	DEPTH TO WATER * (FT.)	PUMPING RATE (GAL/MIN)	ELAPSED TIME (MIN.)	DEPTH TO WATER * (FT.)

* BELOW DATUM

SOIL-WATER SAMPLER INSTALLATION AND SAMPLE COLLECTION (SUCTION LYSIMETERS)

1.0 PURPOSE

To provide a procedure for the installation and documentation of pressure-vacuum soil water samplers and for the collection of water samples.

2.0 SCOPE

This procedure section will outline the steps for the installation of a pressure-vacuum soil water sampler. Also, procedures for conducting field measurements, filtration, preservation, and shipment of samples are presented.

3.0 EQUIPMENT AND SUPPLIES

3.1 Porous ceramic cup

3.2 Body tube

3.3 Nail or similar object

3.4 Neoprene plug

3.5 Clamp ring

3.6 Pinch clamps

3.7 Polyethylene tubing: 1/4" diameter

3.8 Neoprene tubing: 2/16" i.d. x 1/8" wall

3.9 Distilled water

3.10 Vacuum grease

3.11 Tamping rod: PVC, 1" i.d. x 5' (several 5-foot sections, threaded) or a tremie pipe

3.12 PVC pipe: for casing purposes, 6" diameter, should be Schedule 80 type

3.13 PVC pipe cap: for above

3.14 Hollow stem auger (HSA): with nominal 6.25" O.D., and 3.25 I.D. drill auger

3.15 Air rotary drill

3.16 Split spoon: 3" diameter (o.d.)

3.17 Vacuum-pressure pump, hand pump

3.18 Sample bottles

3.19 pH paper

3.20 Filter apparatus

3.21 Filters, 0.45 u membrane

3.22 Syringe filter with filters, disposable

3.23 Kim-wipes or equivalent

3.24 Rubber gloves, disposable

3.25 pH meter and electrode; with temperature compensator and with slope adjustment

3.26 Alkalinity test kit

3.27 Thermometer

3.28 Silica flour: minus 200-mesh silica flour, dry. See Figure 2.

3.29 Silica sand, quartz: ~50-mesh, clean, well-graded

3.30 Bentonite, powdered

3.31 Native soil: from sampler site location (if site is uncontaminated)

3.32 Wooden dowels: 3/16" diameter (o.d) x 2" long

3.33 Posts: wood (4" x 4" x ~6'), steel (~4" diameter x ~6'), or steel tee-bar (~6'). See 16.1.1 (3.7.7).

3.34 (Optional) cement for posts

3.35 Barbed wire

3.36 Flagged material

4.0 CHEMICALS AND REAGENTS

NOTE: Whenever required by the procedure, JEG purchases and uses prepared, calibrated, and certified solutions from chemical supply firms. The following are listed in the event certified solutions are not readily on hand or are used whenever procedure parameters do not require certified solutions.

4.1 Nitric Acid: HNO_3, ~70%, concentrated 16 M (~16 N)

5.0 PROCEDURE: GENERAL COMMENTS

The number of required soil-water samplers (samplers) shall be determined by the Site Hydrologist (SH) and approved by the Task Manager of the Hydrological Services and Technical Data Review Committee (TDRC). The SH shall assign the area and depth, up to a maximum of 50 feet, where the samplers are to be installed. Samplers should not be placed within five (5) feet of a tensiometer. No recommended method for determining station locations can be given that is applicable to all conditions. Each specific site requires preliminary investigation, interpretation of early results, adjustments in frequency, and location of tensiometer stations to meet the unique requirements of each site. The number of installations to be made would depend upon cost, the variability encountered, and the desired precision. Standard sampling analysis which incorporates these variables may be used to establish the sampling frequency (see References 14.1 and 14.2). Fencing around the site(s) may be necessary due to the potential for damage from intrusion by people, wildlife, livestock, or mechanical equipment. The surface area above the samplers should not be covered in a manner that would interfere with the normal percolation of soil moisture down to the depth of the sampler. The following guidelines are provided for drilling holes, installing the suction water samplers, collection of samples, and shipment of samples to the analytical laboratory.

6.0 PROCEDURE: Assembly of Soil Water Sampler

6.1 Before drilling, immerse the porous ceramic cup of the sampler in distilled water for approximately 1 hour or until the tip is saturated. To ensure that the tip is saturated, immerse in a bucket of distilled water, and put suction on the sampler. Proper operation of the sampler can also be observed at this time. During drilling, leave the sampler immersed in a bucket of distilled water to ensure that the tip does not dry out. Prior to installation, disassemble the sampler and remove the distilled water that has entered the sampler body. The sampler should be free of all distilled water and foreign objects prior to installation.

6.2 Once the hole has been drilled, determine the length of access tubes (i.e., 1/4" i.d. polyethylene tubing). Two lengths/colors are required. See Figure 1.

6.3 Push the discharge tube through the neoprene plug so that the end of the tubing reaches to within 1/8" of the bottom of the porous ceramic cup.

6.4 The pressure vacuum tube should protrude approximately 1" through the neoprene plug.

6.5 Leave a sufficient length of tubing sticking above the neoprene plug so that the access tubes are about 6" above ground level after installation of the soil water sampler. Cut the discharge tube approximately 6" longer than the pressure-vacuum tube to identify the different tubes, or use different colored tubing for discharge and vacuum lines.

6.6 Slip 6" of neoprene tubing (2/16" i.d. x 1/8" wall) over the ends of each access tube.

6.7 After installing the access tubes, coat the sides of the neoprene plug with vacuum grease, and insert the plug into the body tube.

6.8 Make sure the plug is held in place with the clamp ring by tightening the clamp with a nail or similar object. Tighten the ring until it meets the body tube. See Figure 1.

7.0 PROCEDURE: Installation of Soil Water Sampler

Depending on subsurface conditions, drilling shall be performed with either a Hollow Stem Auger (HSA) or an air rotary drill. An alternate drilling method can be used that does not involve the use of drilling mud or that does not excessively disturb soils. Holes shall be drilled using a four-inch minimum diameter bit. All drilling shall be accomplished without the addition of drilling mud or water. If the site is uncontaminated, native soils extracted from the drill hole should be removed, saved, and used as backfill.

7.1 Hollow Stem Auger (HSA) Drilling

Perform drilling with a HSA and as provided by a standard soil-sampling drill rig. HSA should be used in unconsolidated granular soils where there is a potential for borehole-wall collapse and cave-in.

7.1.1 Terminate the augering about one foot above the desired depth of instrument installation. Do no withdraw auger (HSA) string at this time. Stockpile the soil removed from the borehole during drilling according to depth (i.e., soil from the 5-10′ interval should be kept separate from the 10-15′ interval) and returned to the borehole at the same depth from which it was removed. Place all stockpiled soil in plastic sheets or tarps to avoid surface contamination of the soil cuttings.

7.1.2 Use a split-spoon (nominal 3" o.d.) to knock the plug out of the bottom of the auger and to collect the final foot of material. NOTE: If site is uncontaminated, save soil for 7.3.5 and use for backfill. See TR.

7.1.3 After completing the borehole, drop approximately one to two pounds of dry silica flour down such a manner that most of the silica hits the bottom of the hole with considerable force. Wet the tip of the saturated ceramic cup with distilled water and rub tip with dry silica flour until a silica cake has formed on the tip.

7.1.4 With the silica flour patted onto the ceramic tip, lower the sampler through the hollow stem (while the auger is in the ground) to the bottom of the borehole so that it rests directly on the native soil. Push lightly on the top of the sampler with the tamping rod to ensure good contact between the ceramic cup, silica flour, and native soil.

7.1.5 Backfill the borehole to the top of the sampler (about 2.5') with the stockpiled native soil retrieved from the appropriate depth. Tamp soil in place using the tamping rod.

7.1.6 Pull a five (5) foot section of auger from the hole using a sand line and chain. Use the tamping rod to hold the instrument in place while pulling out the auger.

7.1.7 Once the five (5) foot section of auger has been removed, backfill the borehole with stockpiled material from the appropriate depth (i.e., from the bottom of the borehole to the face of the auger bit). Perform backfilling in 6-inch lifts, as a maximum, followed by compaction with a tamping rod. After sufficient soil has been added to the borehole so as to bring the level of the soil up to the face of the auger bit, remove an additional five (5) foot section of auger and backfill as stated previously. Continue backfilling and removing auger until a depth equal to 1/3 of the distance from the surface to the top of the sampler is reached. For example: given a 20-foot borehole with a 2-foot sampler, backfill to 12 feet from the surface. NOTE: Use the tamping rod to keep the instrument seated as the HSA auger string is retracted by sand line and chain.

7.1.8 Install a one (1) foot bentonite seal using powdered bentonite. Hydrate the bentonite by pouring in approximately one (1) gallon of distilled water. Wait approximately 30 minutes for bentonite to fully hydrate.

7.1.9 Once the bentonite has been given sufficient time to hydrate. continue pulling five (5) foot sections of auger and backfilling the borehole to a depth of 2 feet below land surface.

7.3 Final Installation

Once the soil water sampler has been assembled, the sampler is installed into the borehole. The primary concern during installation is that the porous ceramic cup be in tight and intimate contact with the soil so that soil moisture can readily move from the soil to the soil water sampler.

7.3.1 JEG personnel shall check the soil water sampler for proper operation prior to final installation.

7.3.2 Replace any instrument which fails to operate properly in the same borehole or in another borehole drilled adjacent to the first.

7.3.3 Refer to operating instructions (Attachment 1) for the Model 1920 pressure-vacuum soil-water sampler for additional methods of installing the pressure-vacuum sampler in the event the method outlined in the SOP is not satisfactory.

7.3.4 As soon as practical after installation, the FTR shall use the pressure-vacuum pump to purge the sampler to obtain representative soil fluids. Continue purging until the slurry water is removed and the soil moisture can be sampled. If the SOP is used, purging will not be necessary because water was not added to the installation process.

7.3.5 Where the lysimeters are to be placed in a traffic area, sink a PVC protective casing in the bentonite-soil plug, thus surrounding the soil-water vacuum tubes. See 3.12.

7.3.6 Extend the casing down about two (2) feet into the plug and allow the casing to protrude above land surface about one (1) foot. Cover the top of the pipe with a slip-on PCV cap. Mark the lysimeter ID on the protective casing with an indelible ink pen.

7.3.7 Protect the soil water sampler from possible damage by vehicular traffic or grazing livestock whenever appropriate. Install 3-4 wood, steel, or tee-bar driven steel posts at a 4-foot radius around each PCV casing. Flagging should be attached to a post to visually mark the location. If livestock present a threat to the sampler, three strands of barbed wire should be affixed to the posts. NOTE: See Section 16.1.1 entitled "Monitor Well Installation" (Step 3.7.7) for details on installation of posts.

8.0 PROCEDURE: Collection of Soil-Water Samples

A vacuum applied within the soil water sampler causes moisture to move from the soil through the porous ceramic cup into the sample bottles. Because the rate at which a sample is collected is a function of the unsaturated hydraulic conductivity of the soil and the amount of vacuum which is created, the time required to collect a sample may vary. Generally, a vacuum between 50 to 80 centibars is sufficient to collect a sample in a few hours. However, under conditions of low conductivity or low soil moisture content, several days or weeks may be required to collect a sample. Because it is usually not possible to collect enough sample for a complete analysis, the order in which the constituents are analyzed must be prioritized. Table I lists the bottle ID and minimum volume required by the lab for analysis in order or priority. Constituents in each bottle are listed from high to low priority. The SH may establish a different set of analysis(es) priorities if concurrence is obtained from the Task Manager of Hydrological Services.

Table I Listed in Decreasing Priority

Bottled ID	Minimum Volume Requirement	Analytes
M	100 ml	Ba, Mo, As, Cd, Cr, Hg, Pb, Sb, Se, Al, Fe, Mn, Ag, Co, Cu, Ni, Sn, V, Zn, U, Be, Tl, Na, K, Mg, Ca, Sr
Ra-226	1000 ml	Ra-226
G α β	200 ml	G α β
Ra-228	1000 ml	Ra-228
Nl	100 ml	NO_3, NO_2+NO_3, NH_4
CN	50 ml	CN
A	100 ml	F, Cl, SO_4, PO_4, SiO_2, B, TDS, Br
S	50 ml	S^{2-}
Th^{230}	500 ml	Th^{230}
TOC	200 ml	TOC

8.1 To collect a sample,* close the pinch clamp on the discharge access tube and connect the vacuum port of the pressure-vacuum hand pump to the pressure-vacuum access tube. Stroke the pump until a vacuum of approximately 65 centibars is created within the sampler. Check the readout on the pump gauge.

8.1.1 *Samples collected from, on, or near tailings piles may be hazardous. Wear disposal surgical-type gloves when collecting such samples. Care should also be taken to avoid splashing the sample liquid in the eyes or on the clothes.

8.2 Securely close the pinch clamp on the pressure-vacuum access tube to seal the sampler under vacuum. Remove the hand pump, if required for other uses. Allow the sampler to set for a period of time under vacuum (see Figure 5B).

8.3 To recover a soil-water sample, attach the pressure-vacuum access tube to the pressure port on the pump. Place the discharge access tube into a small, clean collection bottle and open both pinch clamps. Apply a few strokes on the hand pump to develop enough pressure within the sampler to force the collected water out of the sampler and into the collection bottle (see Figure 6).

8.4 Collect subsequent samples by again creating a vacuum within the sampler and repeating steps 8.1 through 8.3. Be sure to collect each sampler in a separate and clean container. NOTE: Always leave a vacuum on the soil water sampler when leaving a site.

9.0 PROCEDURE: Sample Filtration

Before performing field measurements, filter the samples through a 0.45 micron filter. If more than 500 ml of sample is available, use a large filtering system; otherwise, use a syringe/filter system. Filter samples collected from tailings with a syringe/filter. Follow the Standard Operating Procedures for water sampling documented in Section 16.1.1. Procedures specific to collecting soil-water samples are found below.

9.1 Large filtering system

9.1.1 Disassemble the filter apparatus and discard the old filter. Use distilled water to thoroughly rinse all surfaces which come into contact with the sample.

9.1.2 With clean hands, install a new filter. Handle filter only by its edges. Reassemble the apparatus. NOTE: If possible, use a pair of tweezers. Allow no dirt or dust to blow onto the cleaned apparatus or filter.

9.1.3 Before filtering any samples, rinse filter and filter apparatus with a few ml of sample water. Filter and discard water.

9.1.4 Fill the sample bottles. Allow no dirt or dust to blow into the bottles or onto the bottle caps.

9.2 Syringe/filter system

9.2.1 Insert syringe tip into sample solution and fill the syringe with sample by withdrawing the plunger.

9.2.2 Connect a new syringe filter to the tip of the syringe and force sample through the filter into a clean sample bottle by depressing syringe plunger. NOTE: Sampler should practice with a syringe, filter system, and distilled water before filtering a sample.

9.2.3 Repeat above steps for each sample until entire sample has been filtered.

9.2.4 Discard used syringe and filter.

9.2.5 Repeat above steeps with a new syringe, filter system, and sample bottle for each sample until all of the samples have been filtered.

10.0 PROCEDURE: Field Management of Samples for Temperature, pH, Specific Conductivity, Alkalinity, and Total Acidity

Record all field measurements and cements on Attachment 2 entitled, "soil Water Sampler Data Record." Complete all lines on the field form. If some steps were not taken or were not applicable, so indicate in the appropriate space. Complete the forms with nonwater soluble ink (felt-tip type pens or pencils are not acceptable). If any procedure was not performed as prescribed, state the reason on the field form. Once samples have been collected, perform measurements for temperature, pH, and alkalinity with procedures documented in Section 16.1.10. However, since some sample loss will occur during testing, perform measurements only if a 500-ml or more sample is collected. Also, omit alkalinity tests unless the sample pH is greater than 4.5. As always, exercise care to protect the samples from cross-contamination.

11.0 PROCEDURE: Sample Preservation

11.1 If there is less than 250 ml of sample, check sample pH, and record pH on Attachment 2. NOTE: If soil-water sample pH is less than 2.0 without being acidified, do not add any acid. Record this on Attachment 2.

11.1.1 If the sample pH is 5 or more, acidify the sample with nitric acid (HNO_3 in sufficient volume (~0.15 ml) to lower the sample pH to 2.0. Check sample pH. NOTE: Unless directed otherwise by TR/FTR or SH, use HNO_3.

11.1.2 If micropipets are not available, add HNO_3 drop by drop. Mix sample solution well before checking sample pH.

11.1.3 Record amount of HNO_3 added to the sample on Attachment 2.

11.2 If there is more than 250 ml of sample, put the next 150 ml into a bottle unacidified. Record on Attachment 2.

12.0 PROCEDURE: Shipment of Collected Sample

12.1 Once HNO_3 or other appropriate acid has been added, seal the sample bottles with electrical tape.

12.2 Compare information on sample containers with Attachment 2 to make sure that identification (e.g., sampling date, sample number, site number and location, date, analysis(es), etc.) are correct, sample containers are properly labeled, and that Attachment 2 has been filled with required field data and notes.

12.3 Separate samples into sample lots that consist of at least nine (9) samples, and one (1) known solution.

12.3.1 Include any samples classified as "blank" or "spike" samples.

12.3.2 Fill out chain-of-custody and other required forms with information from Attachment 2 or other field notes.

12.4 Place sample(s), chain-of-custody forms, sample identification forms, etc., into an ice chest containing "blue ice" or its equivalent and seal with appropriate tape.

12.5 Affix laboratory address and JEG return address. Ship samples by fastest mode with appropriate carrier.

12.6 Notify laboratory of time/date of shipment of sample(s), carrier, and expected time/date of shipment arrival at the laboratory.

12.7 Perform close out procedures.

12.7.1 Cleanup field equipment and instruments.

12.7.2 Replace expended time.

12.7.3 Repair and report broken equipment. Replace equipment if necessary.

12.8 Submit completed and xeroxed copies of Attachment 2 and other field forms to the Site Manager, TR/FTR, and Data Manager.

12.8.1 Inform SH by memorandum of completion of soil-water sampler installation and/or sample collection with shipment of sample(s) to the laboratory.

13.0 ATTACHMENTS

13.1 Figure 1 - Description of soil-water samplers

13.2 Figure 2A-C - View of installation of soil-water sampler

13.3 Figure 3A-B - View of installed soil-water sampler

13.4 Figure 4 - Assembly of soil-water sampler

13.5 Figure 5A, B - Procedure for sample collection

13.6 Figure 6 - Procedure for sample removal

13.7 Attachment 1 - Operating instructions for the Model 1920 pressure-vacuum soil-water sampler

13.8 Attachment 2 - Soil-Water Sampler Data Record

14.0 REFERENCES

14.1 Allmaras, R.R, 1965, in C. A. Black, ed., "Methods of Soil Analysis," Agronomy Monograph No. 9, Part 1, American Society of Agronomy, Madison, Wisconsin, pp. 24-42.

14.2 Krumbein, W.C. and F.A. Graybill, 1965. An Introduction to Statistical Models in Geology, McGraw-Hill, New York, New York, pp. 171-181.

14.3 Soil Moisture Equipment Corp., P.O. 3002J, Santa Barbara, CA 93105.

15.0 PROCEDURE REVIEW AND APPROVAL

Prepared By: ______________________

Reviewed By: ______________________
Task Manager

Reviewed By: ______________________ 9/24/90
Quality Assurance Manager

Approved By: ______________________
Project Manager

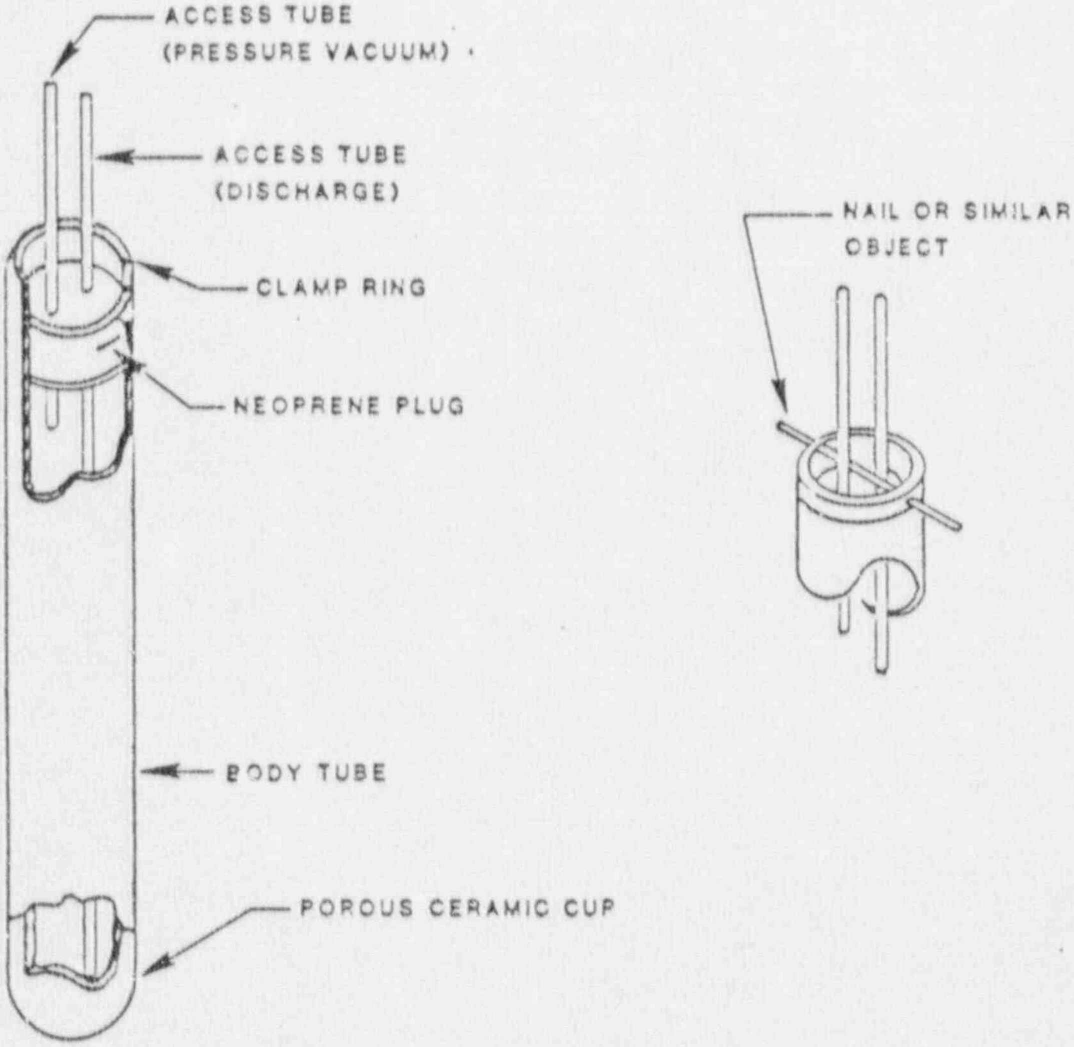


FIGURE 1
DESCRIPTION OF A SOIL WATER SAMPLER

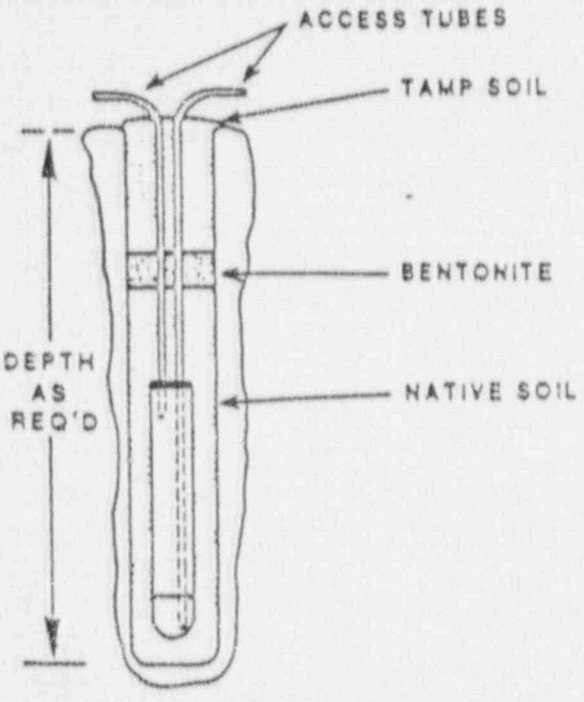


FIGURE 2A

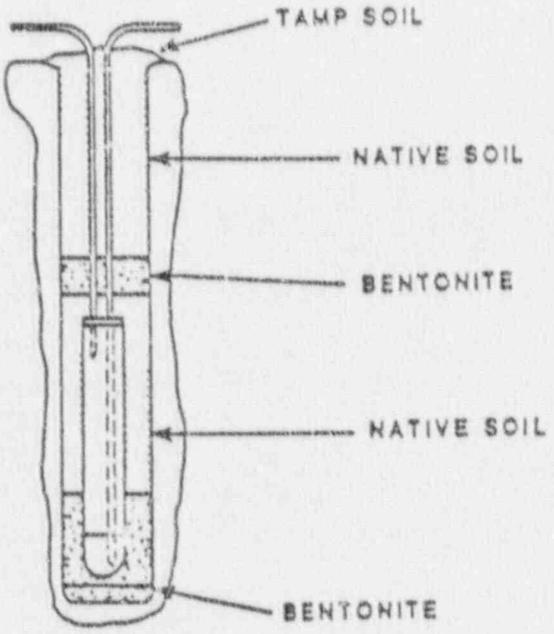


FIGURE 2B

VIEW OF INSTALLATION OF SOIL WATER SAMPLER

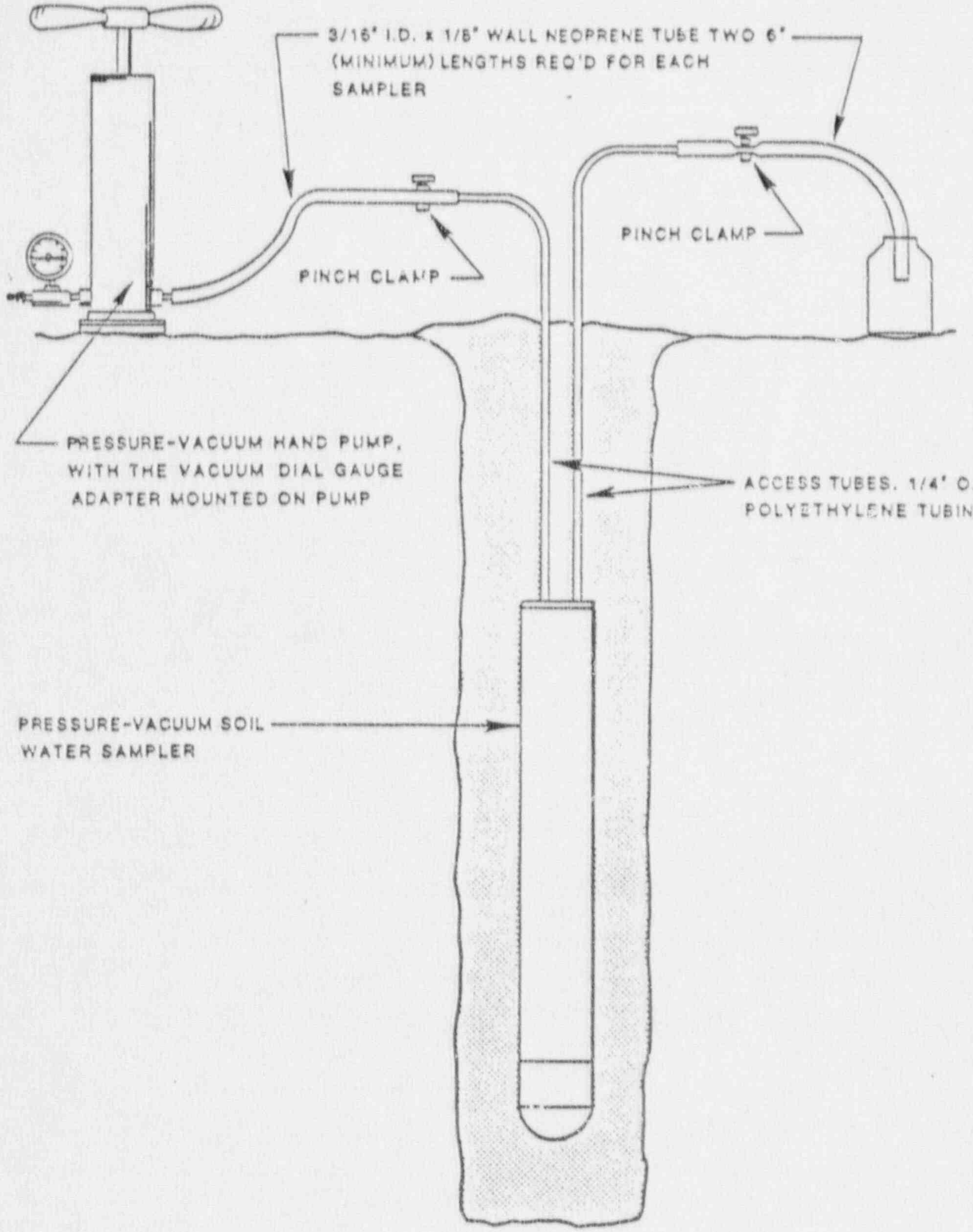


FIGURE 3
ASSEMBLY OF SOIL WATER SAMPLER

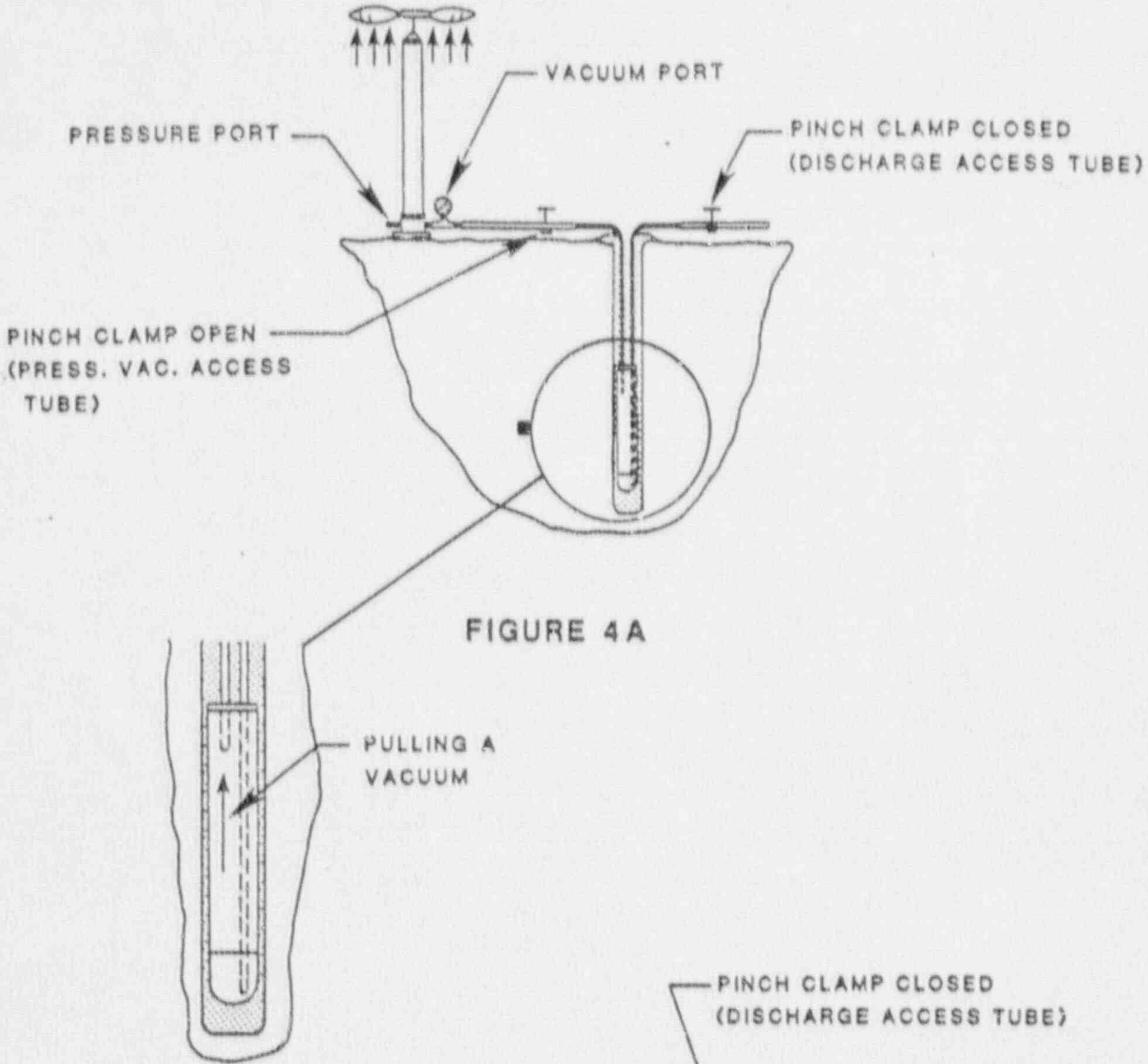


FIGURE 4A

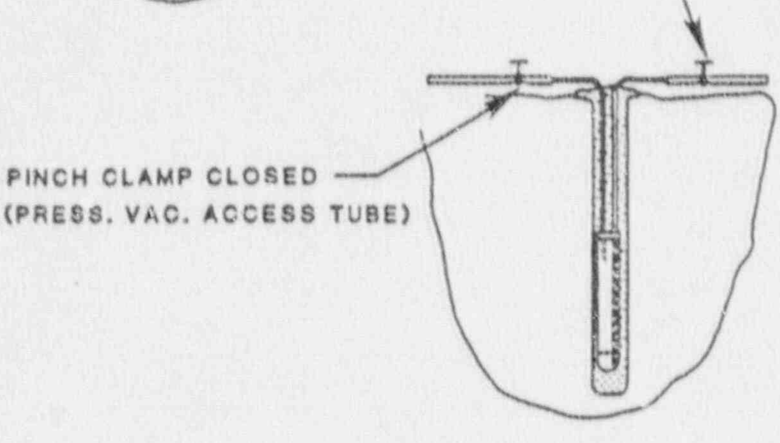


FIGURE 4B

PROCEDURE FOR SAMPLE COLLECTION

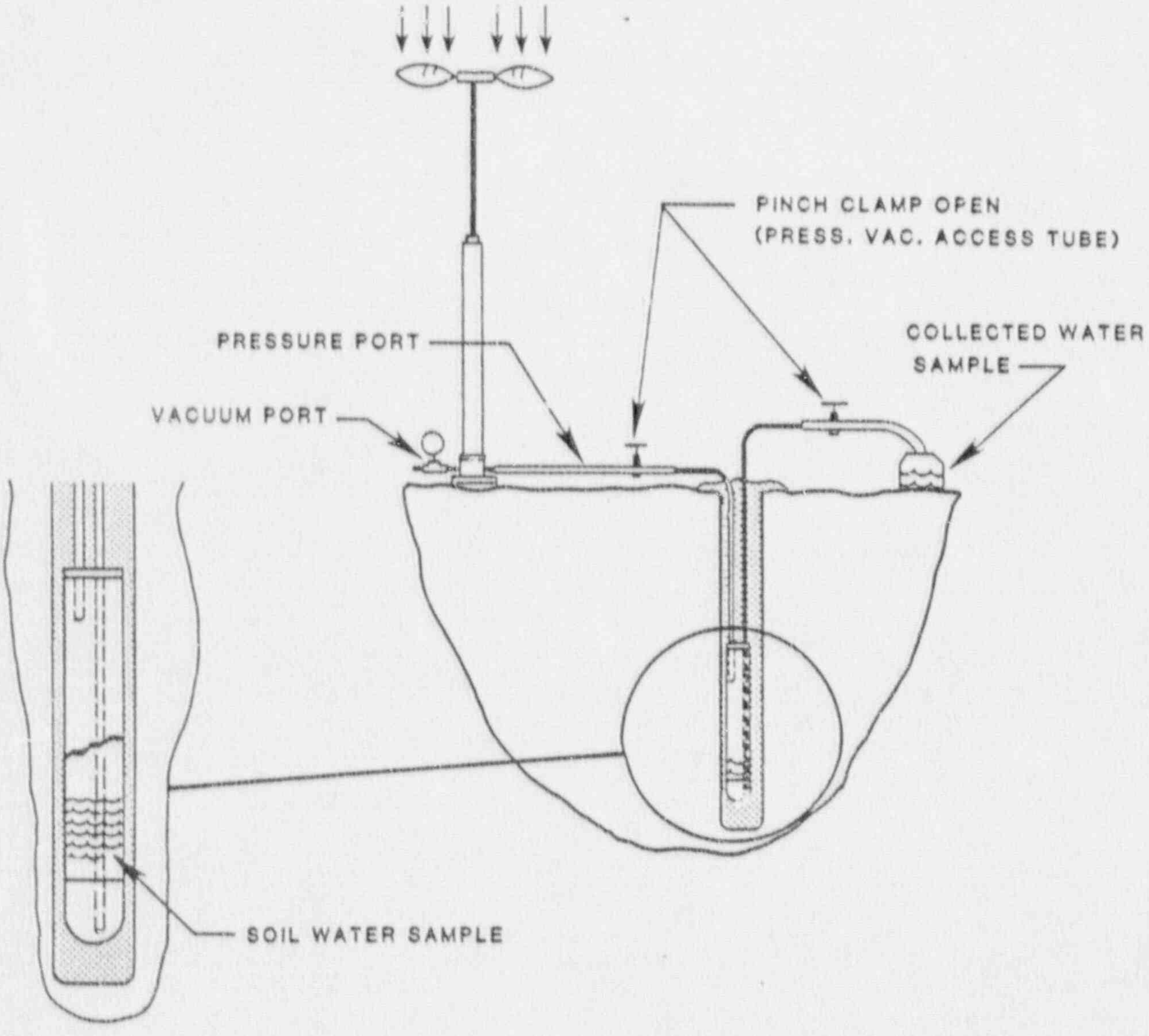


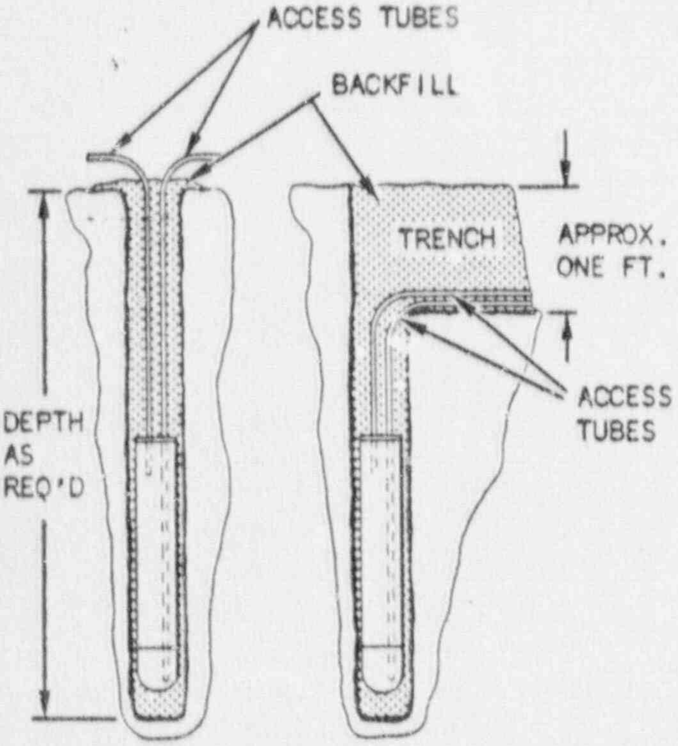
FIGURE 5
PROCEDURE FOR SAMPLE REMOVAL

Attachment 1

OPERATING INSTRUCTIONS for the

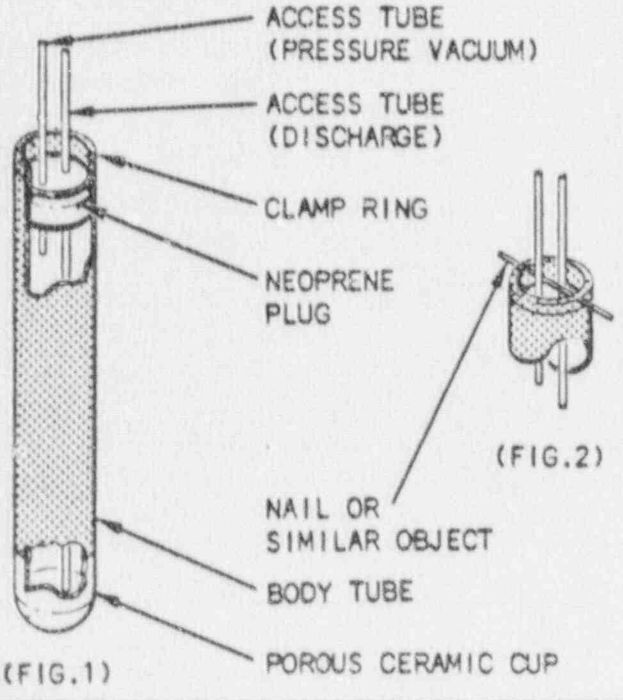
Model 1920

PRESSURE-VACUUM SOIL WATER SAMPLER



SITE LOCATION

The Model 1920 Pressure-Vacuum Soil Water Sampler can be installed in any location, at any depth up to a maximum of 50 ft. The access tubes from the sampler may be terminated directly above the sampler installation or, if conditions require, the access tubes may be laid in a trench and carried to a remote location, terminated above the soil surface. The access tubes should be located so that they will be free from damage by mechanical equipment and by livestock. The surface area directly above the sampler should not be covered in any manner that would interfere with the normal percolation of soil moisture down to the depth of the sampler. Once the depth and location for the pressure-vacuum soil water sampler has been decided, the length of the access tubes should be determined so that they can be cut and mounted into the soil water sampler.



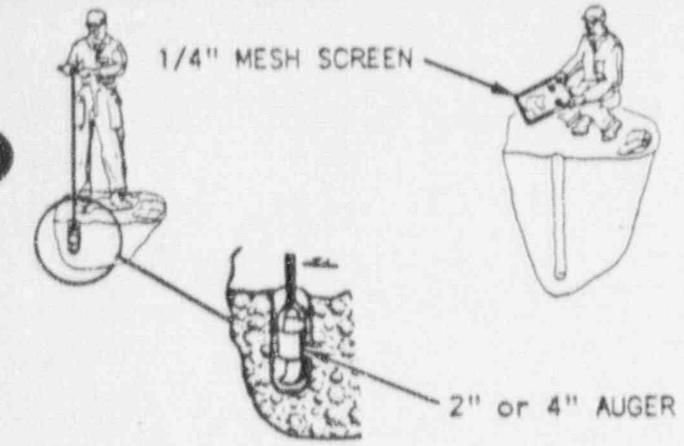
(FIG.2)

(FIG.1)

INSTALLATION OF ACCESS TUBES IN THE SAMPLER

(Fig.1) The access tubes are normally made from 1/4" diameter copper or polyethylene tubing. When installing the tubes, one tube should be pushed through the neoprene plug so that the end of the tubing reaches almost down to the bottom of the porous ceramic cup. This "discharge" access tube should be marked at the other end in some fashion as to identify it. The other "pressure-vacuum" access tube should be inserted into the neoprene plug so that it extends through the plug perhaps one inch.

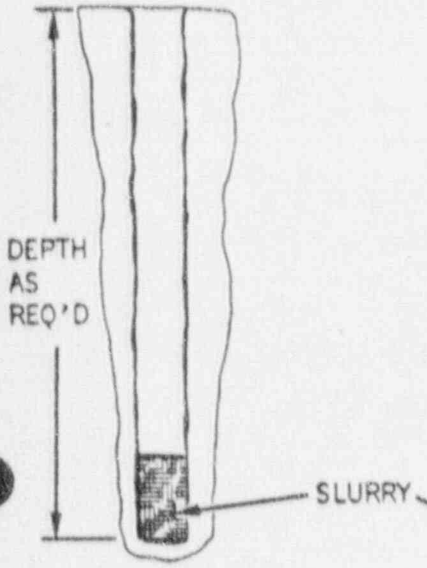
(Fig.2) After the tubes are installed, tighten the clamp ring with a nail or similar object inserted through the holes provided in the clamp ring. Tighten only until it meets the body tube. See note on page 5 if potting is desired.



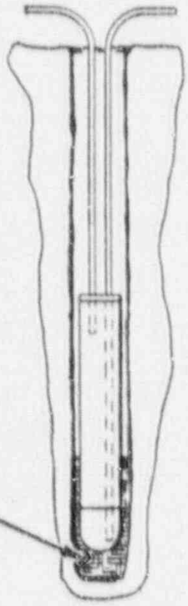
CORING THE HOLE

In rock-free uniform soils at shallow depths, use a 2" screw or bucket auger for coring the hole.

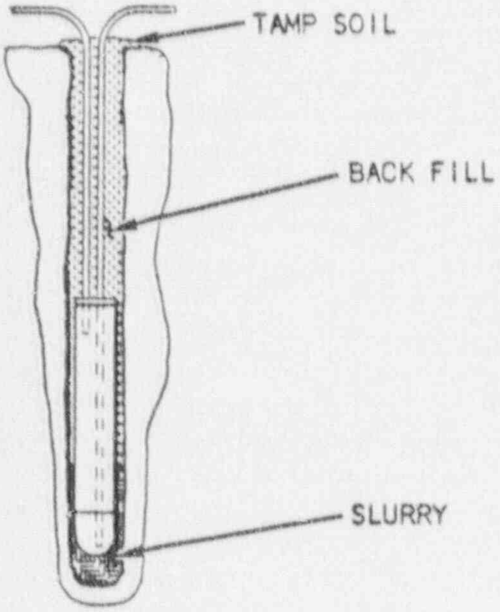
If the soil is rocky, a 4" auger should be used. The soil should then be sifted through a 1/4" mesh screen to free it of pebbles and rocks. This will provide a reasonably uniform backfill soil for filling in around the soil water sampler. The Model 230 Series Soil Augers can be used for this purpose.



(FIG.1)



(FIG.2)



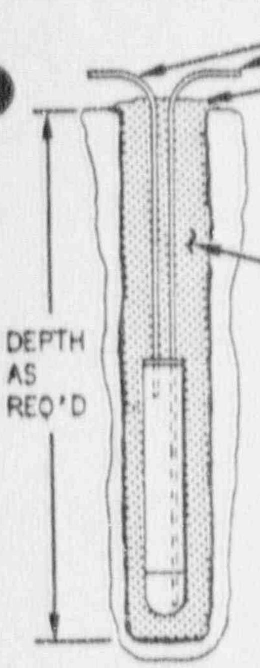
(FIG.3)

INSTALLATION OF PRESSURE-VACUUM SOIL WATER SAMPLER USING A SOIL SLURRY

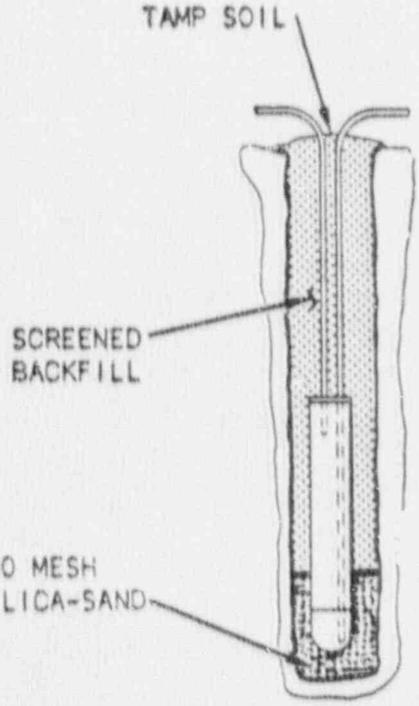
(Fig.1) After the hole has been cored, mix a substantial quantity of soil from the bottom of the hole with water to make a slurry which has a consistency of cement mortar. This slurry is then poured down to the bottom of the cored hole to insure a good soil contact with the porous ceramic cup.

(Fig.2) Immediately after the slurry has been poured, push the soil water sampler down into the hole so that the porous ceramic cup is completely embedded in the soil slurry.

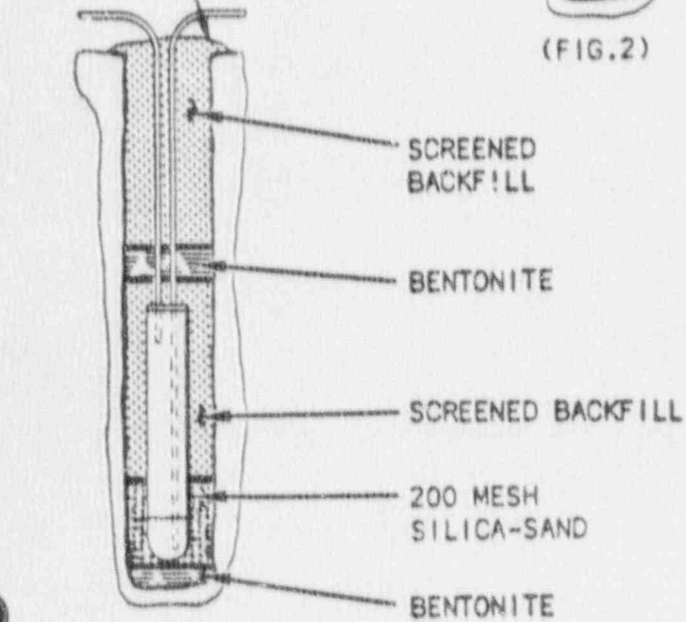
(Fig.3) Backfill the remaining area around the soil water sampler, tamping lightly with a small diameter rod. Backfill the remainder of the hole, tamping soil firmly, to prevent surface water from running down the cored hole. Backfill hole with native soil free of pebbles and rocks.



(FIG.1)



(FIG.2)



(FIG.3)

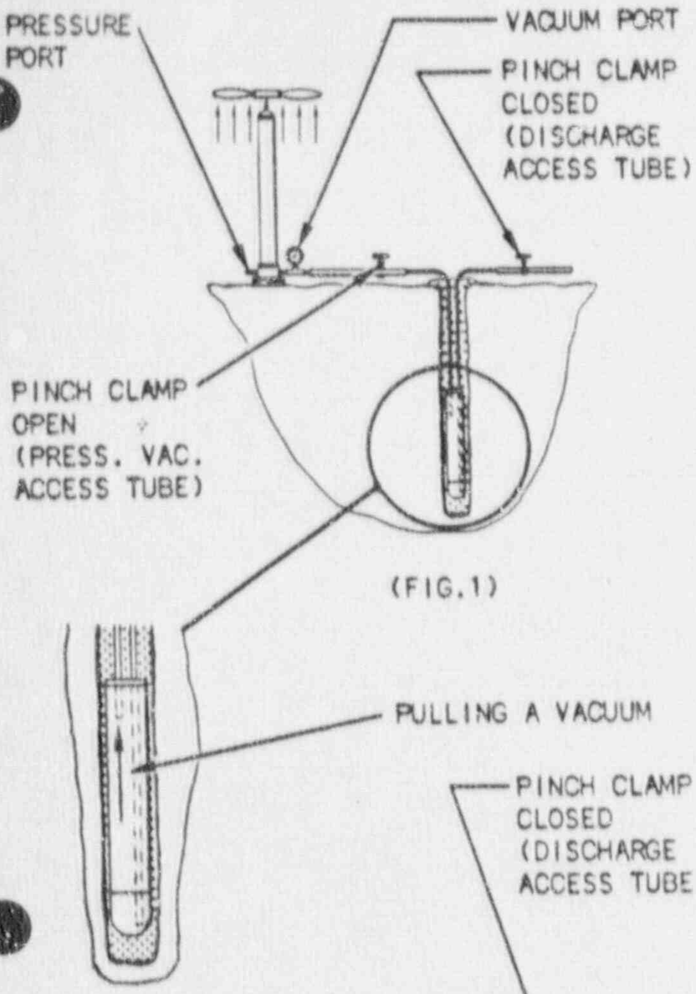
ADDITIONAL METHODS OF INSTALLING THE PRESSURE-VACUUM SAMPLER

(Fig.1) Core hole to desired depth, insert soil water sampler and backfill the hole with native soil, tamping continuously to insure good soil contact with the porous ceramic cup and complete sealing of the cored hole.

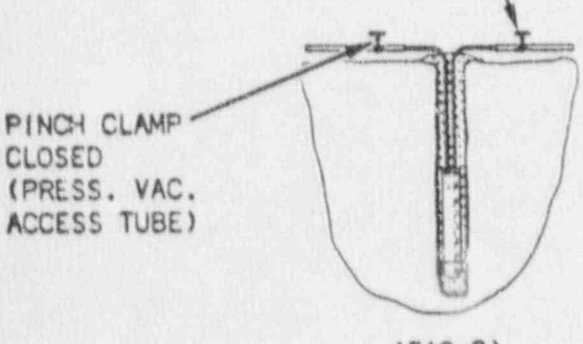
(Fig.2) Core hole to desired depth, pour in a small quantity of crushed 200 mesh pure silica-sand of almost talcum powder consistency (commercially available under trade names of Super-Sil and Silica Flour). Insert soil water sampler and pour another layer of the 200 mesh silica-sand at least six inches deep around cup of the soil water sampler. Backfill the hole with soil free of pebbles and rocks, tamping continuously with a long metal rod to insure against surface water channeling down between the soil and the body tube of the sampler.

(Fig.3) Core hole to desired depth, pour in a small quantity of wet bentonite clay. This will isolate the sampler from the soil below. Pour in a small quantity of 200 mesh silica-sand and insert soil water sampler. Pour another layer of 200 mesh silica-sand at least six inches deep around the cup of the soil water sampler. Backfill with native soil to a level just above the soil water sampler and again add a small quantity of bentonite as a plug, to further isolate the soil water sampler and guard against possible channeling of water down the hole. Backfill the remainder of the hole slowly, tamping continuously with a long metal rod. Again backfill should be of native soil free of pebbles and rocks.

There are other methods of installing the soil water samplers that may be used, largely dictated by the type of soil you are concerned with and the tools available. The primary concern in any method of installation is that the porous ceramic cup of the sampler be in tight, intimate contact with the soil, so that soil moisture can move readily from the pores of the soil through the pores in the ceramic cup and into the soil water sampler.



(FIG.1)



(FIG.2)

COLLECTING SOIL WATER SAMPLE

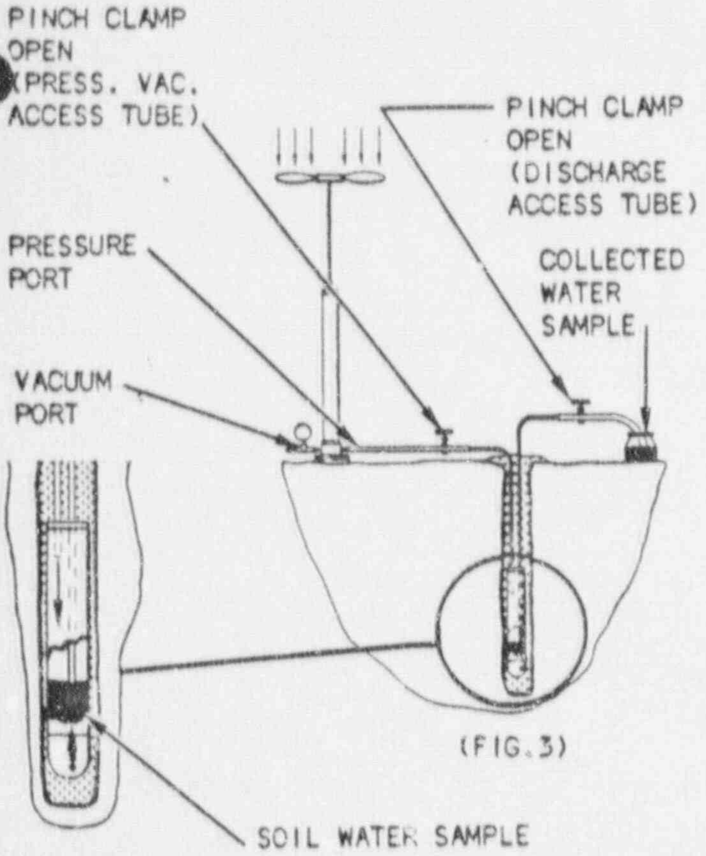
After the pressure-vacuum soil water sampler has been installed in the field, the accessory items are added as shown on page 6 .

(Fig.1) To collect a sample, the pinch clamp on the discharge access tube is closed and the vacuum port of the pressure-vacuum hand pump is connected to the pressure-vacuum access tube. The pump is then stroked until a vacuum of perhaps 60 centibars (18" of mercury) is created within the sampler, as read out on the gauge connected to the pump.

(Fig.2) The pinch clamp on the pressure-vacuum access tube is then closed securely to seal the sampler under vacuum. The hand pump can then be removed for other uses. The sampler is allowed to set for a period of time under vacuum.

The vacuum within the sampler causes the moisture to move from the soil, through the porous ceramic cup, and into the sampler. The rate at which the soil solution will collect within the sampler depends on the capillary conductivity of the soil, the soil suction value within the soil (as measured with tensiometers), and the amount of vacuum that has been created within the sampler. In moist soils of good conductivity, at field capacity (10 to 30 centibars of soil suction as read on a tensiometer) substantial soil water samples can be collected within a few hours. Under more difficult conditions it may require several days to collect an adequate sample.

In general, vacuums of 50 to 85 centibars (15" to 25" of mercury) are normally applied to the soil water sampler. In very sandy soils it has been noted, however, that very high vacuums applied to the soil water sampler seem to result in slower rate of collection of the sample than lower applied vacuums. It is our feeling that in these coarse, sandy soils, the high vacuums within the sampler may deplete the moisture in the immediate vicinity of the porous ceramic cup and hence reduce the capillary conductivity, which creates a barrier to the flow of moisture to the cup under these circumstances. In loams and gravelly clay loams, users have reported collection of 300 to 500 ml of solution over a period of a day with applied vacuum of 15" of mercury (50 centibars) when soils are at field capacity. On waste water disposal sites, some users have obtained up to 1500 m of sample within 24 hours after cessation of irrigation with 1" to 2" of waste water on sandy or clay loam soil.



(FIG.3)

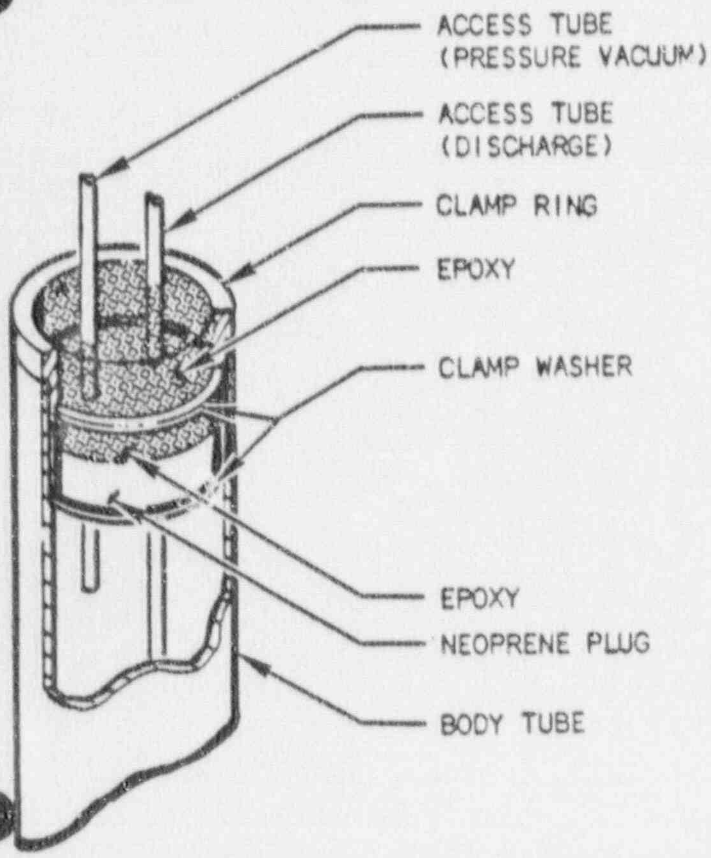
(Fig.3) To recover a soil water sample, attach the pressure-vacuum access tube to the pressure port on the pump. Place the discharge access tube in a small collection bottle and open both pinch clamps. Apply a few strokes on the hand pump to develop enough pressure within the sampler to force the collected water out of the sampler and into the collection bottle.

Subsequent samples are collected by again creating a vacuum within the sampler and following the steps as outlined above.

MAINTENANCE

There are no maintenance requirements for the pressure-vacuum soil water samplers, other than protecting the access tubes from damage. Tube ends should be covered or plugged to prevent debris from entering the tubes and later contaminating the sample.

Freezing conditions will not damage the samplers. The samplers are normally left permanently in place throughout the year.



INSTRUCTIONS FOR POTTING

With our current design, we do not feel that potting of the neoprene plug is necessary to maintain a permanent pressure-vacuum seal; however, if you desire, the design has been arranged so that these elements can be potted with an epoxy resin.

(1) INSTALL ACCESS TUBES

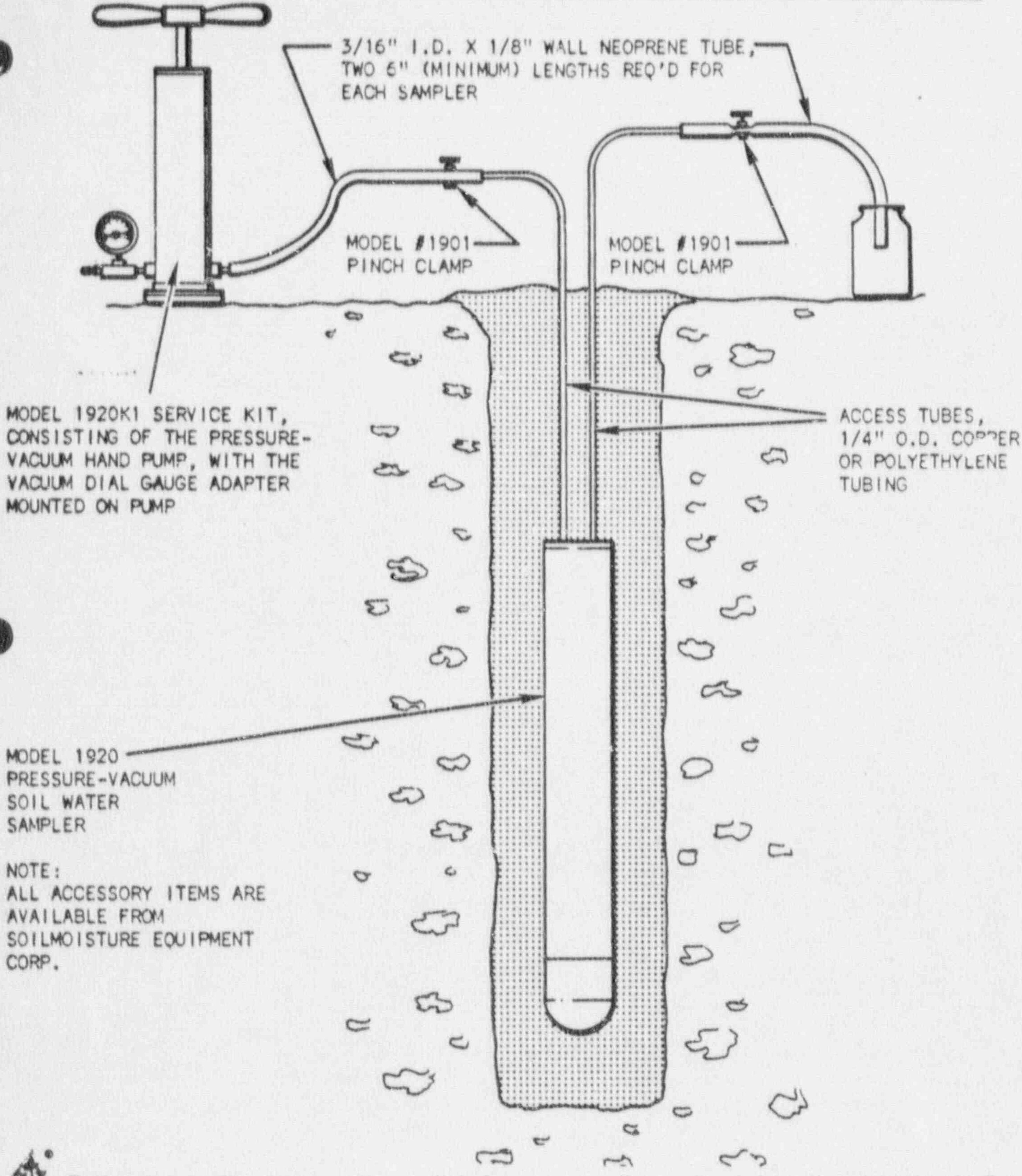
(2) INSTALL FIRST CLAMP WASHER

(3) INSTALL NEOPRENE PLUG AND ADD EPOXY TO THE OUTSIDE DIAMETER

(4) INSTALL SECOND CLAMP WASHER

(5) SCREW CLAMP RING IN PLACE, AND POUR EPOXY INTO CAVITY TO COMPLETELY SEAL THE NEOPRENE PLUG AND ACCESS TUBES

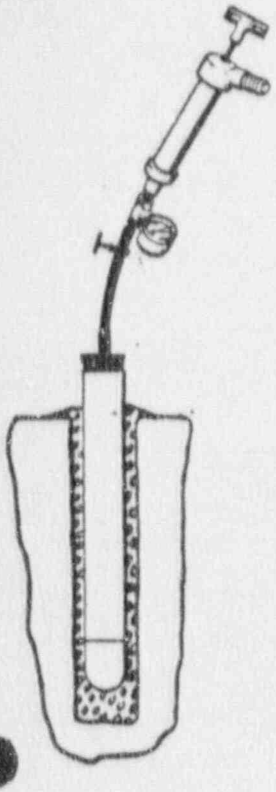
ACCESSORY ITEMS REQUIRED FOR OPERATION OF THE PRESSURE-VACUUM SOIL WATER SAMPLER



NOTE:
ALL ACCESSORY ITEMS ARE AVAILABLE FROM SOILMOISTURE EQUIPMENT CORP.

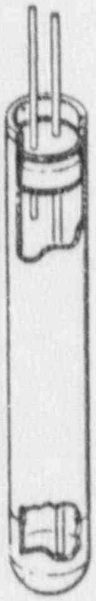
Soilmoisture Equipment Corp.

About Our Soil Water Samplers



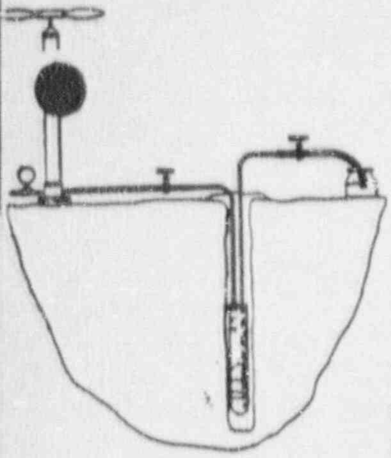
Our Soil Water Samplers, which are sometimes referred to as "suction lysimeters" or "lysimeters" are now in general use, and many thousands of these are currently installed in this country and other countries throughout the world. The soil water samplers had their origin back in 1961 when we cooperated with Dr. George H. Wagner at the University of Missouri to fabricate a porous ceramic cup for this purpose. The outgrowth of this work was the first commercial soil water sampler, which was assigned our Cat. No. 1900. Since that time, these samplers have been generally accepted as an ideal tool for securing soil water samples in situ for a great variety of soil moisture monitoring work.

The most extensive initial use of these samplers was made by Pennsylvania State University, largely under the direction of Dr. L. T. Kardos and others, on the Pennsylvania Waste Water Project. Modifications of the original Cat. No. 1900 Soil Water Sampler to produce a pressure-vacuum type unit was done by Richard R. Parizek and Burke E. Lane at the Pennsylvania State University, and reported on in the Journal of Hydrology. Since that time, we have made available commercially our Model 1920 Pressure-Vacuum Soil Water Sampler. Some of our soil water samplers have been in continuous use now for a period of ten years and are still yielding satisfactory soil moisture samples. The samplers find application not only in research work but for pollution control purposes, such as monitoring the moisture under sanitary landfills and under areas irrigated with wastewater. Various models of our Soil Water Samplers are available for installation at depths ranging from the surface to 300 ft.



Our Model 1900 Soil Water Sampler is designed for installation near the surface, at depths ranging from 6" to 6'. This type of sampler projects several inches above the soil surface after installation and is serviced at the exposed end. The Model 1900 Soil Water Sampler, along with the Model 1920 Pressure-Vacuum Soil Water Sampler, is pictured and described on the backpage of our six-page general brochure entitled, "A Full Range of Soilmoisture Extractors". The enclosed operating instructions for this unit will give you details of installation and operation and also spell out the accessory items required. All items are carried on our current price list.

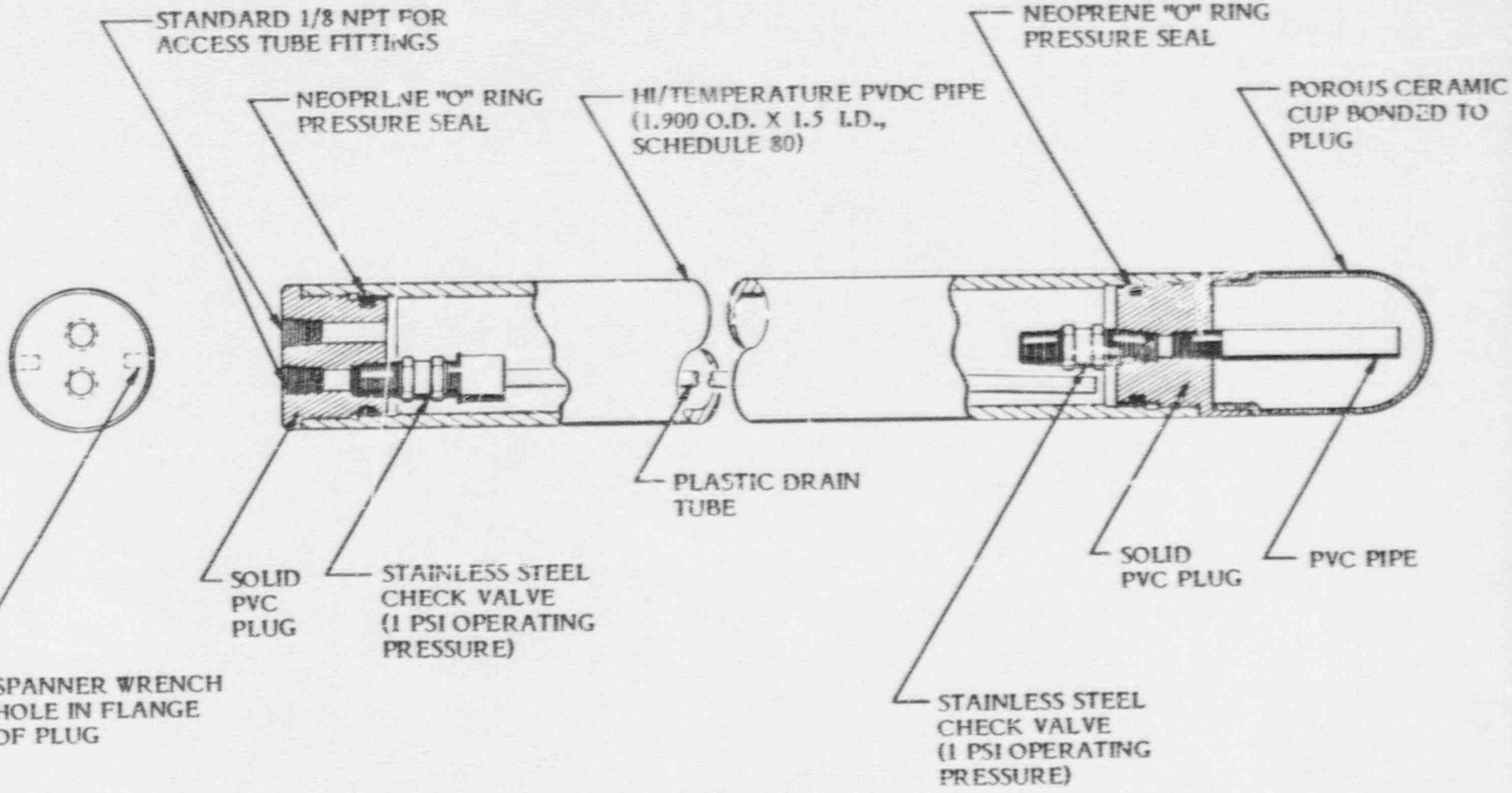
Our Model 1920 Pressure-Vacuum Soil Water Sampler is designed to be completely buried in the soil. The overall length of this unit is approximately 24" and is serviced by two access tubes. This is the type of sampler frequently used in monitoring for polution, since the access tubes can be located at a distance from the sampler and in an area out of the way of surface traffic.



These samplers are normally installed at a minimum depth of 3 ft. and can be used at depths of up to 50 ft. It is possible to use these units at somewhat greater depths than 50 ft., perhaps as high as 70 ft.; however, at greater depths, a substantial amount of the collected sample is forced back into the soil, through the porous ceramic cup, by the high air pressure necessary to force the collected sample up to the surface. If you are concerned with extracting solutions at great depths, our Model 1940 Hi/Pressure-Vacuum Soil Water Sampler should be used.

The enclosed instruction information on the Model 1920 Pressure-Vacuum Soil Water Sampler will give you details of installation and operation. Page 6 of these instructions shows a cross section of the 1920 Pressure-Vacuum Soil Water Sampler installed in the field and indicates the specific accessory items required for its operation. All items are carried on our current price list.

If you are involved with sampling moisture at depths beyond the range of our Model 1920, we have available our Model 1940 Hi/Pressure-Vacuum Soil Water Sampler that can be used up to depths of 300 ft. The enclosed engineering schematic shows the operating features of this type of sampler. Basically, the unit incorporates two check valves which permit the flow of water from the soil into an upper chamber when vacuum is applied. When pressure is subsequently applied to remove the collected sample, the pressure is prevented from reaching the porous ceramic cup chamber by one of the check valves. With this type of arrangement, high pressures can be exerted to remove the collected sample from great depths without damage to the porous ceramic cup. Other than the features mentioned above, the operation of the Hi/Pressure-Vacuum Soil Water Sampler is similar to the Model 1920 Pressure-Vacuum Soil Water Sampler. Prices are carried on the current price list.



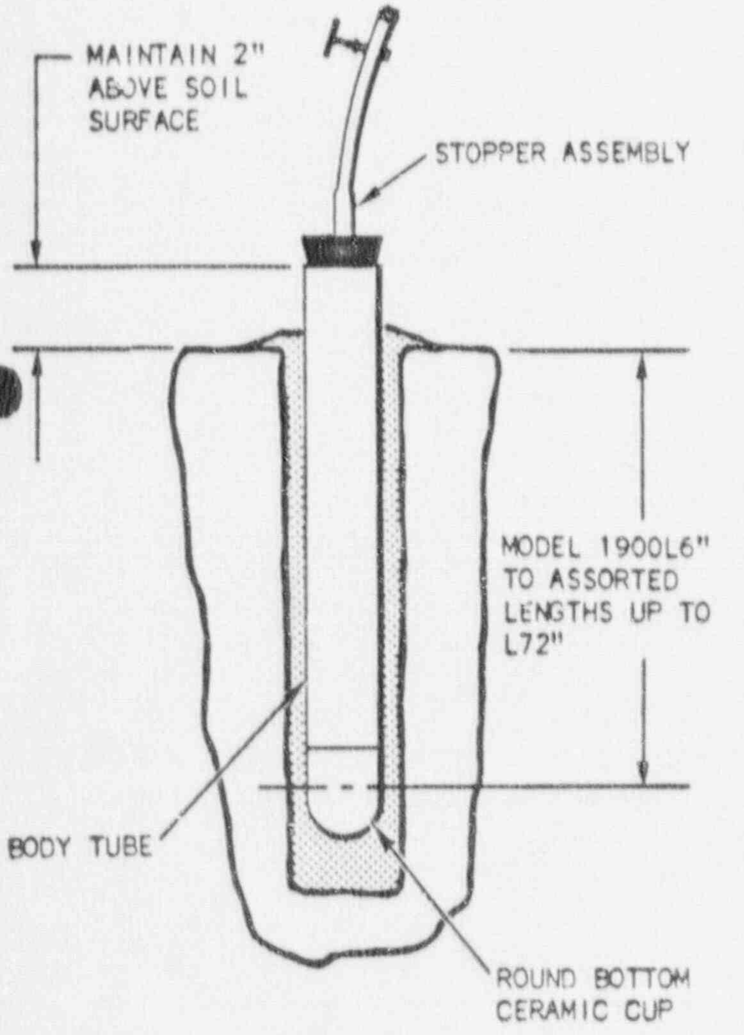
MODEL 1940 HI/PRESSURE-VACUUM SOIL WATER SAMPLER

OVERALL DIMENSIONS: 1.9" OUTSIDE DIAMETER BY 24" LONG

SOILMOISTURE equipment corp.
SANTA BARBARA, CALIF.

SCALE:	APPROVED BY:	DRAWN BY R. Harper
DATE:		REVISED
HI/PRESSURE-VACUUM SOIL WATER SAMPLER		
SCHEMATIC		DRAWING NUMBER 1940

OPERATING INSTRUCTIONS for the *Model 1900* SOIL WATER SAMPLER



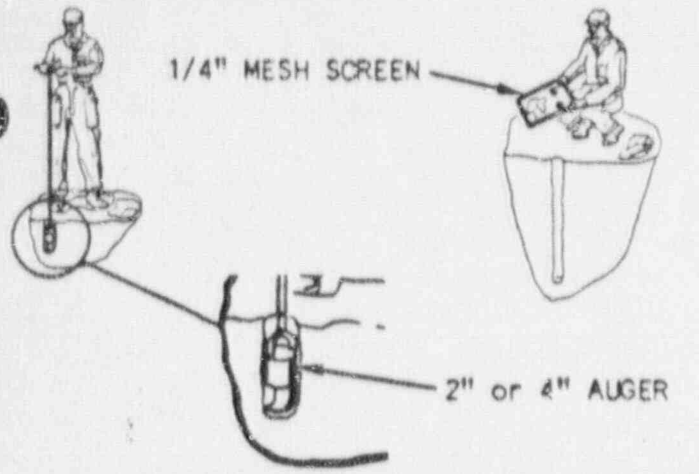
SITE LOCATION

The Model 1900 Soil Water Sampler can be installed in any location. The sampler can be installed in well drained soil or in areas where the water table is above the sampling depth. The surface area directly above the sampler should not be covered in any manner that would interfere with the normal percolation of soil moisture down to the depth of the sampler.

The samplers are normally installed vertically in the soil. However, they can be installed at an angle if this is necessary to reach some otherwise inaccessible point.

The samplers are available in various stock lengths for installation at depths up to 6 ft. Extra length samplers can be provided on special order, if this is necessary. However, for depths greater than 6 ft. it is normally less expensive to use the Model 1920 Pressure-Vacuum Soil Water Sampler.

The Model 1900 Soil Water Sampler has been designed so that the body tube of the sampler projects 2" above the soil surface when the sampler is installed to the proper depth, as shown in the figure to the left.

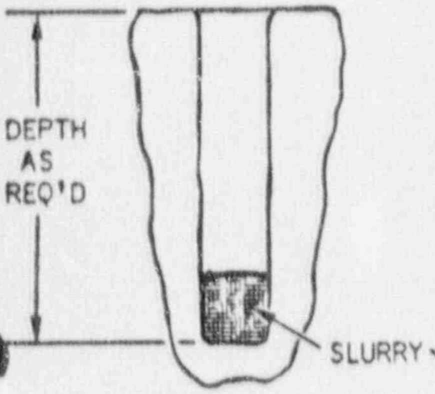


CORING THE HOLE

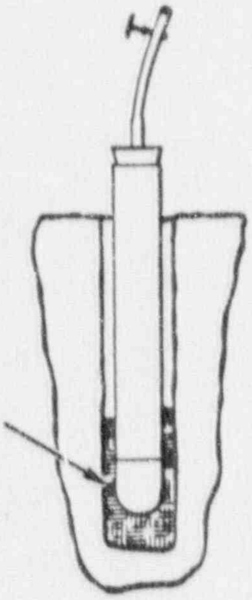
In rock-free uniform soils at shallow depths, use a 2" screw or bucket auger for coring the hole.

If the soil is rocky, a 4" auger should be used. The soil should then be sifted through a 1/4" mesh screen to free it of pebbles and rocks. This will provide a reasonably uniform backfill soil for filling in around the soil water sampler. The Model 230 Series Soil Augers can be used for this purpose.

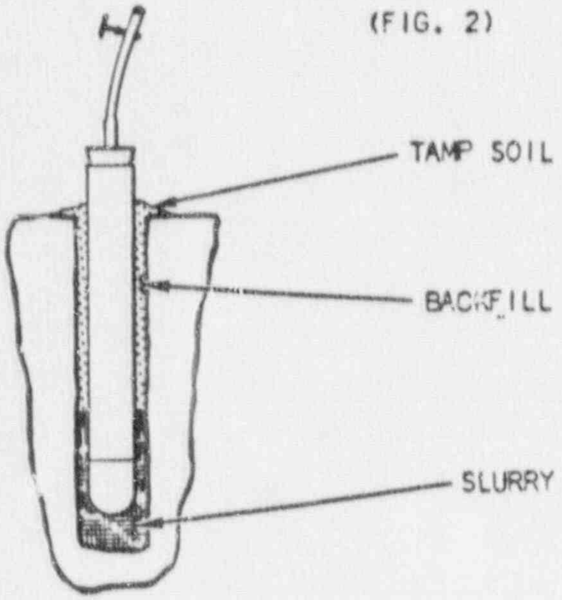
INSTALLATION OF SOIL WATER SAMPLER USING A SOIL SLURRY



(FIG. 1)



(FIG. 2)

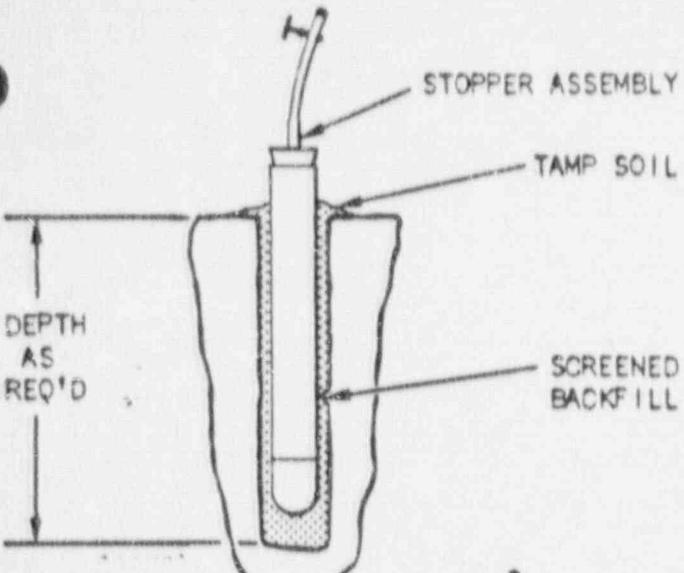


(FIG. 3)

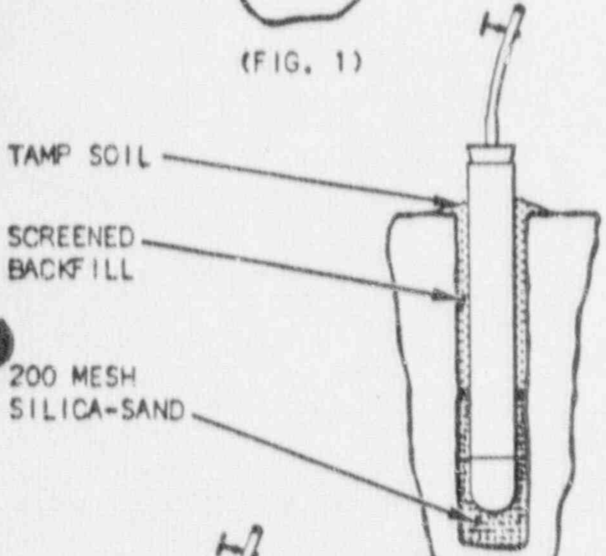
(Fig. 1) After the hole has been cored, mix a substantial quantity of soil from the bottom of the hole with water to make a slurry which has a consistency of cement mortar. This slurry is then poured down to the bottom of the cored hole to insure a good soil contact with the porous ceramic cup.

(Fig. 2) Immediately after the slurry has been poured, push the soil water sampler down into the hole so that the porous ceramic cup is completely embedded in the soil slurry.

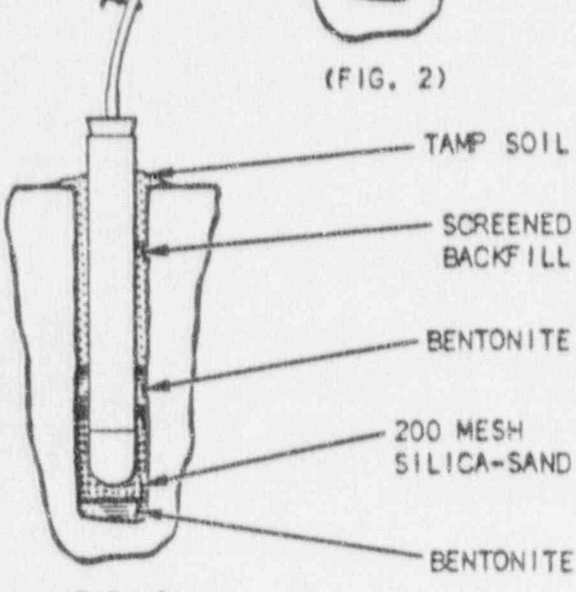
(Fig. 3) Backfill the remaining area around the soil water sampler, tamping soil firmly, to prevent surface water from running down the cored hole. Backfill hole with native soil free of pebbles and rocks.



(FIG. 1)



(FIG. 2)



(FIG. 3)

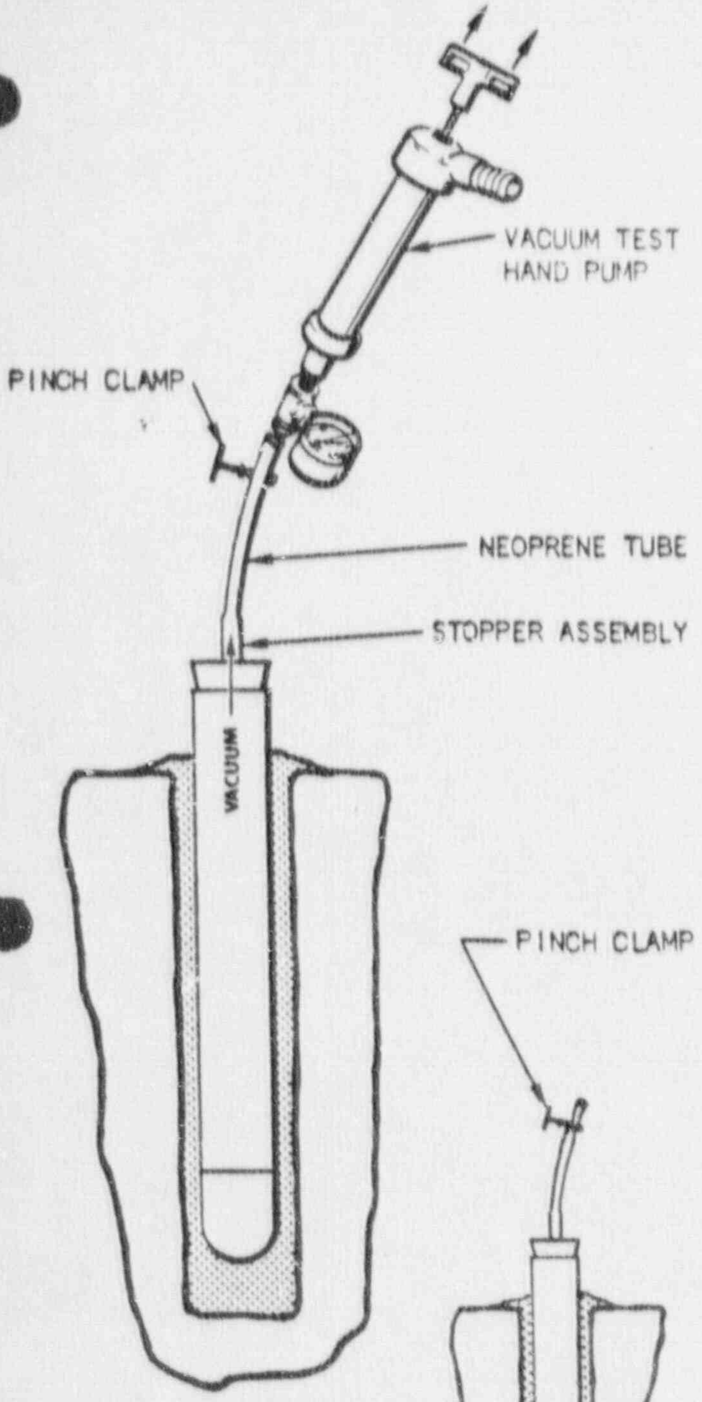
ADDITIONAL METHODS OF INSTALLING THE SOIL WATER SAMPLER

(Fig.1) Core hole to desired depth, insert soil water sampler and backfill the hole with native soil, tamping continuously to insure good soil contact with the porous ceramic cup and complete sealing of the cored hole.

(Fig.2) Core hole to desired depth, pour in a small quantity of crushed 200 mesh pure silica-sand of almost talcum powder consistency (commercially available under trade names of Super-Sil and Silica Flour). Insert soil water sampler and pour another layer of the 200 mesh silica-sand at least six inches deep around cup of the soil water sampler. Backfill the hole with soil free of pebbles and rocks, tamping continuously with a long metal rod to insure against surface water channeling down between the soil and the body tube of the sampler.

(Fig. 3) Core hole to desired depth, pour in a small quantity of wet bentonite clay. This will isolate the sampler from the soil below. Pour in a small quantity of 200 mesh silica-sand and insert soil water sampler. Pour another layer of 200 mesh silica-sand at least six inches deep around the cup of the soil water sampler. Again, add a small quantity of bentonite as a plug to further isolate the ceramic cup and guard against possible channeling of water down the hole. Backfill the remainder of the hole with native soil free of pebbles and rocks, tamping continuously with a long metal rod.

There are other methods of installing the soil water sampler that may be used, largely dictated by the type of soil you are concerned with and the tools available. The primary concern in any method of installation is that the porous cup of the sampler be in tight, intimate contact with the soil, so that soil moisture can move readily from the pores of the soil through the pores in the ceramic cup and into the soil water sampler.



(FIG. 1)

(FIG. 2)

COLLECTING SOIL WATER SAMPLE

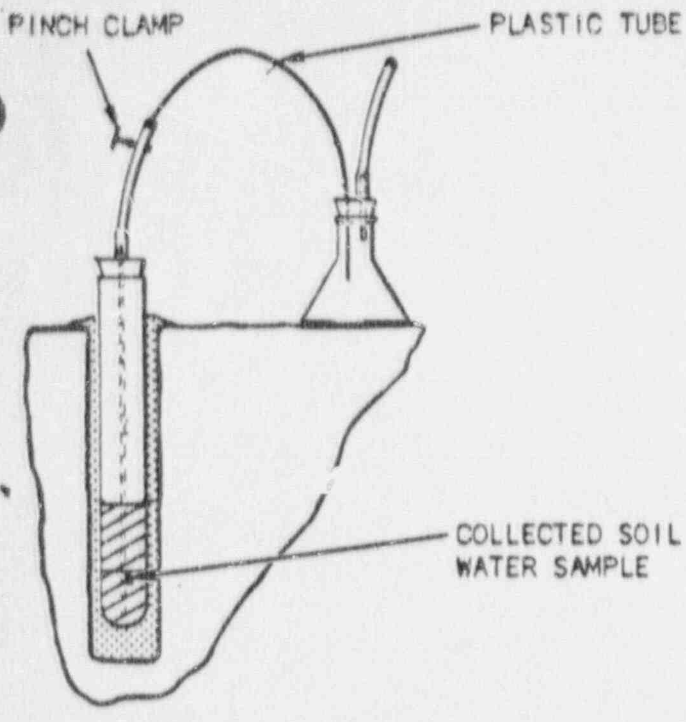
After the soil water sampler has been installed in the field, the accessory items as shown on page 6 are used for collecting a soil water sample.

(Fig.1) To collect a sample, the pinch clamp on the stopper assembly is opened. The serrated tube fitting on the end of the vacuum dial gauge adapter is then inserted into the neoprene tube of the stopper assembly. The vacuum hand pump is then stroked until a vacuum of perhaps 60 centibars (18" of mercury) is created within the sampler, as read out on the vacuum dial gauge.

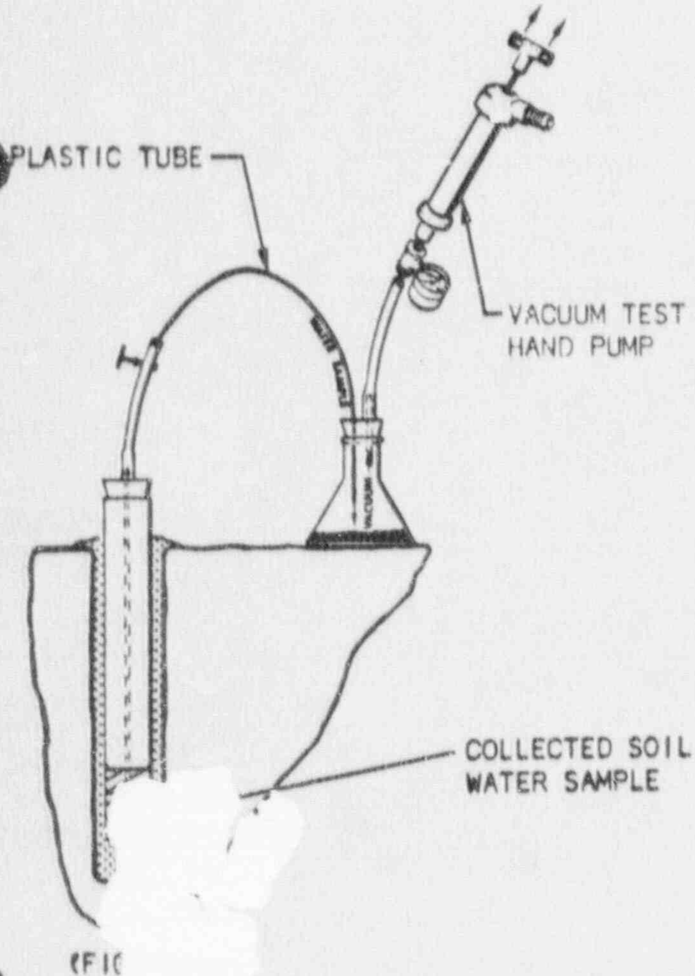
(Fig.2) The pinch clamp is then closed securely to seal the sampler under vacuum. The hand pump can then be removed for other uses. The sampler is allowed to set for a period of time under vacuum.

The vacuum within the sampler causes the moisture to move from the soil, through the porous ceramic cup, and into the sampler. The rate at which the soil solution will collect within the sampler depends on the capillary conductivity of the soil, the soil suction value within the soil (as measured with tensiometers), and the amount of vacuum that has been created within the sampler. In moist soils of good conductivity, at field capacity (10 to 30 centibars of soil suction as read on a tensiometer), substantial soil water samples can be collected within a few hours. Under more difficult conditions it may require several days to collect an adequate sample.

In general, vacuums of 50 to 85 centibars (15" to 25" of mercury) are normally applied to the soil water sampler. In very sandy soils it has been noted, however, that very high vacuums applied to the soil water sampler seem to result in slower rate of collection of the sample than lower applied vacuums. It is our feeling that in these coarse, sandy soils, the high vacuum within the sampler may deplete the moisture in the immediate vicinity of the porous ceramic cup and hence reduce the capillary conductivity, which creates a barrier to the flow of moisture to the cup under these circumstances. In loams and gravelly clay loams, users have reported collection of 300 to 500 ml of solution over a period of a day with applied vacuum of 15" of mercury (50 centibars) when soils are at field capacity. On waste water disposal sites,



(FIG. 3)



(FI

some users have obtained up to 1500 ml of sample within 24 hours after cessation of irrigation with 1" to 2" waste water on sandy or clay loam soil.

(Fig.3) To remove the soil water sample from the sampler, a simple assembly is usually made up consisting of a small diameter (3/32" O.D. or less) plastic tube, a two-hole rubber stopper, a flask or bottle, as shown.

The pinch clamp on the sampler is opened and the small diameter plastic tube is inserted into the end of the neoprene tube on the stopper assembly and pushed down until it reaches the bottom of the sampler.

(Fig.4) The vacuum hand pump is then connected to the other hole in the stopper. Stroking the hand pump creates a vacuum within the bottle or flask which in turn sucks the sample up from the sampler and into the collection bottle or flask.

If it is more convenient, the stopper assembly can be removed from the sampler so that the collected sample can be removed with a pipette or other means. However, repeated removal and replacement of the rubber stopper assembly can disturb the seal between the soil and the body tube of the sampler, particularly on shallow units.

Subsequent samples are collected by again creating a vacuum within the sampler and following the steps as outlined above.

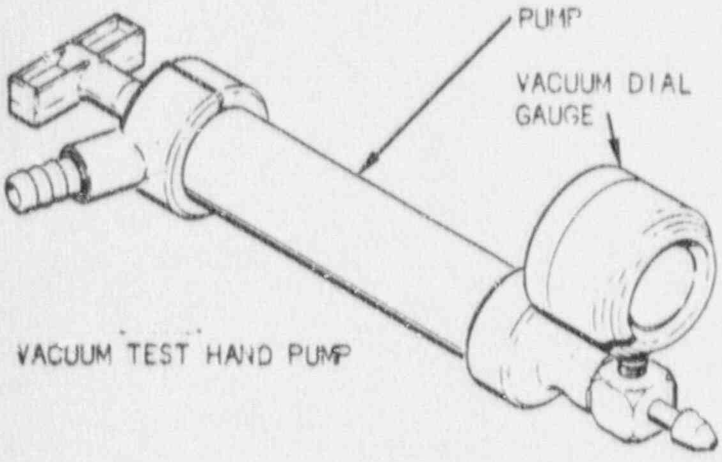
MAINTENANCE

There are no maintenance requirements for the soil water samplers other than protecting the exposed end of the body tube and the stopper assembly from physical damage. The end of the neoprene tube on the stopper assembly should be covered or plugged to prevent debris from entering the tube and later contaminating the sample.

Freezing conditions will not damage the samplers. The samplers are normally left permanently in place throughout the year.

ACCESSORY ITEMS FOR OPERATION OF THE SOIL WATER SAMPLER

1900K1 SERVICE KIT
CONSISTING OF:



TUBING

1/16" O.D. X 1/64" WALL NYLON TUBE

5/64" O.D. X 1/64" WALL NYLON TUBE

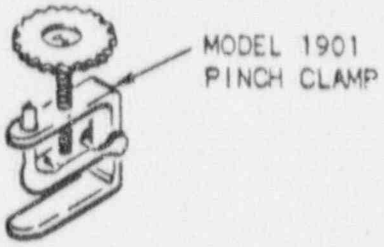
3/32" O.D. X 1/64" WALL NYLON TUBE

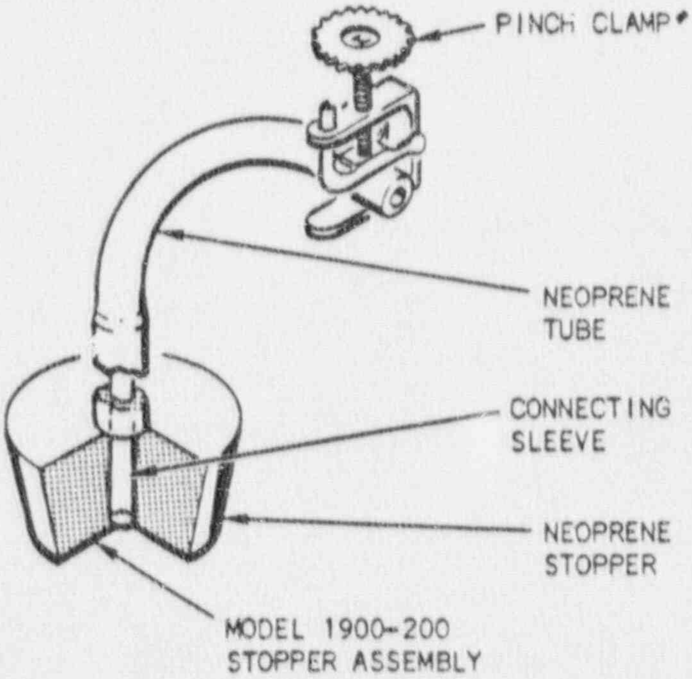
3/16" I.D. X 1/8" WALL NEOPRENE TUBE

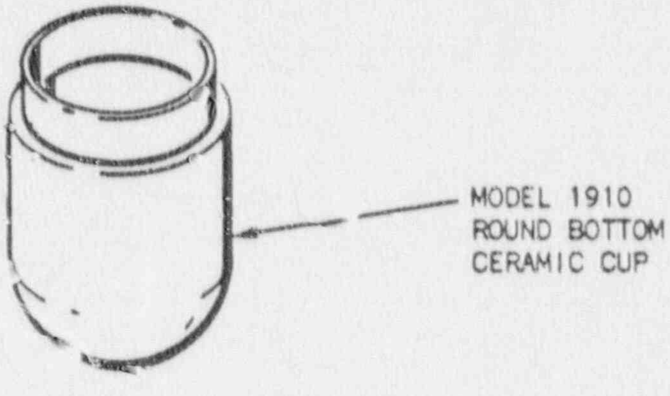
(ORDER NUMBER OF FEET REQUIRED)

NOTE:
ALL ACCESSORY ITEMS ARE AVAILABLE FROM SOILMOISTURE EQUIPMENT CORP.

REPLACEMENT ITEMS FOR THE SOIL WATER SAMPLER







JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

SOIL WATER SAMPLING RECORD

SITE ID : ______

LOCATION ID : ______

SAMPLE ID : ______

SAMPLE DEPTH (FT.) ______

SAMPLING DATE ______

SAMPLING TIME ______

VOLUME SAMPLE COLLECTED (ml) ______

VACUUM APPLIED ______

FINAL FIELD VALUES:

pH (S.U.): ______

Ec (mhos/cm) ______

TEMP. (°C): ______

ALKANLINITY (mg/l $CaCO_3$): ______

LOCATION DESCRIPTION ______

	CONTAINER SIZE	NONACIDIFIED	ACIDIFIED	VOL ACID (ml)
NUMBER OF CONTAINERS COLLECTED :	ONE-LITER			
	500 ml			
	250 ml			
SPECIFY OTHERS :				

COMMENTS : ______

FIELD REPRESENTATIVE . ______

ATTACHMENT 2

JEG-AL-ENG-18 (6/87)

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

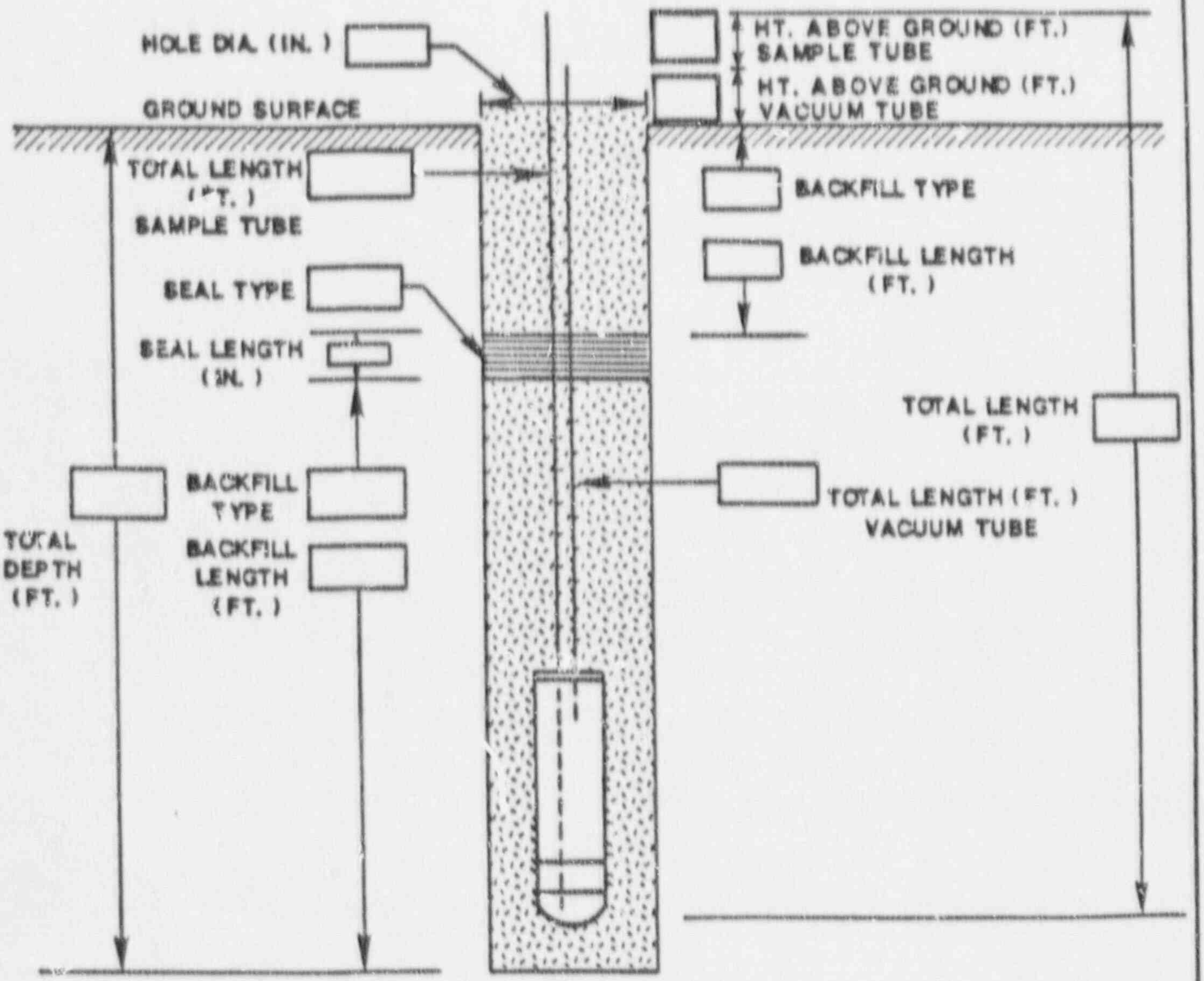
LYSIMETER COMPLETION RECORD

SITE ID : ____________________ LOCATION ID : ________________ DATE INSTALLED : ________________

APPROX. SITE COORINATES :(FT.) N ______________________________ E ________________________

FORMATION OF COMPLETION : ____

FIELD REP : ____

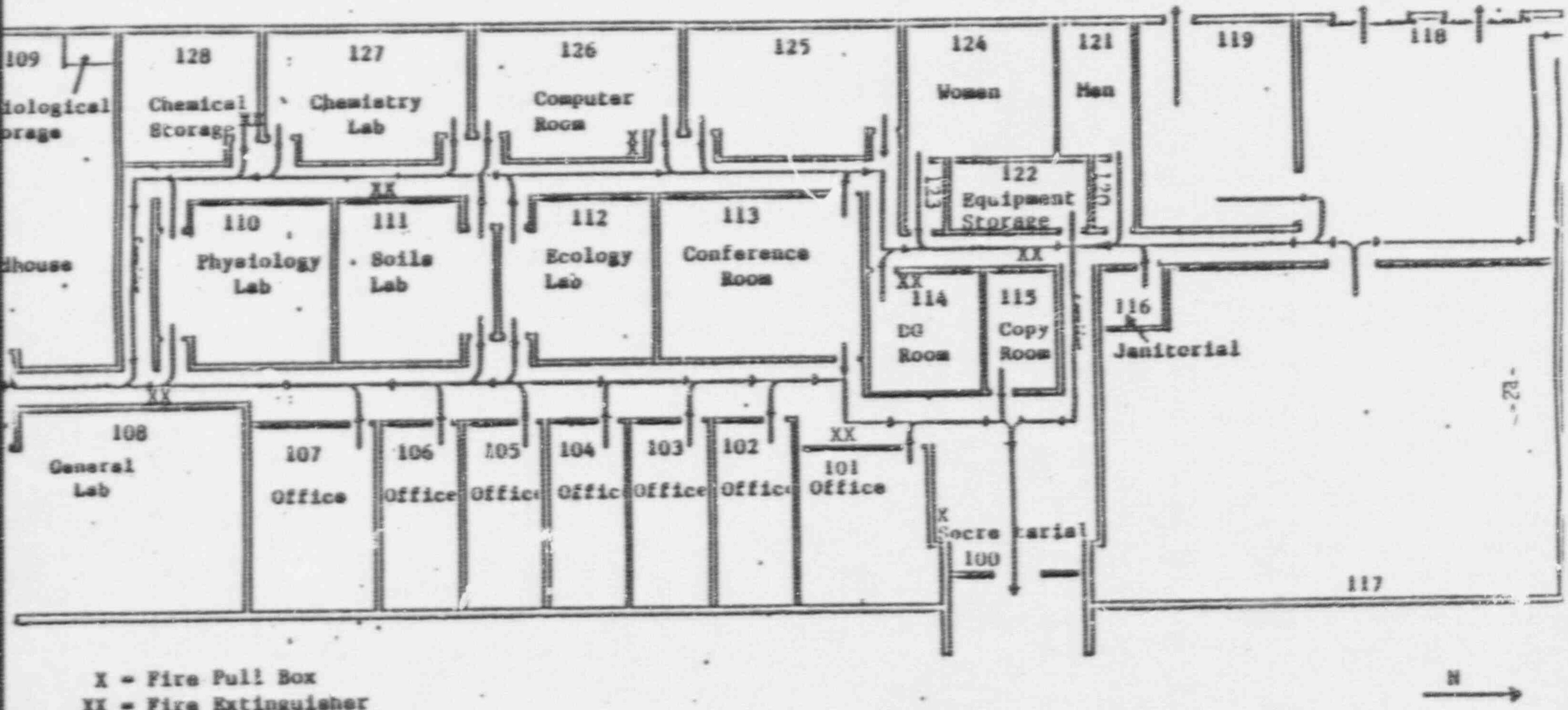


COMMENTS : ____

ATTACHMENT 3

JEG-AL-ENG-48 (8/87)

ROCKY MOUNTAIN FOREST [illegible] RANGE EXPERIMENT STATION
2205 COLUMBIA SE
ALBUQUERQUE, NEW MEXICO 87106
APPENDIX I
EMERGENCY EVACUATION ROUTE



X = Fire Pull Box
XX = Fire Extinguisher

EXHIBIT I

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL

SECTION	16.1.7
DATE	06/09/89
EFFECTIVE	12/04/89
SUPERSEDES	
PAGE	1 OF 10

INSTALLATION/SERVICING OF TENSIOMETERS AND MEASUREMENT OF SOIL WATER POTENTIAL

1.0 PURPOSE

To provide a procedure for the installation and servicing of tensiometers so that field programs for the collection of tensiometer/pressure potential data are properly conducted and documented.

2.0 SCOPE

This procedure is applicable to the TAC and its subcontractors who have duties and responsibilities for the collection of all tensiometer/pressure potential data from tailings sites (both onsite and offsite) and at alternate disposal sites.

3.0 EQUIPMENT & SUPPLIES

3.1 Tensiometer

3.2 Tensiometer Pressure Gauge

3.3 Bourdon Tube Gauge

3.4 Distilled water

3.5 Tamping Rod: PVC, 1" i.d. x 5' (several 5' sections, threaded) OR a Tremie Pipe.

3.6 PVC Pipe: for casing purposes. ~6" diameter, should be Schedule 80 type.

3.7 PVC Pipe cap: for 3.6 above.

3.8 Hollow Stem Auger Drill Rig or

3.9 Air Rotary Drill Rig or

3.10 Head auger

3.11 Split Spoon: 2" diameter (o.d.)

3.12 Vacuum-Pressure Pump, Hand pump

3.13 Kim-wipes or equivalent

3.14 Bentonite, raw or granular.

3.15 Bentonite slurry: a mixture of bentonite and distilled water as specified by the SH.

3.16 Bentonite/soil seal: a 1:1 mixture of bentonite, clean native soil, and distilled water as specified by the SH.

3.17 Native Soil: from Sample Site Location only if site is uncontaminated.

3.18 Wooden dowels: 3/16" diameter (o.d.) x 2" long

3.19 Posts: wood (4" x 4" x ~6'), steel (~4" diameter x ~5'), or Tee-bar steel driven. 3-4 posts per site. See Section 16.1.1 (3.7.7).

3.20 (Optional). Cement for posts.

3.21 Barbed wire, ~100 ft. roll.

3.22 Flagging Material

4.0 PROCEDURE: Pre-field Preparation

The following steps shall be performed no less than ten (10) days before leaving for the field.

4.1 The Site Hydrogeologist (SH) shall determine the number of required tensiometers and locations and shall be approved by the Task Manager of Hydrological Services and the Technical Data Review Committee. NOTE: The tensiometer is an instrument which provides a direct measurement of the negative pressure potential or suction in soil. Tensiometers are used in field experiments where it is necessary to measure the gradient in pressure potential in order to determine the direction and rate of water movement in a soil profile.

4.2 The SH or the Field Technical Representative (FTR) shall check all equipment to ensure that a) there is a sufficient amount of equipment, b) they are in good condition, and c) they are working properly.

4.3 The FTR shall check the supply of distilled water to ensure that there is a sufficient quantity for the proposed field activities or that distilled water can be obtained near the site location before the tensiometers are to be installed.

4.4 For transportation to a site, the SH or FTR shall properly pack the tensiometers so that the dial gauges and ceramic tips are not damaged. Individual tensiometer pieces should be separately wrapped in paper and must be packaged so that they are secure inside the shipping boxes. Use special care so that ceramic tips do not touch grease or similar material that could clog the ceramic tip pores. Label all boxes with proper shipping and return addresses.

4.5 The FTR shall use Attachment 12.1 entitled "Tensiometer Equipment Checklist" to record the checkout and readiness of the equipment.

5.0 PROCEDURE: Principles for Field Placement of a Tensiometer

5.1 Location of the tensiometer stations and the number of tensiometers installed depends on the variability of the soil at the site, the nature of the topography, depth to the water table, and the depth at which water flow is to be studied. Locate stations in areas which represent the site's soil/water characteristics. The SM shall select tensiometer depths and locations (stations) based on data such as borehole geophysical data, core samples, and surface geophysical data.

5.2 Stations should be located in areas of either maximum past or potential contaminant sources. Each station must have tensiometers at multiple depths. Increased density of tensiometer installation will give more information about water movement within the soil profile. In most cases, install the tensiometers at a minimum of three depths above the capillary fringe region of the water table at increments of two feet or less. Monitoring should be intensified on those sites which exhibit a high potential for contributing contamination to the ground-water system.

5.3 Each specific site requires preliminary investigation, interpretation of early results, and may require adjustments in sampling frequency and number of tensiometer stations to ensure adequate characterization. The number of installations to be made would depend upon cost, the variability of the soil types and geochemical environments encountered, and the desired precision. Statistical analyses which incorporate these variables may be used as guidelines in establishing the sampling frequency. See References 13.1 and 13.2.

5.4 Protection of the tensiometers is essential. The FTR may need to construct a fenced area around each station to limit damage from intrusion by people or animals. See 3.7.7 of AOM, Section 16.1.1 (3.7.7) entitled "Well Installation".

6.0 PROCEDURE: Tensiometer Assembly and Preparation

6.1 Tensiometer Assembly

6.1.1 Before assembling the tensiometer, make sure all parts are clean and have not been damaged in shipping. Do not use any damaged equipment. NOTE: See Figure 1 for component parts of a tensiometer.

6.1.2 Screw the vacuum dial gauge into the threaded port located in the side of the body tube until the backup washer on the stem body touches the body tube. NOTE: Do not overtighten the dial gauge in the body tube as the "O" ring on the stem makes the vacuum seal.

6.1.3 Screw the ceramic tip into the body tube to the desired length as specified by the FTR or SH.

6.1.4 Before putting the tensiometer to use, vent the dial gauge by momentarily removing the vent screw in the center of the dial gauge cover. NOTE: This is done to adjust the dial gauge to local conditions because the gauges are usually set at sea-level atmospheric conditions.

6.2 Tensiometer Preparation

6.2.1 Fill the tensiometer with distilled water and place the tensiometer body tube in an upright and vertical position until fluid completely saturates the ceramic tip and drips from the end of the tip for about five minutes.

6.2.2 Once the tip is saturated, fill the tube completely with distilled water and pull a vacuum within the top of the tensiometer using the vacuum hand pump. See Figure 2. Alternatively, if the hand pump is not available, air can be adequately removed from the tensiometer by pushing the reservoir button down repeatedly, after the tensiometer and reservoir have been filled. See Figure 3.

6.2.3 Screw the fill reservoir cap onto the top of the tube body.

6.2.4 Peel the neoprene reservoir cover back and fill the reservoir ~3/4 full with distilled water. Replace the neoprene cover back over the fill reservoir cap and push the reservoir button down several times to remove air from the reservoir pump cylinder and any accumulated air in the tensiometer. See Figure 3.

6.2.5 The vacuum/pumping operation should be repeated four or five times until no further air bubbles from the stem of the vacuum gauge.

6.2.6 Because commercial gauge type tensiometers generally are not corrected for the length of the tensiometer, adjust the dial on the vacuum gauge to zero when the tip of the tensiometer is immersed in water. See Figure 4.

6.2.7 If the tensiometer is not to be installed immediately, store the tensiometer with the ceramic tip immersed in distilled water or covered with a plastic bag to prevent evaporation.

7.0 PROCEDURE: Drill Tensiometer Site

Drilling can be accomplished using either a hollow-stem auger (HSA), air-rotary equipment or hand auger, depending on subsurface conditions. Drill holes with a two (2) inch minimum diameter bit. Perform all drilling without the addition of drilling mud or water.

HSA drilling as provided by a standard soil-sampling drill rig should be used in unconsolidated, granular soils where there is a potential for borehole-wall collapse and cave-in. Air rotary drilling should only be used for well-consolidated borehole soils, clays, or tight silts where the borehole wall can be expected to maintain its integrity. A hand auger may be used when drill-site accessibility is a problem for shallow (<25') installations.

7.1 Hollow-stem auger drilling

7.1.1 Terminate the augering approximately one foot above the desired depth at which the tensiometer is to be installed. Leave the auger string in the ground. NOTE: Stockpile the soil cuttings on a clean plastic sheet in the order in which they were removed from the borehole and save the cuttings for 7.1.4.

7.1.2 Use a split spoon to knock the plug out of the bottom of the auger and to collect the final foot of material. See 3.10.

7.1.3 Install the tensiometer by lowering the instrument through the hollow stem auger until the tensiometer makes contact with the bottom of the borehole. Push down lightly on the tensiometer to insure that good contact is made between the ceramic tip and native soil.

7.1.4 Remove one five-foot joint of auger using a sand line and chain. Add ~6 inches of native soil to the borehole. NOTE: Use the stockpiled cuttings of 7.1.1 and add the cuttings to the borehole at the same depth from which they were removed so as to simulate as near as possible the original downhole conditions.

7.1.5 Compact the backfill around the tensiometer using a 1-inch tamping rod. See 3.5. NOTE: Initial backfill lifts should be limited to 6-inches or less to insure that sufficient compaction of the soil around the instrument occurs.

7.1.6 After ~4 feet of backfill has been added and compacted, place a one (1) foot thick bentonite seal in the borehole so that no vertical migration of water is possible. See 3.18 and 3.19. NOTE: Introduce the bentonite seal into the borehole by either pouring it down the borehole or by use of a tremie pipe.

7.1.7 Once the bentonite has been placed, pour ~5 gallons of distilled water down the borehole in order to hydrate the bentonite.

7.1.8 Wait at least 30 minutes between the addition of the water and the addition of the next lift of native soil so that the bentonite has sufficient time to hydrate.

7.1.9 After at least 30 minutes has elapsed, remove another five (5) foot section of auger. Add bentonite/native soil mixture to the borehole and compact the bentonite/soil mixture with a one-inch tamping rod. See 3.15 and 3.5.

7.1.10 Continue backfilling and tamping until the borehole is filled to ground level.

7.2 Air rotary drilling

7.2.1 Terminate the drilling at the desired depth of tensiometer installation. NOTE: Stockpile the soil cuttings on a clean plastic sheet in the order in which they were removed from the borehole and save the cuttings for 7.2.4.

7.2.2 Withdraw and remove all drill pipe and bit from the borehole.

7.2.3 Install the tensiometer by lowering the instrument to the bottom of the borehole. Push down lightly on the tensiometer to insure that good contact is made between the ceramic tip and native soil.

7.2.4 Add ~6 inches of native soil to the borehole. NOTE: Use the stockpiled cuttings of 7.2.1 and add the cuttings to the borehole at the same depth from which they were removed so as to simulate as near as possible the original downhole conditions.

7.2.5 Compact the backfill around the tensiometer using a 1-inch tamping rod. NOTE: Initial backfill lifts should be limited to 6-inches or less to insure that sufficient compaction of the soil around the instrument occurs.

7.2.6 After ~4 feet of backfill has been added and compacted, place a one (1) foot thick bentonite seal in the borehole so that no vertical migration of water is possible. NOTE: Introduce the bentonite seal into the borehole by either pouring it down the borehole or by use of a tremie pipe.

7.2.7 Once the bentonite has been placed, pour ~5 gallons of distilled water down the borehole in order to hydrate the bentonite.

7.2.8 Wait at least 30 minutes between the addition of the water and the addition of the next lift of native soil so that the bentonite has sufficient time to hydrate.

7.2.9 Add bentonite/native soil mixture to the borehole and compact the bentonite/soil mixture with a one-inch tamping rod. See 3.15 and 3.5.

7.2.10 Continue backfilling and tamping until the borehole is filled to ground level.

7.3 Hand Auger Drilling

7.3.1 Terminate the drilling at the desired depth of tensiometer installation. NOTE: Stockpile the soil cuttings on a clean plastic sheet in the order in which they were removed from the borehole and save the cuttings for 7.2.4.

7.3.2 Withdraw and remove the hand auger from the borehole.

7.3.3 Install the tensiometer by lowering the instrument to the bottom of the borehole. Push down lightly on the tensiometer to insure that good contact is made between the ceramic tip and native soil.

7.3.4 Add ~6 inches of native soil to the borehole. NOTE: Use the stockpiled cuttings of 7.2.1 and add the cuttings to the borehole at the same depth from which they were removed so as to simulate as near as possible the original downhole conditions.

7.3.5 Compact the backfill around the tensiometer using a 1-inch tamping rod. NOTE: Initial backfill lifts should be limited to 6-inches or less to insure that sufficient compaction of the soil around the instrument occurs.

7.3.6 After ~4 feet of backfill has been added and compacted, place a one (1) foot thick bentonite seal in the borehole so that no vertical migration of water is possible. NOTE: Introduce the bentonite seal into the borehole by either pouring it down the borehole or by use of a tremie pipe.

7.3.7 Once the bentonite has been placed, pour ~5 gallons of distilled water down the borehole in order to hydrate the bentonite.

7.3.8 Wait at least 30 minutes between the addition of the water and the addition of the next lift of native soil so that the bentonite has sufficient time to hydrate.

7.3.9 Add bentonite/native soil mixture to the borehole and compact the bentonite/soil mixture with a one-inch tamping rod. See 3.15 and 3.5.

7.3.10 Continue backfilling and tamping until the borehole is filled to ground level.

8.0 PROCEDURE: Tensiometer Installation

8.1 TAC personnel shall check the tensiometer for proper operation prior to final installation.

8.2 Replace any tensiometer which fails to operate properly in the same borehole, or in another borehole drilled adjacent to the first.

8.3 Sink a PVC pipe as protective casing into the bentonite/soil plug, thus surrounding the tensiometer top and gauge.

8.4 Extend the casing down approximately two feet into the plug and allow the casing to protrude above the land surface about one (1) foot. Cover the top of the casing with a slip-on PVC cap.

8.5 Protect the tensiometer from possible damage by vehicular traffic or grazing livestock whenever appropriate. Place 3-4 wood, steel, or tee-bar driven steel posts in a four-foot radius around each protective casing to protect the casing. Set each post two feet below ground surface and extend at least four feet above the ground surface. Attach flagging to a post to mark the location. If livestock present a threat to the tensiometer, affix three strands of barbed wire to the posts. See Albuquerque Operations Manual, Section 16.1.1, paragraph 3.7.7 for details on the installation of the posts.

9.0 PROCEDURE: Gauge Calibration

9.1 The tensiometer section pressures are measured using a Bourdon tube gauge. These gauges are calibrated by the manufacturer. Check, recalibrate, or replace the gauges under the following circumstances:

9.1.1 If it is known that the tensiometer has been subjected to sub-freezing conditions.

9.1.2 If there is evidence of physical damage to the gauge.

9.2 Check the zero adjustment of the gauges after they are taken out of the soil and before the onset of freezing conditions.

9.2.1 Place the ceramic tip in distilled water and read gauge value. The gauge should read zero because it was set at zero at the time of installation.

9.3 If freezing conditions are expected to occur, keep the water level in the tubes at least five feet below the surface. NOTE: Do not refill and calibrate until actual measurements are to be made. The gauge should be protected by insulation or placed in the project storage facility for the winter to protect from freezing.

10.0 PROCEDURE: Field Measurements

10.1 Most tensiometers have a dial type manometer to indicate pressure potential. Their scale is given in centibars, from 0 to -100. Therefore, -50 centibars is equal to -0.5 bar which in turn is equivalent to a pressure potential of -38.0 cm water.

10.2 Read gauge and record tensiometer pressure potentials on the field form entitled "Tensiometer Sampling Record". See Attachment 12.2.

11.0 PROCEDURE: Completion of Duties

11.1 Clean field equipment.

11.2 Replace and report any broken or damaged items.

11.3 Make copies of field forms and give the original data to document control. Transmit copies of the field forms to the SH.

12.0 ATTACHMENTS

12.1 Tensiometer checklist

12.2 Tensiometer Sampling Record

12.3 Figure 1: Component Parts of a Tensiometer

12.4 Figure 2 and 3: Removing Air from Tensiometer

12.5 Figure 4: Adjusting the Vacuum Gauge Dial

13.0 REFERENCES

13.1 Allmaras, R. R., 1965. Bias, in C. A. Black, ed., "Methods of Soil Analysis", Agronomy Monograph No. 9, Part 1, Madison, Wisconsin, American Society of Agronomy, pp. 24-42.

13.2 Krumbein, W. C., and F. A. Graybill, 1965. An Introduction to Statistical Models in Geology, McGraw-Hill, New York, New York, pp. 171-181.

Prepared By: ______________________
TAC Technical Representative

Reviewed By: ______________________
Task Manager

Reviewed By: ______________________
Quality Assurance Manager

Approved By: ______________________
Project Manager

Location identification ____________
Date: ________________
Name: ________________

Tensiometer checklist:

Tensiometer tubes:

Length: 6"	Quantity: ______
12"	______
18"	______
24"	______
30"	______
36"	______
42"	______
48"	______
60"	______

Other: _______

Vacuum dial gauges:

Quantity: _______ Condition: _______

Ceramic tips:

Quantity: _______ Condition: _______

Reservoir fill caps:

Quantity: _______ Condition: _______

Installation equipment:

4" soil auger: _______
insertion tool: _______
1/4" soil screen: _______
vacuum hand pump: _______
other: _______

Comments:

Attachment 12.1 - Tensiometer equipment checklist

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

PAGE ___ OF ___

TENSIOMETER SAMPLING RECORD

SITE ID ____________________

LOCATION ID ____________________

	SAMPLE ID	TENSIOMETER DEPTH (INCHES)	PRESSURE POTENTIAL (CENTIBARS)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

COMMENTS:

FIELD REP. (S):

ATTACHMENT 12.2

JEG-AL-ENG-13 (6/87)

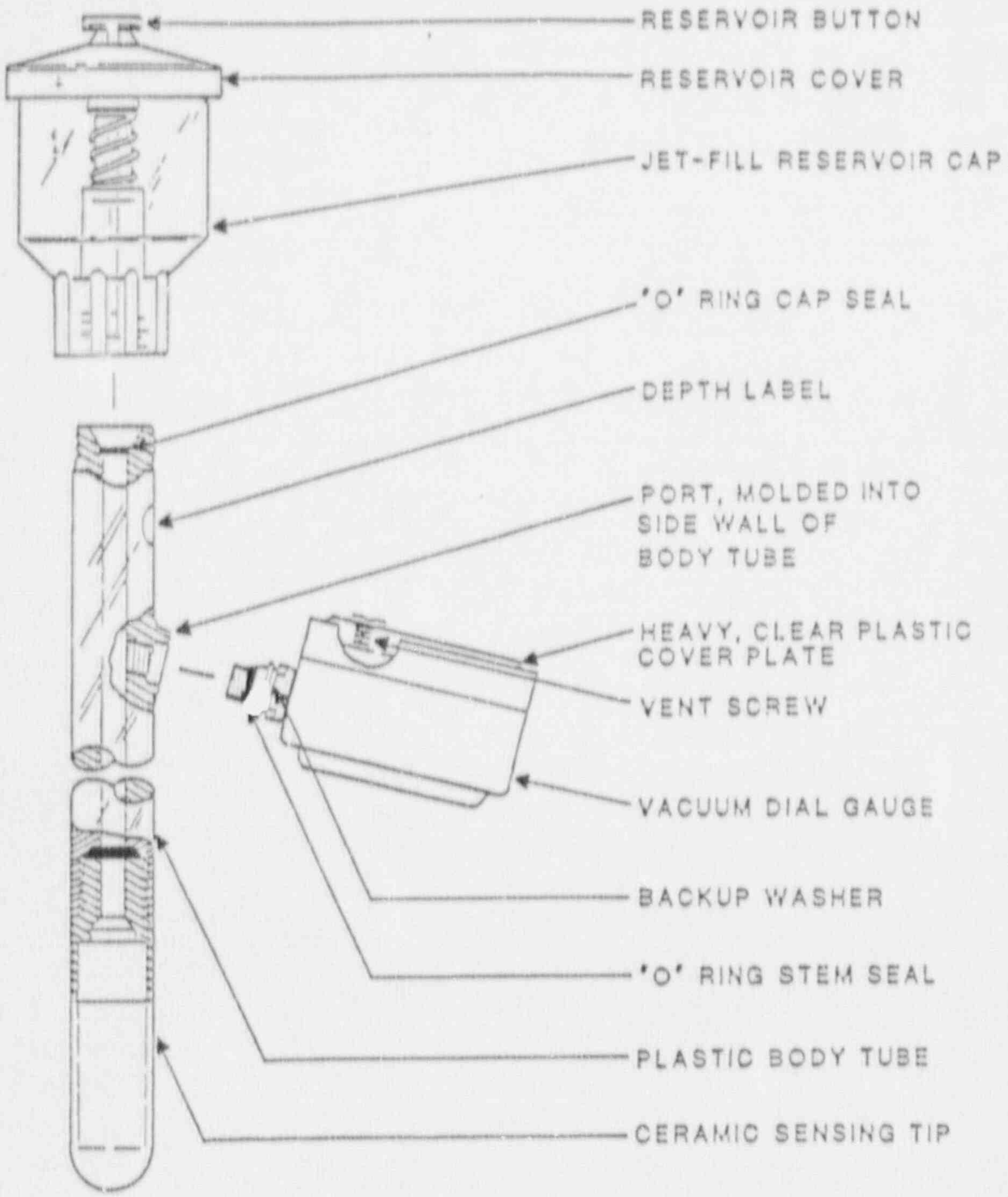


FIGURE 1
CONPONENT PARTS OF A TENSIOMETER

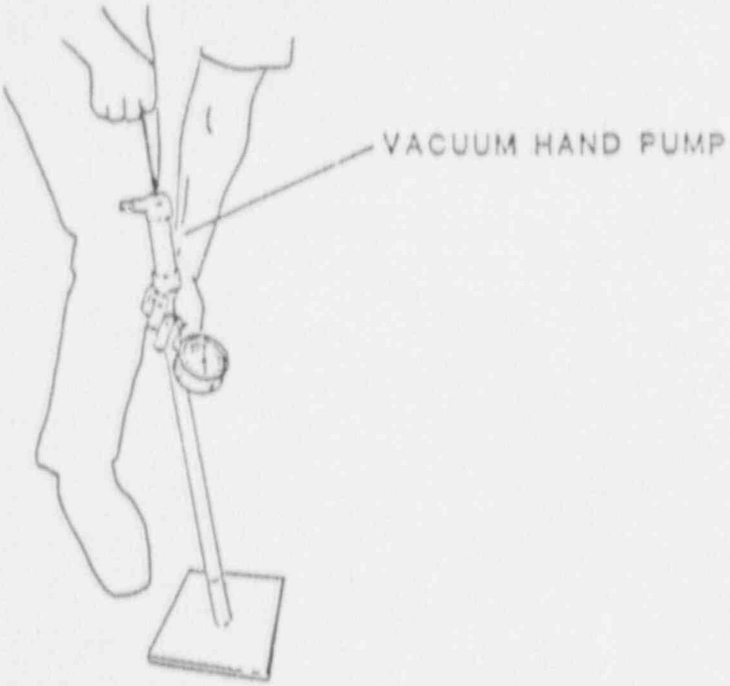


FIGURE 2

FILLING TENSIONMETER TUBE BY INDUCING VACUUM

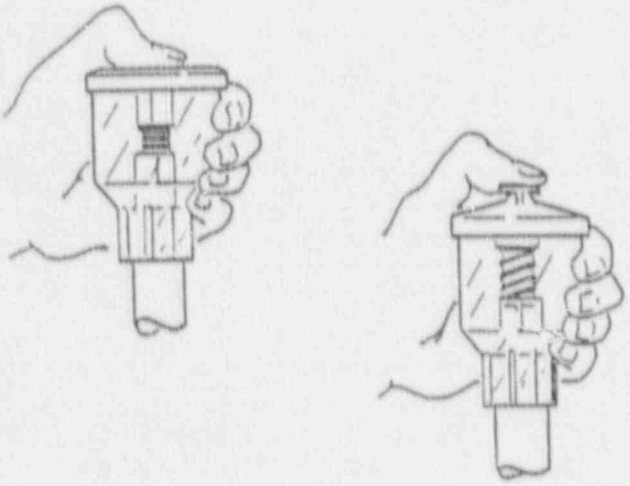
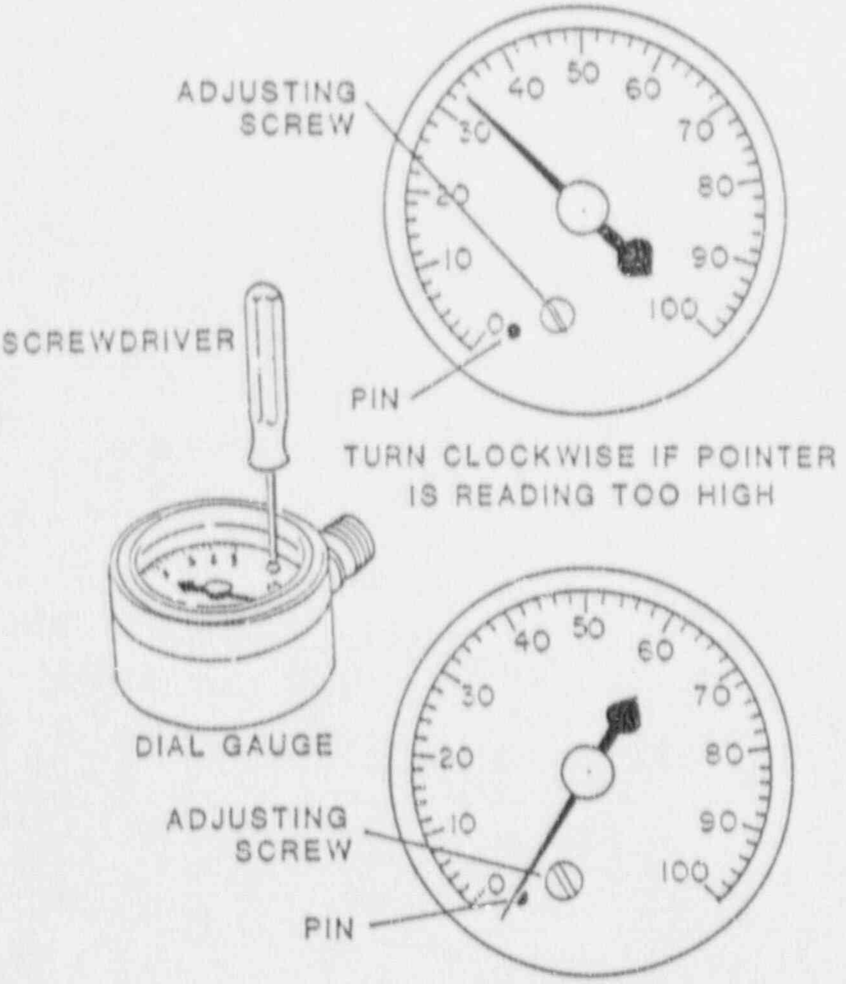


FIGURE 3

REMOVING AIR FROM TENSIOMETER



TURN CLOCKWISE IF POINTER IS READING TOO HIGH

TURN COUNTERCLOCKWISE IF POINTER IS READING TOO LOW

FIGURE 4

ADJUSTING THE VACUUM GAUGE DIAL

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

TRANSMITTAL OF DOCUMENTS

DATE SENT : 11/29/89

PAGE 1 OF 1

CONTROL NUMBER 17

TO : F TITUS

FROM : Quality Assurance Department

TYPE AND TITLE OF MATERIAL SENT :

Albuquerque Operations Manual, Section 16.1.6
Soil-Water Sampler Installation and Sample Collection
06/22/89

SPECIAL INSTRUCTIONS :

Replace old version with new version

DISPOSITION OF PREVIOUS VERSIONS :

Discard

ACKNOWLEDGMENT OF RECEIPT OF MATERIALS

I ACKNOWLEDGE RECEIPT OF THE MATERIAL LISTED ABOVE.

SIGNATURE

DATE 12/01/89

ETURN THIS FORM TO : TAC Quality Assurance Deaprtment
ATTN: D. Van Bibber

JEG-AL-QA-11 (12/88)

ALBUQUERQUE OPERATIONS MANUAL	SECTION 16.1.8
	DATE 9/12/88
BATCH AND COLUMN LEACH TESTING	EFFECTIVE 10/27/88
	SUPERSEDES
	PAGE 1 OF 5

1.0 PURPOSE

To provide standard instructions for personnel conducting batch and column leach tests on uranium mill tailings, soils, sediments, or combinations thereof.

2.0 SCOPE

This procedure establishes guidance for setting up and conducting batch or column leach experiments. In addition, criteria are set forth that address record keeping, instrument calibration, and the various data necessary to allow reconstruction of the experiments at a later date by people who were not associated with the original work.

3.0 PROCEDURES

Collect soil, sediment, or tailings samples using clean utensils and sample containers. The methods for cleaning will be dependent upon the components of interest (e.g., samples collected for organic analyses should not come in contact with plastic, etc.). Logs of test pits and core holes shall be prepared as per AOM, Section 14.1.4.

3.1 Moisture content determination

a. A 100g homogenized aliquot of each sample will be weighed, oven dried at 100° and reweighed per ASTM Method 2216 (ASTM Annual Book of Standards, 1984, Volume 04.08, Soil and Rock).

b. Record the results in the laboratory log book.

3.2 Batch leach experiments

Batch leach experiments will be according to the following procedure (modified from ASTM Standard Test Method 4319-83):

3.2.1 Apparatus:

a. Pyrex glassware or FEP TFE (teflon) beakers, centrifuge tubes, flasks, etc.; cleaned by washing with a laboratory detergent, rinsed a minimum of three times in deionized water (ASTM Class II or better) and air dried.

b. Centrifuge (min. cap 1400g) or filtering apparatus.

c. Laboratory shaker or rotator.

d. Analytical balance.

e. Laboratory log book.

3.2.2 Solutions

a. Site specific waters, synthetic groundwater or lixiviant solutions can be used as a leach medium.

b. Prepare synthetic groundwater or lixiviant solutions using reagent grade chemicals.

c. Record masses of chemicals and volumes of liquid used in making the solutions in the laboratory log book.

3.2.3 Procedure:

a. Based upon the results of the moisture content determination, weigh out the equivalent of 75g ± 5 g (dry weight) of sample and record the weight (nearest 0.01 g).

b. Introduce about 300 mL of solution into the sample container. The actual volume (mL) of lixiviant should be four times the weight of the solid sample in grams.

c. Shake the contents of the vessel to ensure contact between the liquid and solid phases. Place the vessel on a laboratory shaker/rotator and gently agitate for a minimum of two hours per day for a minimum of three days.

d. At the end of the contact period, centrifuge (minimum 1400g) or filter (maximum 0.45 mm pore size) the lixiviant solid sample mixture. One hundred mL of the solution will be acidified to pH 2.0 with HNO_3 and placed in refrigerated (4°) storage. The remainder of the solution will be refrigerated (4°C) without treatment and will have the following parameters measured upon it within one hour of collection: pH, Eh (Redox Potential), and electrical conductivity.

3.3 Column leach experiments

3.3.1 Apparatus:

a. 4" diameter by 12" long polycarbonate cylinders with either rubber stoppers or machined fittings to seal each end. The lower end seal will be breached by an exit tube with a stopcock or other means to control flow. The interior end of this exit tube will be protected from soil sample intrusion by an inert filter. The cylinders and all associated apparatus will be washed using a laboratory detergent and will be rinsed a minimum of three times with deionized water (ASTM Class II or better) and air dried.

3.3.2 Solution

a. Deionized water (ASTM Class II or better)
b. Synthetic or natural groundwaters
c. Lixiviant solutions

3.3.3 Procedures

a. The solid sample mixture will be packed into [illegible] columns to a depth of 10 inches. The upper [illegible] inches of the column will serve as a fluid reservoir. The tailings should be packed into the column in ten lifts. The density should produce a transmissivity of 10^{-3} to 10^{-5} cm sec^{-1}. In the event that lixiviants are to be added in their dry form, measured amount should be either mixed in with the solids or added as a layer to the top of the solids column.

b. A deionized water, lixiviant, or selected specific water reservoir will be connected to the top of the columns and the solids will be allowed to come to saturation. At saturation, the flow rate will be controlled at one pore volume per day by adjusting the exit flow. The head should be adjusted to ensure a minimum flow rate of one pore volume per five days.

c. The experiment will be concluded at the end of 20 days (or a specified number of pore volumes). Samples will be collected for analysis after elution of the following pore volumes: 2, 5, 10, and immediately before termination of the experiment.

d. Sample aliquots will be collected directly from the effluent stream. A 100 mL aliquot will be collected, acidified to pH 2.0 with HNO_3 and refrigerated (4°C). This will be followed by the collection of a 200 mL aliquot which will be refrigerated until collection for analysis. The pH, Eh, and electrical conductivity will be measured on this second sample aliquot.

4.0 RECORDS

In order to document the activities associated with each testing a laboratory notebook will be maintained. This notebook will contain the following information:

A. Instrumentation calibration
  1. pH meter - listed by number or description
    a. Date and time of calibration
    b. Standard used as set point
    c. Readings for other known pHs
    d. Slope factor

  2. Redox potential (Eh) meter - listed by number or description
    a. Date and time of calibration
    b. Standard used as set point
    c. Readings for other known Ehs

  3. Conductivity meter listed by number or description
    a. Date and time of calibration
    b. Conductivities of standards

B. Solid sample moisture content
  1. Date and time of determination
  2. Sample number and description
  3. Mass of sample before drying
  4. Drying time and temperature
  5. Mass of dry sample
  6. Calculated percent moisture

C. Effluent characteristics
  1. Date and time of sample collection
  2. Sample number and description
  3. Physical description - clear brown, cloudy yellow, etc.
  4. Chemical parameters measured at time of collection - dependent upon type of experiment.
    a. pH
    b. Eh
    c. Conductivity
    d. Excess lixiviant
    e. Alkalinity
    f. Any other parameters that may be specific to the type of experiment

5.0 REFERENCES

ASTM, 1984, Method D2216, Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil Aggregate Mixtures; Vol. 04.08, Soil and Rock, Building Stones; ASTM, 1916 Race St., Philadelphia, PA.

ASTM, 1984, Method 4319, Distribution Ratios by the Short-Term Batch Method, Vol. 04.08, Soil and Rock, Building Stones; ASTM, 1916 Race St., Philadelphia, PA.

Prepared By: ______________________

Reviewed By: ______________________
Task Manager

Reviewed By: ______________________
Quality Assurance Manager

Approved By: ______________________
Project Manager

JE JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL	SECTION 16.1.10
	DATE 8/29/90
FIELD MEASUREMENT OF WATER SAMPLES FOR TEMPERATURE, CONDUCTIVITY, pH, ALKALINITY, AND TOTAL ACID	EFFECTIVE 9/10/90
	SUPERSEDES
	PAGE 1 OF 16

1.0 PURPOSE

To provide procedures by which field determinations for temperature, pH, conductivity, alkalinity, and total acidity will be performed and documented.

2.0 SCOPE

These procedures are applicable to members of the TAC and its contractors, subcontractors with responsibilities and duties for the field measurements of collected water samples prior to shipment to the analytical laboratory.

3.0 EQUIPMENT

3.1 Pumps

3.2 Hoses/Tubes

3.3 pH Meter & Electrode with "slope" adjustment feature and with temperature compensator.

3.4 Conductivity Meter & Electrode with thermometer.

3.5 Thermometer

3.6 Magnetic Stirrers and Magnetic stirring bars (Available at Laboratory)

3.7 Titrator

3.8 Filter Apparatus and Filters

3.9 Erlenmeyer Flask: 125 mL (Available at Laboratory)

3.10 Volumetric Flasks, Class A: 100, 250, 500, and 1000 mL (Available at Laboratory) All but 100 mL are required only if preparing solutions listed in 4.0.

3.11 Graduated Cylinder: 50, 100, 250, and 500 mL (Available at Laboratory) All but 100 mL are required only if preparing solutions listed in 4.0.

3.12 Beakers: 150, 250, and 400 mL (Available at Laboratory) Required only if preparing solutions listed in 4.0.

3.13 Sample Bottles: 250, 500, 1000 mL (or U.S. equivalents)

3.14 Cooler w/"blue ice" or equivalent

3.15 Parafilm or its equivalent

4.0 REAGENTS & SUPPLIES

NOTE: Whenever required by the procedure, JEG purchases and uses prepared, calibrated and certified solutions from chemical supply firms. The following are listed in the event certified solutions are not readily available or are used whenever procedure parameters do not require use of certified solutions. In the event that solutions require preparation, they will be prepared at the laboratory before going into the field. Items 4.12 through 4.21 are required only as needed.

4.1 Potassium Chloride: KCl. Reagent Grade. Purchased from chemical supply firms.

4.1.1 0.2 M Potassium Chloride: 0.2 M KCl Standard Solution (equivalent to 24,820 umhos/cm and 14,910 mg KCl/L). Weigh out 14.91 grams of KCl crystals into a 1000 mL volumetric flask containing 750 mL of distilled water. Mix solution to dissolve KCl salt. Add distilled water to 1000 mL mark, stopper flask, and mix solution well. Store solution in a polyethylene or glass bottle labelled with "24,820 umhos/cm: 14,910 mg KCl/L", "0.2 M KCl: 14.91 g KCl/L distilled water", date, and preparer's initials. Make all dilutions from this bottle.

Conductance of KCl Solutions @ 25° C.*

Concentration		Conductance (umho/cm)	
M	PPM	Equivalent	Specific
0.0	---	149.85	---
0.0001	7.5	149.43	14.94
0.0005	37.3	147.81	73.90
0.001	74.6	146.95	147.0
0.005	373	143.55	717.8
0.01	746	41.27	1,413
0.02	1,491	138.34	2,767
0.05	3,728	133.37	6,668
0.1	7,455	128.96	12,900
0.2	14,910	124.08	24,820
0.5	37,276	117.27	58,640
1.0	74,551	111.87	111,900

*From Reference 12.1. See 12.0.

4.2 KCl-A Solution: Pipet 10 mL of the 0.2 M KCl Standard Solution into a 200 mL volumetric flask containing 150 mL of distilled water and mix solution well. Add distilled water to 200 mL mark of flask, stopper flask, and mix solution well. Label flask as "KCl-A", "1,413 umhos/cm", "10 mL of KCl Standard Solution/ 200 mL of distilled water", date, and preparer's initials.

4.3 KCl-B Solution: Pipet 10 mL of the KCl Standard Solution into a 100 mL volumetric flask containing 70 mL of distilled water and mix solution well. Add distilled water to 100 mL mark, stopper flask, and mix solution well. Label flask as "KCl-B", 2,767 umhos/cm", 10 mL of KCl Standard Solution/100 mL of distilled water", date, and preparer's initials.

4.4 KCl-C Solution: Pipet 25 mL of the KCl Standard Solution into a 100 mL volumetric flask containing 70 mL of distilled water and mix solution well. Add distilled water to 100 mL mark, stopper flask, and mix solution well. Label flask as "KCl-C", "6,668 umhos/cm", "25 mL of KCl Standard Solution/100 mL of distilled water", date, and preparer's initials.

4.5 KCl-D Solution: Pipet 50 mL of the KCl Standard Solution into a 100 mL volumetric flask containing 40 mL of distilled water and mix solution well. Add distilled water to 100 mL mark, stopper flask, and mix solution well. Label flask as "KCl-D", "7,446 umhos/cm", "50 mL of KCl Standard Solution/100 mL of distilled water", date, and preparer's initials.

4.6 Hydrochloric Acid: HCl. 36.5-38%, 12 M (~12 N); Reagent Grade. Purchased from chemical supply firms.

4.7 Nitric Acid: HNO_3. 70%, 16 M (~16 N); Reagent Grade. Purchased from chemical supply firms.

4.8 Sulfuric Acid: H_2SO_4. 98%, 18 M (~36 N); Reagent Grade. Purchased from chemical supply firms.

4.9 Sodium Hydroxide: NaOH. Reagent Grade. In pellet form. Purchased from chemical supply firms.

4.10 ~1 N NaOH Solution: Add 40 g of reagent grade Sodium Hydroxide pellets to a 1000 mL volumetric flask containing 900 mL of distilled water or its equivalent and swirl solution to dissolve the NaOH pellets. Cool solution in an ice water bath. Add distilled water to the 1000 mL mark, stopper flask, and mix solution well. Store solution in a polyethylene bottle labeled with "~1 N NaOH", "40 g NaOH/1000 mL of distilled water', date, and preparer's initials. Prepare fresh solution every 30 days and add new date.

4.11 1.6 N NaOH. HACH cartridge. Purchased from chemical supply firms.

4.12 0.16 N NaOH. HACH cartridge. Purchased from chemical supply firms.

4.13 pH 1 Buffer Solution: Certified as ±0.02 pH units and with expiration date. Purchased from chemical supply firm. Supplied in tablet or powder form. NOTE: Prepare fresh before use as instructed. Discard solution after use.

4.14 pH 4 Buffer Solution: Certified as ±0.02 pH units and with expiration date. Purchased in solution form from chemical supply firm. NOTE: Discard any solution whose expiration date has elapsed.

4.15 pH 5 Buffer Solution: Certified as ±0.02 pH units and with expiration date. Purchased in solution form from chemical supply firm. NOTE: Discard any solution whose expiration date has elapsed.

4.16 pH 7 Buffer Solution: Certified as ±0.02 pH units and with expiration date. Purchased in solution form from chemical supply firm. NOTE: Discard any solution whose expiration date has elapsed.

4.17 pH 10 Buffer Solution: Certified as ±0.02 pH units and with expiration date. Purchased in solution form from chemical supply firm. NOTE: Discard any solution whose expiration date has elapsed.

4.18 pH 12.45 Buffer Solution: Certified as ±0.02 pH units and with expiration date. Purchased from chemical supply firm. Supplied in powder form. NOTE: Prepare fresh before use as instructed. Discard solution after use. Due to the instability of this high pH buffer solution, prepare this buffer solution fresh as needed and do not store.

4.19 Distilled Water or Deionized Water

4.20 Masking Tape, Nylon Tape, Electricians Tape, and Magic Marker.

4.21 Plastic Sheet and Aluminum Foil.

4.22 Lint-free Tissue(s).

4.23 Data Collection Sheets: Water Quality Sampling Record Forms, Chain-of-Custody Forms, and Sample Collection Procedures.

5.0 PROCEDURE: Field Measurements of a Collected Water Sample

5.1 Whenever practical, final field measurements are to be taken after at least three (3) borehole volumes have been pumped from the well and as close to the time of sampling as is possible.

5.2 Field measurements to determine temperature, conductivity, and pH are performed on a water sample as it is being collected and are to be recorded on Attachment 16.1.10.2.

5.3 Alkalinity is determined on an aliquot of the raw water sample and prior to shipment of the sample to the laboratory. Titration volumes at a specified pH are observed and recorded on Attachment 16.1.10.2, page 3 of 4. Known alkalinity solution data are observed and recorded on Attachment 16.1.10.3.

5.4 Total Acid determinations are performed on selected groundwater or lysimeter (pore water) samples. This data is recorded in the "COMMENTS" portion of Attachment 16.1.10.2.

6.0 PROCEDURE: Temperature Measurement

A conductivity meter and electrode with a thermometer built into the electrode are strongly recommended for this procedure.

6.1 Clean thermometer by washing it in a solution of soap and water. Use a brush to scrub the thermometer. Rinse thermometer well with distilled water and blot dry with lint-free tissue(s).

6.1.1 NOTE: Always blot dry thermometer and electrode with tissue. Water droplets remaining on these probes may dilute or otherwise affect measurement data. [illegible] probes with tissue may result in warming the thermometer or produce an electrostatic charge on the electrode and so directly alter meter readings.

6.1.2 If Conductivity Meter has a thermometer built into the electrode, use instructions of 6.1.

6.2 A combination conductivity-temperature probe is used in the field. This thermometer must be checked against a lab grade mercury thermometer at least once a month. At the same time, the conductivity meter is also tested for accuracy, using the following procedure.

6.2.1 Pour approximately 30 ml of lab prepared KCL solution of 4.3 above into a clean beaker. Place the clean temperature- conductivity probe into the solution. Place the beaker in an ice bath, and using a lab grade mercury thermometer, chill the solution to as near 0° C as possible. Salt should be placed on the ice to reach this low temperature.

6.2.2 When the KCL solution has reached a maximum of 3° C, read and record the temperature from the lab thermometer and the meter.
Also read and record the conductance.

NOTE: If meter has an automatic temperature compensator (ATC), turn off ATC or turn dial to "0." Do not use ATC for this test.

6.2.3 Remove the beaker from the ice bath to allow it to warm. Continue reading and recording temperature pairs as well as conductance at least every 2° C up to 25° C. Remove thermometer from the beaker, clean with distilled water, pat dry with tissue(s) and store.

6.2.4 Remove temperature-conductivity probe from beaker, rinse with distilled water, and blot dry with tissues. Pour approximately 20 mL of the other three KCl standards (at room temperature) into four separate clean beakers. Measure and record the conductance of each solution, being sure to rinse and dry the probe between measurements.

6.2.5 Remove temperature-conductivity probe from the final beaker, rinse with distilled water, dry with tissue(s) and store.

6.2.6 Using the data from 6.2.2, 6.2.3, and 6.2.4, plot lab thermometer temperature versus meter temperature on arithmetic graph paper. Plot meter temperature versus meter conductivity and meter conductivity versus known conductivity on arithmetic graph paper. Submit the data and graphs to the water sampling manager.

6.2.7 The meter is now ready for measuring temperature and conductance in the field.

6.3 Insert the dry and clean thermometer into the flow-through cell. Allow the temperature to stabilize. Record the temperature measurements periodically on Attachment 16.1.10.2 throughout the time of pumping.

6.3.1 Place the flow-through cell close to the wellhead. Be sure to keep the cell and discharge hose/tube out of direct sunlight.

6.3.2 Use the temperature data to adjust the pH temperature compensator.

6.4 When the sample bottle is full, shut off the pump, and carefully withdraw the thermometer from the flow-through cell. NOTE: If water sample looks "dirty" and contains residue that will not be removed with distilled water, clean thermometer probe as stated in 6.1.

6.5 Rinse thermometer probe with distilled water and blot dry with lint-free tissue(s). The probe is now ready for another water sampling activity or storage.

6.5.1 If the probe is to be stored, place it in its carrying case. Label with "clean", date, and initials.

6.6 Clean equipment as described in 8.8 through 8.10 of Section 16.2.1.

6.7 If Conductivity, pH, Alkalinity, or Total Acidity determination is required, proceed with 7.0, 8.0, 9.0, or 10.0.

6.8 To prepare sample for filtration (if required), preservation (if required), and shipment of samples to the analytical laboratory, proceed with 12.0 of Section 16.2.1.

7.0 PROCEDURE: Conductivity Measurement

A Conductivity Meter and electrode with a thermometer built into the electrode is strongly recommended for this procedure. Because conductivity measurement instruments and instrument operation instructions vary with each manufacturer, the analyst is advised to use the specific instructions for instrument operations that are provided with the conductivity meter to be used by the analyst.

If not already performed, test conductivity meter as described in Section 6.2.

7.1 Remove electrode and cable from carrying case, rinse well with distilled water, and blot dry with tissue.

7.1.1 Always blot dry electrode with tissue. Water droplet(s) remaining on the electrode may dilute or otherwise affect conductivity measurement(s). Rubbing electrodes with tissue may also produce electrostatic charges on the electrode and thus directly alter meter readings.

7.2 Insert clean and dry electrode/cable into the flow-through cell before water sampling is to begin. Read sample conductivity and record value(s) periodically throughout the sampling period and especially just after sampling is completed.

7.3 Withdraw electrode and cable, rinse well with distilled water, and blot dry with tissue paper. Electrode/cable now ready for another sampling activity or storage.

7.3.1 Label with "clean", date, and initials if electrode is to be stored.

7.4 If pH, Alkalinity or Total Acidity determination is required, proceed with 8.0, 9.0, or 10.0. If pH, Alkalinity or Total Acidity determination <u>is not</u> required, proceed with 12.0 of Section 16.2.1.

7.4.1 To prepare water sample(s) for filtration (if required), preservation (if required), and shipment to the analytical laboratory, proceed with 12.0 of Section 16 2.1.

7.5 Check Attachment 16.1.10.2 to make sure that all of the required sampling data has been recorded.

7.6 Proceed with 12.9 of Section 16.2.1 to complete required duties.

8.0 PROCEDURE: pH Measurement

A pH meter and electrode with a temperature compensator and a slope adjustment feature are strongly recommended for this procedure. Because pH measurement instruments and instrument operation instructions vary with each manufacturer, the analyst is advised to use the specific instructions for instrument operations that are provided with the pH meter to be used by the analyst. The meter and electrode can be readily adjusted to the temperature of the sample solution and can be calibrated with pH buffer solutions so that the analyst may easily and quickly work with samples having a pH range of 1-4, 4-7, 7-10, or >10.

8.1 Rinse the pH electrode with distilled water and blot dry with lint-free tissue(s).

8.1.1 <u>Always</u> blot dry pH electrode with tissue. Water droplet(s) remaining on the electrode may dilute or otherwise affect measurement data. Rubbing electrodes with tissue may result in producing an electrostatic charge on the electrode and so directly alter the meter readings.

8.1.2 When not using pH meter/electrode, <u>always</u> place pH electrode in a container of pH 4 buffer solution and seal with parafilm or its equivalent.

8.2 Prior to performing pH measurements in the field or in the lab, at least once per quarter, test the pH meter and Electrode: Determine Temperature and pH. The description below is for a meter with an Automatic Temperature Compensator (ATC). For meters not equipped with an ATC, the procedure is the same.

8.2.1 Prepare a pH 5.0 buffer solution as described on the pH tablet bottle and label as "pH 5.0 Buffer Solution", add date, and write initials on bottle.

8.2.2 Pour 30 mL of pH 5.0 buffer solution into each of three (3) beakers labelled as "A-pH 5.0" (beaker A), "B-pH 5.0" (beaker B), and "C-pH 5.0" (beaker C).

8.2.3 Place beaker A in an ice water bath, beaker B on the lab bench, and beaker C in a hot water bath. Allow beakers 10-15 minutes to acclimate to their media. Swirl beakers to mix solution.

8.2.4 With automatic temperature compensator (ATC) off or dialed to "0", place a clean and dry pH electrode and a clean and dry lab thermometer into beaker A. Read pH to the nearest 0.01 pH units and temperature to the nearest 0.1° C. Record pH and temperature on Attachment 16.1.10.1.

8.2.5 Withdraw electrode and thermometer, rinse each with distilled water, and dry with tissue.

8.2.6 Repeat 8.2.4 and 8.2.5 with beaker B.

8.2.7 Repeat 8.2.4 and 8.2.5 with beaker C. Store clean electrode as stated in 8.1.2. Store clean thermometer as stated in 6.5.

8.2.8 Plot pH and temperature data on semi-log graph paper (pH versus temperature). Attach this data to Attachment 16.1.10.1.

8.2.9 Unless foregoing data indicates that pH meter/electrode are not operating properly, pH meter/electrode is ready for sample collection trip in the field or laboratory work.

8.3 Calibrate the pH meter and electrode with standardized pH buffer solutions. NOTE: See 4.13 to 4.21.

8.3.1 If pH meter has a slope adjustment feature, calibrate pH meter and electrode with buffer solutions which bracket the sample pH.

A. Set ATC on pH meter to the temperature of the water sample. Use temperature data from 6.3. Alternatively, if the pH meter does not have an ATC, chill the pH buffer solution(s) to equal the water sample temperature.

B. To calibrate pH meter/electrode for pH 4-7 range, insert clean and dry pH electrode into a labelled beaker containing a fresh solution of pH 7 buffer. Measure pH. Adjust pH reading to 7.0. Withdraw electrode, rinse with distilled water, and blot dry with tissue. Insert clean and dry pH electrode into a labelled beaker containing a fresh solution of pH 4. Measure pH. Adjust the slope to give a pH reading of 4. Withdraw electrode, rinse with distilled water, and blot dry with tissue.

- To calibrate pH meter/electrode for pH 1-4 range, use pH 1 and pH 4 buffer solutions. Use pH 4 buffer solution instead of pH 7 buffer solution and pH 1 instead of pH 4 as stated in B. above.

- To calibrate pH meter/electrode for pH 7-10 range, use pH 7 and pH 10 buffer solutions. Use pH 7 buffer solution and pH 10 buffer solution instead of pH 4 as stated in B. above.

- To calibrate pH meter/electrode for pH 10-12.45 range, use pH 10 and pH 12.45 buffer solutions. Use pH 10 instead of pH 7 buffer solution and pH 12.45 buffer solution instead of pH 4 as stated in B. above.

C. Insert clean and dry pH electrode into a labelled beaker containing a fresh solution of one of the buffers which bracket the sample. Measure pH. Withdraw electrode, rinse with distilled water, and blot dry with tissue. Repeat with the other buffer which brackets the sample.

- If pH is within ±0.02 units, depending on certification of pH buffer solution, proceed with 8.4 and with pH measurements of water samples.

- If pH is not within ±0.02 units, depending on certification of pH buffer solution, repeat A, B, and C until pH meter/electrode gives repetitive readings. Repeat at least twice. If pH meter or electrode does not work satisfactorily, see Troubleshooting Instructions for pH meter and electrode.

8.3.2 <u>If the pH meter does not have a slope adjustment feature</u>, set ATC on pH meter to the temperature of the water sample. Use temperature data from 6.3. Alternatively, if the pH meter does not have an ATC, chill the pH buffer solution(s) to be used for the calibration or calibration checks to equal the water sample temperature.

A. Insert a clean and dry pH meter into a pH 7 buffer solution. If necessary, adjust pH meter to 7 or pH reading on pH 7 buffer bottle. Record pH meter reading. NOTE: Record all pH readings on Attachment 16.1.10.2.

B. Withdraw probe, rinse probe well with distilled water, and blot probe dry with tissue paper.

C. Repeat A and B.

D. Insert clean and dry pH probe into the sample solution, obtain pH reading, and record pH reading.

E. Repeat B.

F. Insert clean and dry pH probe into a pH buffer solution that best approximates the pH of the sample solution. Obtain and record pH reading.

G. Repeat B.

H. Repeat A and B. NOTE: Analyst should determine when and how often 1) pH meter should be recalibrated with pH 7 buffer solution, and 2) pH buffer solution that best approximates the sample pH should be used.

I. Analyst should continue with sample(s) until all of pH data has been obtained and recorded. Use A through H.

8.4 Insert clean and dry pH electrode into the flow-through cell soon after well pumping has begun. This will eliminate or reduce pH meter drift.

8.5 If the pH meter has an ATC, adjust the temperature setting on the pH meter to the temperature of the sample solution. NOTE: Use temperature measurement data from 6.3.

8.5.1 Alternatively, if the pH meter has no ATC, reduce the temperature of the pH buffer solutions when calibrating the pH meter.

8.6 Read pH and record measurement within five (5) minutes or after drift has ceased, whichever is sooner. Rinse and blot dry electrode. If possible, perform pH measurement at least three (3) times during the purging of the well.

8.7 Periodically during purging, check accuracy of the pH meter with buffer solution(s) that bracket the sample solution and adjust pH meter as needed according to 8.3.1 or 8.3.2.

8.8 When purging is completed, withdraw the electrode from the flow-through cell, rinse the electrode with distilled water, and blot dry with tissue(s). Measure the final pH of each of the two (2) bracketing buffers, being sure to clean the electrode between use of the buffer solutions.

8.8.1 If the meter is accurate within 0.10 units of each buffer, record the results on Attachment 16.1.10.2. Proceed to 8.9.

8.8.2 If the meter is inaccurate (greater than 0.10 units variance with either buffer) recalibrate the meter. Continue purging and recording pH of the sample for at least four (4) to eight (8) liters of sample. Return to 8.7 and repeat until consistent pH reading within 0.10 units is achieved.

8.9 When a sufficient volume of sample has been collected in the sample bottle, remove hoses and pumps from the well hole.

8.10 Clean pH electrode: rinse with distilled water and blot dry with tissue. pH electrode now ready for another sampling activity or storage. To store electrode, see 8.1. Label with "clean", date, and initials.

8.11 Clean equipment as described in 8.8 through 8.10 of Section 16.2.1.

8.12 Check Attachment 16.1.10.2 to make sure that all of the sampling data has been recorded on the form.

8.13. If Alkalinity or Total Acidity determination is required, proceed with 9.0 or 10.0 respectively.

8.14 To prepare sample for filtration (if required), preservation (if required), and shipment to the analytical laboratory, proceed with 12.0 of section 16.2.1.

9.0 PROCEDURE: Alkalinity Measurement

Alkalinity determination (total carbonate) is performed on an aliquot of the raw, unfiltered, and unpreserved water sample by titration of the sample with an acid and measured by a pH meter.

9.1 Fill in all sample information on Attachment 16.1.10.2, page 3 of 4. NOTE: Record all procedure information on Attachment 16.1.10.2, page 3 of 4.

9.2 Wash the Erlenmeyer flask(s) and volumetric flask(s), to be used for this determination, with soap and water. Rinse the flasks THREE (3) times with 20 mL of distilled water. Discard rinses. Set flasks upside down to drain. After 10 minutes, remove remaining water droplets by shaking flasks vigorously.

9.3 Connect clean pH electrode to the pH meter and rinse electrode well with distilled water and blot dry with tissue.

9.4 Calibrate the pH meter/electrode as described in 8.3 and store electrode as described in 8.1.

9.5 Without too much splashing or other vigorous agitation of the water sample, carefully pour the water sample into a labelled 100 mL volumetric flask. Add water sample to the 100 mL mark. NOTE: Pour sample down the side of the flask.

9.6 With as little agitation as possible, carefully pour the water sample from the flask into a labelled 125 mL Erlenmeyer flask. If available, add a magnetic stirring bar, turn magnetic stirrer on, and stir sample slowly. Record sample aliquot volume on Attachment 16.1.10.2, page 3 of 4.

9.7 Insert the pH electrode into the sample and suspend the electrode in the water sample. Adjust the ATC on the pH meter to the temperature of the water sample. Determine sample pH and record value.

9.8 Place a 1.6 N H_2SO_4 cartridge in the titrator. Record the titrant lot number of the cartridge (on Attachment 16.1.10.2). Eject a few drops of titrant from the titrator tip, wipe tip with a clean tissue, and reset the counter to "0000".

9.9 While gently stirring the sample, titrate the sample with acid by turning the titrator delivery knob. Obtain pairs of pH and alkalinity readings at each pH value listed on Attachment 16.1.10.2, page 3 of 4. NOTE: The alkalinity value at the inflection point between pH 5 and pH 4 will be determined by the Site Hydrologist. The volume in mL equals digital titrator reading divided by 800.

9.9.1 Alkalinity titration endpoints depend upon the total alkalinity concentration. The following endpoints will be used:

Alkalinity	End Point
0-30 mg/L	pH 5.1
31-150 mg/L	pH 4.8
150 mg/L	pH 4.5

9.9.2 When the titration is complete, check pH meter calibration (See 8.3). If the meter is accurate within 0.2 units of each buffer value, record the results on Attachment 16.1.10.3. If the meter is inaccurate (greater than 0.2 units of each buffer value), recalibrate the meter and repeat the alkalinity test.

9.10 Repeat this procedure with a second Tech Rep performing the titration on a fresh aliquot of water sample.

9.11 Calculate the relative error (R.E.) as:

$$\text{R.E. (\%)} = \frac{(X_1 - X_2) \times 100\%}{X_s}$$

Where X_1 is the first alkalinity measurement at pH endpoint, X_2 is the second alkalinity measurement at pH endpoint, and X_s is the lesser of X_1 or X_2.

9.12 If the percentage error is greater than ten percent (>10%), repeat the foregoing procedure until two (2) consecutive measurements are within 10% relative error.

9.13 Perform alkalinity determinations on three (3) known solution(s) submitted to JEG by a quality control laboratory and record the pH and alkalinity values on Attachment 16.1.10.3. When performing this procedure, the standard solution identification, site identification, alkalinity test kit identification, pH meter identification, date, and Tech Rep name must be filled out on Attachment 16.1.10.3. Send this attachment to the Quality Control Laboratory

9.13.1 Send a copy of Attachment 16.1.10.3 to the Data Manager who will record this data on a form similar to Attachment 16.1.10.3 provided by a quality control laboratory.

9.13.2 Field alkalinity values and known solution values must agree within 10% of each other or the field test will have to be repeated until the values are accurate.

9.14 To prepare the sample(s) for filtration (if required), preservation (if required), and shipment, proceed with 12.0 of Section 16.2.1.

9.15 If Total Acidity is required, proceed with 10.0.

9.16 To complete duties, proceed with 12.9 of Section 16.2.1.

10.0 PROCEDURE: Total Acidity

This procedure is performed on selected groundwater or lysimeter (pore water) samples to determine the total acidity of the solutions and to determine the acid-neutralizing potential of carbonate materials within silty soils or sediments.

Digital Titration with HACH Cartridge

10.1 Record site identification, location identification, date, and all titration data under "Comments" on the Soil Water Sampler Data Record, under "Notes" of Attachment 16.1.10.2, or on a separate data sheet.

10.2 Calibrate the pH meter/electrode as described in 8.3 and store pH electrode as described in 8.1.

10.3 Rinse a 100 mL graduated cylinder and a 125 mL Erlenmeyer flask with distilled water. Place cylinder and flask upside down to allow excess water to drain. Remove residual water droplets by vigorously shaking the cylindar and flask. NOTE: If a 100 mL cylinder is unavailable, use a 100 mL volumetric flask.

10.4 Carefully pour a 100 mL aliquot of the unfiltered water sample into the graduated cylinder and then carefully pour the sample into the 125 mL titration flask. NOTE: Pour sample down the side of the cylinder and flask.

10.4.1If necessary, use a sample aliquot of less than 100 mL to perform a second titration. NOTE: Two (2) sample aliquots of 50 mL each with titrations on each aliquot are preferred to one (1) sample aliquot of 100 mL and one (1) titration.

10.5 Place clean pH electrode into the water sample, add a magnetic stirring bar, place sample on a magnetic stirrer, and gently stir sample. Record the initial sample pH. Withdraw pH electrode, rinse electrode with distilled water and blot dry with tissue.

10.6 Place a 1.6 N NaOH cartridge in the titrator. Record the HACH titrant lot number of the NaOH cartridge. Eject a few drops of titrant from the titrator tip, wipe tip with clean tissue, and reset the counter to "0000".

10.7 While gently stirring the sample, turn titrator delivery knob and start titration. Record sample pH and corresponding volume of NaOH titrant after every 1-2 turns of the titrator delivery knob (volume in mL = digital titrator reading divided by 800). If pH endpoint of 8.3 is obtained after less than eight (8) turns, then re-do the titration.

10.7.1 Do not use color indicator tablets to determine the pH endpoint.

10.7.2 Use a 0.16 N NaOH cartridge to re-do the titration. Record use of 0.16 N NaOH on the data sheet Form 10.1.

10.8 Rinse all glassware with distilled water. Set glassware upside down to allow excess water to drain.

10.9 Calculate the total acidity as follows:

$$\text{Acidity, u equiv/liter} = \frac{V_t \times N_t \times 10}{V_a}$$

Where V_t = Volume, in mL, of NaOH titrant used to obtain pH 8.3, N_t = Normality of NaOH used to titrate the sample, and V_a = Volume, in mL, of sample aliquot (should be 50 or 100 mL, unless lysimeter produces very little water). NOTE: Be sure to specify and record which NaOH and Volume of NaOH are used for the titration.

10.10 Repeat the titration procedure with a second Tech Rep performing the titration unless there is insufficient sample volume produced by the well or lysimeter.

10.11 Calculate the relative error in percent (R.E., %) as previously described in 9.11.

10.12 If the relative error is greater than 10%, repeat the procedure a third time, unless there is insufficient sample volume available.

10.13 Check Attachment 16.1.10.2 to see that all of the required data has been recorded on the forms.

10.14 See 12.9 of Section 16.2.1 to complete required duties.

11.0 ATTACHMENT(S): Supporting Document(s)

16.1.10.1 Equipment Checklist

16.1.10.2 Water Quality Sampling Record Form

16.1.10.2 Alkalinity Titration Form (page 3 of 4)

16.1.10.3 Standard Alkalinity Test

12.0 REFERENCES

12.1 APHA/AWWA/WPCF, 1985. Standard Methods for the Examination of Water and Wastewater, 16th Edition. American Public Health Association, Washington, D.C. 20005.

12.2 Korte, N. and P. Kearl, 1984. "Procedures for the Collection and Preservation of Ground Water and Surface Water Samples and for the Installation of Monitoring Wells," U.S. Department of Energy, Grand Junction, Colorado.

13.0 PROCEDURE REVIEW AND APPROVAL

Prepared By: 8-30-90
TAC Representative Date

Reviewed By: 9/7/90
Task Manager Date

Reviewed By: 9-7-90
Quality Assurance Manager Date

Approved By:
Project Manager/Deputy Project Manager Date

JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

ALBUQUERQUE OPERATIONS MANUAL	SECTION 16.1.10
	DATE 8-29-90
FIELD MEASUREMENT OF WATER SAMPLES FOR TEMPERATURE, CONDUCTIVITY, pH, ALKALINITY, AND TOTAL ACID	EFFECTIVE 09/10/90
	SUPERSEDES
	PAGE 1 OF 17

1.0 PURPOSE

To provide procedures by which field determinations for temperature, pH, conductivity, alkalinity, and total acidity will be performed and documented.

2.0 SCOPE

These procedures are applicable to members of the TAC and its contractors, subcontractors with responsibilities and duties for the field measurements of collected water samples prior to shipment to the analytical laboratory.

3.0 EQUIPMENT

3.1 Pumps

3.2 Hoses/Tubes

3.3 pH Meter & Electrode with "slope" adjustment feature and with temperature compensator.

3.4 Conductivity Meter & Electrode with thermometer.

3.5 Thermometer

3.6 Magnetic Stirrers and Magnetic stirring bars (Available at Laboratory)

3.7 Titrator

3.8 Filter Apparatus and Filters

3.9 Erlenmeyer Flask: 125 mL (Available at Laboratory)

3.10 Volumetric Flasks, Class A: 100, 250, 500, and 1000 mL (Available at Laboratory) All but 100 mL are required only if preparing solutions listed in 4.0.

3.11 Graduated Cylinder: 50, 100, 250, and 500 mL (Available at Laboratory) All but 100 mL are required only if preparing solutions listed in 4.0.

3.12 Beakers: 150, 250, and 400 mL (Available at Laboratory) Required only if preparing solutions listed in 4.0.

3.13 Sample Bottles: 250, 500, 1000 mL (or U.S. equivalents)

3.14 Cooler w/"blue ice" or equivalent

3.15 Parafilm or its equivalent

4.0 REAGENTS & SUPPLIES

NOTE: Whenever required by the procedure, JEG purchases and uses prepared, calibrated and certified solutions from chemical supply firms. The following are listed in the event certified solutions are not readily available or are used whenever procedure parameters do not require use of certified solutions. In the event that solutions require preparation, they will be prepared at the laboratory before going into the field. Items 4.12 through 4.21 are required only as needed.

4.1 Potassium Chloride: KCl. Reagent Grade. Purchased from chemical supply firms.

4.1.1 0.2 M Potassium Chloride: 0.2 M KCl Standard Solution (equivalent to 24,820 umhos/cm and 14,910 mg KCl/L). Weigh out 14.91 grams of KCl crystals into a 1000 mL volumetric flask containing 750 mL of distilled water. Mix solution to dissolve KCl salt. Add distilled water to 1000 mL mark, stopper flask, and mix solution well. Store solution in a polyethylene or glass bottle labelled with "24,820 umhos/cm: 14,910 mg KCl/L", "0.2 M KCl: 14.91 g KCl/L distilled water", date, and preparer's initials. Make all dilutions from this bottle.

Conductance of KCl Solutions @ 25° C.*

Concentration		Conductance (umho/cm)	
M	PPM	Equivalent	Specific
0.0	---	149.85	---
0.0001	7.5	149.43	14.94
0.0005	37.3	147.81	73.90
0.001	74.6	146.95	147.0
0.005	373	143.55	717.8
0.01	746	141.27	1,413
0.02	1,491	138.34	2,767
0.05	3,728	133.37	6,668
0.1	7,455	128.96	12,900
0.2	14,910	124.08	24,820
0.5	37,276	117.27	58,640
1.0	74,551	111.87	111,900

*From Reference 12.1. See 12.0.

4.2 KCl-A Solution: Pipet 10 mL of the 0.2 M KCl Standard Solution into a 200 mL volumetric flask containing 150 mL of distilled water and mix solution well. Add distilled water to 200 mL mark of flask, stopper flask, and mix solution well. Label flask as "KCl-A", "1,413 umhos/cm", "10 mL of KCl Standard Solution/ 200 mL of distilled water", date, and preparer's initials.

4.3 KCl-B Solution: Pipet 10 mL of the KCl Standard Solution into a 100 mL volumetric flask containing 70 mL of distilled water and mix solution well. Add distilled water to 100 mL mark, stopper flask, and mix solution well. Label flask as "KCl-B", 2,767 umhos/cm", 10 mL of KCl Standard Solution/100 mL of distilled water", date, and preparer's initials.

4.4 KCl-C Solution: Pipet 25 mL of the KCl Standard Solution into a 100 mL volumetric flask containing 70 mL of distilled water and mix solution well. Add distilled water to 100 mL mark, stopper flask, and mix solution well. Label flask as "KCl-C", "6,668 umhos/cm", "25 mL of KCl Standard Solution/100 mL of distilled water", date, and preparer's initials.

4.5 KCl-D Solution: Pipet 50 mL of the KCl Standard Solution into a 100 mL volumetric flask containing 40 mL of distilled water and mix solution well. Add distilled water to 100 mL mark, stopper flask, and mix solution well. Label flask as "KCl-D", "7,446 umhos/cm", "50 mL of KCl Standard Solution/100 mL of distilled water", date, and preparer's initials.

4.6 Hydrochloric Acid: HCl. 36.5-38%, 12 M (12 N); Reagent Grade. Purchased from chemical supply firms.

4.7 Nitric Acid: HNO_3. 70%, 16 M (16 N); Reagent Grade. Purchased from chemical supply firms.

4.8 Sulfuric Acid: H_2SO_4. 98%, 18 M (36 N); Reagent Grade. Purchased from chemical supply firms.

4.9 Sodium Hydroxide: NaOH. Reagent Grade. In pellet form. Purchased from chemical supply firms.

4.10 1 N NaOH Solution: Add 40 g of reagent grade Sodium Hydroxide pellets to a 1000 mL volumetric flask containing 900 mL of distilled water or its equivalent and swirl solution to dissolve the NaOH pellets. Cool solution in an ice water bath. Add distilled water to the 1000 mL mark, stopper flask, and mix solution well. Store solution in a polyethylene bottle labeled with " 1 N NaOH", "40 g NaOH/1000 mL of distilled water", date, and preparer's initials. Prepare fresh solution every 30 days and add new date.

4.11 1.6 N NaOH. HACH cartridge. Purchased from chemical supply firms.

4.12 0.16 N NaOH. HACH cartridge. Purchased from chemical supply firms.

4.13 pH 1 Buffer Solution: Certified as ±0.02 pH units and with expiration date. Purchased from chemical supply firm. Supplied in tablet or powder form. NOTE: Prepare fresh before use as instructed. Discard solution after use.

4.14 pH 4 Buffer Solution: Certified as ±0.02 pH units and with expiration date. Purchased in solution form from chemical supply firm. NOTE: Discard any solution whose expiration date has elapsed.

4.15 pH 5 Buffer Solution: Certified as ±0.02 pH units and with expiration date. Purchased in solution form from chemical supply firm. NOTE: Discard any solution whose expiration date has elapsed.

4.16 pH 7 Buffer Solution: Certified as ±0.02 pH units and with expiration date. Purchased in solution form from chemical supply firm. NOTE: Discard any solution whose expiration date has elapsed.

4.17 pH 10 Buffer Solution: Certified as ±0.02 pH units and with expiration date. Purchased in solution form from chemical supply firm. NOTE: Discard any solution whose expiration date has elapsed.

4.18 pH 12.45 Buffer Solution: Certified as ±0.02 pH units and with expiration date. Purchased from chemical supply firm. Supplied in powder form. NOTE: Prepare fresh before use as instructed. Discard solution after use. Due to the instability of this high pH buffer solution, prepare this buffer solution fresh as needed and **do not store**.

4.19 Distilled Water or Deionized Water

4.20 Masking Tape, Nylon Tape, Electricians Tape, and Magic Marker.

4.21 Plastic Sheet and Aluminum Foil.

4.22 Lint-free Tissue(s).