PROCEDURES FOR GROUND-WATER
INVESTIGATIONS

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MASTER

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INTRODUCTION

This manual was developed by the Pacific Northwest Laboratory (PNL)^(a) to document the procedures used to carry out and control the technical aspects of ground-water investigations at the PNL. Ground-water investigations are carried out to fulfill the requirements for the U.S. Department of Energy (DOE) to meet the requirements of DOE Orders. Investigations are also performed for various clients to meet the requirements of the Resource Conservation and Recovery Act of 1976 (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). National standards including procedures published by the American Society for Testing and Materials (ASTM) and the U.S. Geological Survey were utilized in developing the procedures contained in this manual.

MANUAL USE

Ground-water monitoring procedures are developed and used in accordance with the PNL Quality Assurance Program. This program requires that the current version of the applicable procedure is at or accessible to the location where the work is being performed during the conduct of the work. The procedure shall be identified as the workplace copy. Individuals performing the work are responsible for ensuring that they are working to the correct procedure revision and that data taken are traceable to the procedure.

The PNL Document Control group generally distributes procedure manuals and all changes to procedures to the PNL and its clients. However, to make this manual more publicly accessible, this special edition has been prepared. While the internal version of the manual must be updated whenever changes are warranted, this edition will be updated only yearly to include any changes made during that year. The December 1992 edition includes manual updates made before September 1, 1992.

(a) PNL is operated for the U.S. Department of Energy by Battelle Memorial Institute.

REFERENCES

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. Public Law 96-510, as amended. 94 Stat 2767 (Title 26).

Resource Conservation and Recovery Act (RCRA) of 1976. 42 USC 6901 et seq., as amended.

AD-1 CHANGE CONTROL PROCEDURE

1.0 APPLICABILITY

This procedure details the methods for initiating, processing, implementing, and recording changes to the functional characteristics of approved documents affecting design, fabrication, construction, installation, or testing.

All changes shall be traceable from the initial identification of the need for the change through the construction process and into the permanent as-built drawings and specifications. The changes must also be traceable into the schedule control documentation.

Authorized changes to approved documents shall be documented on a Design Field Change form (DFC) (Figure 1). The DFC form is to be used only for changes occurring during the construction phase.

2.0 DEFINITIONS

- DFC - Design Field Change
- PNL - Pacific Northwest Laboratory.

3.0 RESPONSIBLE STAFF

- PNL Site Geologist
- Project Manager.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- DFC form.

4.2 Step-by-Step Instructions

4.2.1 Initiating a Design Field Change

Position Responsible: PNL SITE GEOLOGIST OR PROJECT MANAGER

All DFCs shall be typed or completed in black indelible ink (including all approval signatures).

1. The Project Manager shall maintain the DFC Log for all DFCs associated with project-directed work. This log shall record a list of DFCs sequentially numbered by Project. Numbers are assigned on request.

DESIGN FIELD CHANGE			DFC No. _____	
TASK NO.	PROJECT TITLE		FINAL APPROVAL DATE	
DOCUMENTS AFFECTED				
DESCRIPTION OF CHANGE			DISTRIBUTION	
JUSTIFICATION				
REMARKS				
INITIATOR/AUTHOR		PHONE	ORGANIZATION	DATE
APPROVALS				
PROJECT MANAGER			QAD REPRESENTATIVE	

FIGURE 1. Example of a Design Field Change Form

The Project Manager shall review all approved DFCs for completeness (returning incomplete DFCs to the initiator for completion), verify that the distribution shown on the DFC form is complete and up to date, fill in the block with the latest approval date, and distribute the DFC form. The Project Manager shall retain the original in the appropriate Project File and log the final approval date in the DFC Log.

2. On determination of the requirement for a document revision, the person(s) requesting the change shall contact the Project Manager, or his designee, to explain and justify the change request. On concurrence of the Project Manager that a revision is required, a DFC shall be initiated. The DFC requester shall be given the responsibility of authoring the DFC.
3. The author shall list on the form a DFC number obtained from the Project DFC Log maintained by the Field Record custodian. The author shall write the project number and title on the DFC form.
4. The author shall list on the form all documents affected by implementation of the DFC, including drawings, Acceptance Test Procedures, specifications, and Nonconformance Reports.
5. The author shall enter a description of the change on the form. The description must contain sufficient detail to allow implementation of the change. Required sketches must be attached, with the DFC number and a place for review and approval on each sketch page. All pages (including attachment) shall be numbered sequentially (i.e., Page X of Y).
6. The author shall enter a clear and concise justification for the DFC.
7. The author shall review the change control form for completeness, sign the DFC form, and enter phone number, organization, and date.
8. The author shall enter under "Remarks" any data or references that, while not directly pertaining to the particular DFC, may clarify the DFC.
9. The author shall obtain the following signatures (as a minimum):
 - Project Manager (if not originator)
 - Quality Engineer
 - Senior Technical Reviewer.

Other organizations may need to review/approve the DFC, and it shall be the responsibility of the DFC author and/or the Project Manager to ensure that any other required signatures are obtained.

10. Approval of the Project Manager or a Senior Technical Reviewer may be obtained by telephone/radio. In such cases, the person obtaining the approval shall document the approval on the DFC and initial and date each approval received. The author shall arrange to obtain the signatures as soon as possible on the first normal day shift.
11. DFC numbers that are assigned but not approved and issued shall be voided on notification from the requesting individual or the Project Manager. The DFC Log shall be updated to show the void numbers. Numbers shall not be reassigned.

4.2.2 Revising Design Field Changes

Position Responsible: PNL SITE GEOLOGIST OR PROJECT MANAGER

Before final approval of a DFC form, revisions may be made through use of a single line strike-out on the original (black indelible ink only). New information shall be entered, and the originator of the revision shall initial and date the change. If the change is of a technical nature, all approval signatures obtained before the revision must be initialed and dated by the approver(s) subsequent to the change. Changes having no impact on the technical aspects of the DFC shall be initialed and dated by the author of the change. Revisions to approved DFCs that have already been issued require initiation of a new DFC (with a new number).

AD-2 GROUND-WATER SAMPLE CHAIN-OF-CUSTODY PROCEDURE

1.0 APPLICABILITY

To ensure the integrity of ground-water samples from the time of collection through data reporting, the history of the custody of each sample will be documented according to this procedure. Anyone having custody of samples must comply with the procedure described below.

2.0 DEFINITIONS

- Custody - a sample is considered to be under a person's custody if it is in any of the following states: 1) in his physical possession; 2) in his view after he has taken possession; 3) secured by him so that no one can tamper with the sample; or 4) secured by him in an area that is restricted to authorized personnel
- RPT - Radiation Protection Technologist
- Sample Custodian - the person responsible for sample custody.

3.0 RESPONSIBLE STAFF

- Radiation Protection Technologist
- Technical Staff
- Sample Custodian
- Sample Recipient.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- appropriate sample containers
- sample labels
- sample seals
- Field Record Forms
- Chain-of-Custody Forms
- Sample Analysis Request Forms.

4.2 Step-by-Step Instructions

4.2.1 Sample Identification and Delivery

Position Responsible: RADIATION PROTECTION TECHNOLOGIST OR TECHNICAL STAFF (SAMPLE CUSTODIAN)

1. Record in permanent ink all pertinent information about each sample on a Chain-of-Custody Form. An example of the form to be used for samples collected for radionuclide analysis only is shown

in Figure 1. An example of the form to be used for samples collected for multiple chemical and radionuclide analyses is shown in Figure 2.

NOTE: A Chain-of-Custody Form will accompany all samples from the time they are collected until they are disposed of after analysis and reporting. A single form may be used for as many samples as possible.

2. Fill out and affix sample labels to the sample containers before or at the time of sample collection. Examples of the label to be used are shown in Figure 3.
3. Once all samples have been placed in the cooler, attach the seal in such a way that the cooler cannot be opened without breaking the seal. Attach a sample custody seal across the bottle top for any samples not transported in the sealed cooler.
4. Record (in black ink) all pertinent information about each sample on a Ground-Water Sample Field Record Form. A sample of a Ground-Water Sample Field Record Form is shown in Figure 4.
5. Record all pertinent information about each sample on a Sample-Analysis Request (SAR) Form. An example of the form to be used is shown in Figure 5. This does not apply to radionuclide samples (Figure 1).
6. Deliver the samples to the analytical laboratory along with the Chain-of-Custody and Sample-Analysis Request Forms. Deliver samples only to authorized laboratory personnel.

Samples are normally delivered directly to the laboratory on the day of collection. If they cannot be delivered on the day of collection, the Sample Custodian stores them in a locked building.

4.2.2 Transferring Custody of Samples

Position Responsible: SAMPLE CUSTODIAN AND SAMPLE RECIPIENT

1. At the time the custody of the samples is transferred the Sample Custodian signs the Chain-of-Custody Form in the uppermost blank "Relinquished by" space. The signature is witnessed by the Sample Recipient.
2. The Sample Recipient signs the "Received by" space on the same line the Sample Custodian signed. The signature is witnessed by the Sample Custodian. Either the Sample Recipient or the Sample Custodian records the date and time of the transfer.

The Sample Recipient becomes the Sample Custodian on completion of this step in the procedure.

Battelle <small>Pacific Northwest Laboratories 5000 University Blvd. Richland, Washington 99212</small>	CHAIN OF CUSTODY/FIELD RECORD SHEET (RADIONUCLIDES)	
Company Contact: _____ Telephone: _____ Samples Collected By: _____ Date: _____ Time: _____ Sample Location: _____ Ice Chest No. _____ Method of Shipment: _____ Submersible (Time On) _____ Pumping Time: _____ Comments: _____ _____ _____		
Sample No.	Volume	Comments

FIELD MEASUREMENTS Steel Tape No. _____ (E - Tape = _____)	Mold Wet Level below T.C.	WATER LEVEL <table border="1" style="width: 100%; height: 100px; border-collapse: collapse;"> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> </table>																	Time pH Temp Cond	<table border="1" style="width: 100%; height: 100px; border-collapse: collapse;"> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </table>																																
FIELD OBSERVATIONS _____ _____ _____ _____																																																				

CHAIN OF POSSESSION		
Relinquished by	Received by	Date/Time
Relinquished by	Received by	Date/Time
Relinquished by	Received by	Date/Time

BC-1280-256 (11/87)

FIGURE 1. Sample Chain-of-Custody Form, Radionuclides

Battelle Pacific Northwest Laboratories P.O. Box 999 Richland, Washington 99222	CHAIN OF CUSTODY	
Company Contact: _____ Telephone: _____ Sample Collected by: _____ Date: _____ Time: _____ Sample Location: _____ Ice Chest No.: _____ Field Logbook Page No.: _____ Remarks: _____ _____ Method of Shipment: _____		
Sample Identification		
_____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____	_____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____	
CHAIN OF POSSESSION		
Relinquished by: _____ _____	Received by: _____ _____	Date/Time: _____ _____
Relinquished by: _____ _____	Received by: _____ _____	Date/Time: _____ _____
Relinquished by: _____ _____	Received by: _____ _____	Date/Time: _____ _____
Relinquished by: _____ _____	Received by: _____ _____	Date/Time: _____ _____

OC-1308-846 (7-82)

FIGURE 2. Sample Chain-of Custody Form for Multiple Chemical and Radionuclide Analyses

GROUNDWATER		
Sponsor:		
Lab:		
Sample Size:		
Bottle:		
Date/Time:		
Collector:		

T 2396-0	2-E25-25	
G	GROUNDWATER	741 741
Sponsor:	B	H37 FARSENI
Lab:	H/IL	H39 FSELENI
Sample Size:	1000 ML	H41 FLEAD
07/01/88	Bottle:	PWC
Date/Time:	7/20/88	
Collector:	<i>Andrew J. Morton</i>	
		*** Filter

T 1888	1-F8-1	111 BETA
	GROUNDWATER	998 GAMMA
Sponsor:		121 SR 90
Lab:	M/LL	108 TRITIUM
Sample Size:	3000 ML	104 U
08/01/88	M	
Date/Time:	8/17/88	
Collector:	<i>Andrew J. Morton</i>	

FIGURE 3. Blank Sample Label and Two Examples of Completed Sample Labels. A description of each item on the sample label is contained in the procedure for ground-water sample collection (Procedure GC-1).

NOTE: Sample collection is routinely accomplished by a team of two RPTs. either one of the team members identified on the "Samples Collected by" space at the top of the Chain-of-Custody Form is a sample custodian and may sign the form when the sample is relinquished.

BC-1500-113 (01,89)

12

PROJECT GROUT
 DATE _____
 CHAIN OF CUSTODY # _____
 EMA # _____

SAMPLE ANALYSIS REQUEST

from Battelle PNL

UNITED STATES TESTING
 2800 GEORGE WASHINGTON WAY
 RICHLAND, WA 99352
 WATER _____ SOIL _____ OTHER _____

	109	H42	C89	726	741	A21	H38	742	H57	728	737	112	181	188
				A28	H37							111		
				A22	H39									
				A51	H41									
ANA_1														
ANA_2														
ANA_3														
ANA_4														
ANA_5														
BTL_S	126	250	250	1L	1L	500	500	125	2L	4L	4L	1L	1L	125
BTL_T	P	GA/S	GA/S	PCW	PVC	QC	QC	P	QA	GA	GA	P BC	P BC	P BC
M_BTL	2	2	1	1	1	1	1	1	1	1	1	1	1	1
PRESE	--	H2SO	H3PO	HM03	HM03	HM03	HM03	--	--	--	--	HM03	HM03	--
NOTES														
H60 TURBIDITY														
H17 TOTAL DISSOLVED SOLIDS														
109 COLIFORM BACTERIA	X													
207 pH (LAB)														
000 CONDUCTIVITY (LAB)														
H50 ALKALINITY														
H42 TOX LOWER DET LIMIT		XXXX												
C89 TOC			XXXX											
H16 TOTAL CARBON														
726 ICP METALS 8010 ENHANCED				X										
741 FILTERED ICP METALS ENHA					X									
A20 ARSENIC				X										
A21 MERCURY						X								
A22 SELENIUM				X										
A23 THALLIUM				X										
A51 LEAD BY GFAA				X										
H37 FILTERED ARSENIC					X									
H38 FILTERED MERCURY						X								
H39 FILTERED SELENIUM					X									
H40 FILTERED THALLIUM					X									
H41 FILTERED LEAD					X									
742 (COMBINATION OF 735, H60								X						
H65 NITRATE (HOL)														
H63 FLUORIDE (LDL)														
749 HALOGENATED VOLATILE ORGA														
730 VOA METHOD 8240														
731 VOA METHOD 8240 ENHANCED														
750 VOA METHOD 8240 ENHANCED														
749 VOA BY GC 8010														
732 A/B/N 8270														
733 A/B/N 8270 ENHANCED														
751 A/B/N 8270 ENHANCED														
H57 PHENOL									X					
728 PESTICIDES 8000										X				
729 PESTICIDES 8000 ENHANCED														
737 HERBICIDE 8150 ENHANCED												X		
A24 THIUREA 8330														
727 METHOD 8330 ENHANCED (th														
734 PESTICIDES METHOD 8140 (														
736 DIRECT AQUEOUS INJECTION														
H62 HYDRAZINE (LDL)														
739 PCB														
752 TCDD, PCDDs, PCDFs														
C78 CYANIDE														
P09 FERROCYANIDE														
P10 OXALATE														
P11 CHROMIUM (VI)														
C77 PERCHLORATE														
C78 SULFIDE														
C80 AMMONIUM ION														
C81 ETHYLENE GLYCOL														
C87 CITRUS RED #2														
112 ALPHA												X		
111 BETA												X		
181 RADIUM													X	
184 URANIUM														
998 GAMMA														
121 SR-90														
108 SH														X
107 TC99														
001 I 129 15 PCI/L														
201 I 129 (LDL) 1 PCI/L														
998 PU ISOTOPES														
105 AM														

FIGURE 5. Sample Analysis Request Form

3. The new Sample Custodian examines the sample containers or ensures that the samples and sample seals are intact, the total number of bottles match the number on the Chain-of-Custody Form, and that the samples were in contact with the ice. If there is an observed problem with the samples, the new Sample Custodian records the condition of the samples in the remarks section of the Chain-of-Custody Form and notifies the Sample Analysis Task Leader of the problem.
4. The person relinquishing custody of the sample to the analytical laboratory returns the top or original copy of the form to the company contact whose name appears on the top line of the form. If the sample was collected by an RPT, the copy of the form is transmitted to the company contact through the RPT supervisor.

4.2.3 Disposal of Samples

Position Responsible: TECHNICAL STAFF

When all analyses for a sample have been completed, the laboratory continues to hold the samples in secure storage for 30 days. This allows time for reanalysis if requested. Information on the sample label may also be verified during this time. The laboratory notifies the contact person identified on the Chain-of-Custody Form when the sample holding time is completed. The requirement for notification of the contact person by letter is contained in the contract or letter of instruction to the laboratory.

When samples are disposed of by the analytical laboratory:

1. If the contract or letter of instruction for the analysis includes a provision for disposal of the samples, the contact person notifies the laboratory by letter that the samples may be destroyed or that an extended holding period is desired. When the samples are destroyed, a copy of the Chain-of-Custody Form is returned to the contact person by the analytical laboratory.
2. The contact person records the date of receipt of the Chain-of-Custody Form in the Chain-of-Possession section of the form.
3. Following completion of the chain of possession, the Chain-of-Custody Form is included in the files of the appropriate project.

When samples are disposed of by the Pacific Northwest Laboratory (PNL):

1. If the contract or letter of instruction does not contain provisions for the disposal of samples, samples are picked up at the laboratory by PNL personnel and disposed of in accordance with established shipping procedures. These procedures are under the direction of the Waste Management and Environmental Compliance

Section, Laboratory Safety. The disposal procedure uses the Onsite Radioactive Shipment Record Form to document sample radioactivity.

2. Record the date samples are relinquished to PNL personnel in the Chain-of-Possession section of the Chain-of-Custody Form.
3. Following completion of the chain of possession, the Chain-of-Custody Form is included in the files of the appropriate project.

5.0 REFERENCE

- Procedure GC-1, "Ground-Water Sample Collection Procedure."

AD-3 MODIFICATIONS TO FIELD SAMPLING PROGRAM

1.0 APPLICABILITY

Modification of the field sampling program requires changes to the sampling schedule and data base, and notification of analytical subcontractors of the changes to be made. This procedure identifies who needs to be notified and what information each participant needs in order to add new wells to the sampling program or to add or delete constituents to be analyzed for at wells already on the schedule.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Project Manager
- Data Handling Task Leader
- Sample Analysis Task Leader
- Sample Collection Task Leader
- Sample Preparation Task Leader
- Radiation Protection Technologist (RPT) Supervisor.

4.0 PROCEDURE

4.1 Prerequisites

N/A

4.2 Step-by-Step Instructions

4.2.1 Identifying Changes to Be Made

Position Responsible: PROJECT MANAGER

NOTE: The project manager should initiate the process of modifying the sampling program at least 6 weeks before the changes are required to go into effect.

1. Determine the sampling interval desired (e.g., monthly, quarterly, semiannually, or annually).
2. Determine the analyses to be performed on samples collected from the added wells.
3. Provide surveyed well locations and the list of analyses to be performed to the Data Handling Task Leader.

4. Provide the list of wells to be sampled, intended sampling period, and work package number for sample collection to Sample Collection Task Leader. Notify the Sample Collection Task Leader when the changes are to be initiated.
5. Provide list of analyses required on samples from new wells or changes to list of analyses required from old wells to Sample Analysis Task Leader. Also identify the project and indicate the work package number to be charged so that an account can be set up with the analytical subcontractor.
6. Notifications in steps 3 to 5 should be in writing, with copies maintained by the Project Manager.

4.2.2 Obtaining Formal Identification for Wells and Analyses to Be Added

Position Responsible: DATA HANDLING TASK LEADER

1. Obtain formal well names if new wells are involved.
2. Provide well codes and well names to Sample Analysis Task Leader and Project Manager.
3. Generate labels for sample bottles for the analyses requested.
4. Give the labels to the Sample Preparation Task Leader.
5. Update the sample schedule in the data base from information provided by Sample Analysis Task Leader.

4.2.3 Notifying an Analytical Subcontractor of Changes to the Sampling Programs

Position Responsible: SAMPLE ANALYSIS TASK LEADER

1. Set up an account with the analytical subcontractor to cover the cost of additional analyses.
2. Provide the list of analyses to be performed and the related analytical subcontractor constituent code for each well to the Data Handling Task Leader.
3. Provide a list of the sample bottles that will be required to collect the requested samples to the Sample Preparation Task Leader.

4.2.4 Coordinating Sample Collection with RPT Supervisor

Position Responsible: SAMPLE COLLECTION TASK LEADER

1. Inform the RPT Supervisor of the additional wells to be sampled and the intended sampling period as soon as information is available from the Project Manager.
2. Inform the Project Manager when all preparations for collecting samples from the new wells are complete.
3. With approval of the Project Manager, inform the RPT Supervisor that the well is ready to be incorporated into the sampling plan and sampled.

4.2.5 Preparing Containers for Sample Collection

Position Responsible: SAMPLE PREPARATION TASK LEADER

1. Order sample containers after being informed by the Sample Analysis Task Leader of the appropriate size, type, and quantity needed.
2. Label and prepare the sample containers for sample collection.
3. Inform the Sample Collection Task Leader when sample container preparation is complete. Indicate where the containers are stored.

4.2.6 Scheduling Sample Collection

Position Responsible: RPT SUPERVISOR

1. Schedule new wells to be sampled by RPTs.

AD-4 SEDIMENT SAMPLE CHAIN-OF-CUSTODY

1.0 APPLICABILITY

This procedure details the methods for establishing the traceability of sediment samples that will undergo hazardous chemical and radionuclide analysis. This process ensures the integrity of the sediment samples from the time of collection through sample disposal. The sequential custody of sediment samples will be documented using this procedure. Each custodian of the samples shall comply with the procedures described below. The applicability of sediment samples requiring this chain-of-custody procedure shall be identified in the appropriate sediment sampling and analysis plans. See also procedure DO-3, Contaminated Sediment Sampling.

2.0 DEFINITIONS

- Custody - custody of a sample requires control of the sample in one or more of the following manners: 1) physical possession, 2) in his/her view after taking possession, 3) secured by him/her in a manner that prevents tampering of sample, and/or 4) secured by him/her in an area restricted to authorized personnel.
- Sample Custodian - responsible person in custody of sample.

3.0 RESPONSIBLE STAFF

- technical staff in charge of sediment sampling
- technical staff in charge of analysis
- Sample Custodian
- Sample Recipient
- Company Contact
- Project Manager.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- permanent ink markers
- appropriate sample containers
- sample labels
- sample seals
- Chain-of-Custody Forms
- Drill Log Forms
- applicable Sampling and Analysis Plan
- applicable Health and Safety Plan.

4.1.2 Safety Precautions

Sediment samples may pose a hazard to the responsible staff; therefore, the applicable safety precautions outlined in the Health and Safety Plan shall be adhered to.

4.2 Step-by-Step Instructions

4.2.1 Sample Identification and Delivery

Position Responsible: TECHNICAL STAFF IN CHARGE OF SEDIMENT SAMPLING

1. Record in permanent ink all pertinent information about each sample on a Chain-of-Custody Form. Multiple samples collected on the same date may be recorded on one Chain-of-Custody Form provided each sample is identified individually on the form. Record the procedure and revision number in the remarks section. (An example of a Chain-of-Custody Form is shown in Figure 1.)
2. Record date, time, depth, location, type of sample, sample size, preservation method (if applicable), and other pertinent information on the Drill Log. (An example of a Drill Log form is shown in Figure 2.)
3. Fill out and affix sample labels to the sample containers before or at the time of sample collection. Sample label will identify the time, date, depth, location, preservation method, constituents to be analyzed for, and name of sample collector.
4. Attach sample seals to the samples immediately on sample collection. Attach the seal in a way that the sample cannot be reached without breaking the seal.
5. Deliver the samples to the analytical laboratory and transfer custody of the samples to authorized laboratory personnel.

NOTE: If custody of the sediment samples cannot be transferred to the authorized laboratory personnel on the same day of sample collection, the samples must be stored in a locked and secure building until a transfer can be made.

4.2.2 Transferring Custody of Samples

Positions Responsible: SAMPLE CUSTODIAN AND SAMPLE RECIPIENT

1. The SAMPLE CUSTODIAN and the SAMPLE RECIPIENT shall examine the container to ensure the sample seals are intact and the sample containers have not been damaged. If any seals have been broken and/or the sample containers are damaged, the SAMPLE RECIPIENT records the condition of the seals and containers in the remarks section of the Chain-of-Custody Form.

Battelle Pacific Northwest Laboratories P.O. Box 999 Richland, Washington 99352	CHAIN OF CUSTODY	
Company Contact: _____ Telephone: _____		
Samples Collected by: _____ Date: _____ Time: _____		
Sample Location: _____		
Ice Chest No.: _____ Field Logbook Page No.: _____		
Remarks: _____ _____ _____		
Method of Shipment: _____		
Sample Identification		
_____ _____ _____ _____ _____ _____ _____ _____ _____ _____	_____ _____ _____ _____ _____ _____ _____ _____ _____ _____	
CHAIN OF POSSESSION		
Relinquished by: _____ _____	Received by: _____ _____	Date/Time: _____ _____
Relinquished by: _____ _____	Received by: _____ _____	Date/Time: _____ _____
Relinquished by: _____ _____	Received by: _____ _____	Date/Time: _____ _____
Relinquished by: _____ _____	Received by: _____ _____	Date/Time: _____ _____

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FIGURE 1. Chain-of-Custody Form

2. The SAMPLE CUSTODIAN signs the Chain-of-Custody Form in the upper-most blank "Relinquished by" space.
3. The SAMPLE RECIPIENT signs and records the date and time in the "Received by" space next to the Sample Custodian's signature. The Sample Recipient now becomes the Sample Custodian completing the transfer of sample possession.
4. The SAMPLE CUSTODIAN relinquishing custody of the sample to the analytical laboratory returns the top or original copy of the form to the Company Contact, whose name appears on the top line of the form.

4.2.3 Disposal of Samples

Positions Responsible: COMPANY CONTACT, SAMPLE CUSTODIAN, SAMPLE RECIPIENT, AND PROJECT MANAGER

Samples are to be maintained for 30 days in secure storage after sample analyses are complete. This allows for re-analysis if requested. The laboratory or responsible technical staff in custody of the samples will notify the contact person identified on the Chain-of-Custody Form when the holding time is complete.

When samples are disposed of by the analytical laboratory:

1. If the contract or letter of instruction includes a provision for disposal of the samples by the analytical laboratory, the COMPANY CONTACT will notify the laboratory that the samples may be destroyed, or that an extended period of storage is required.
2. After destruction of samples, the analytical laboratory returns a copy of the Chain-of-Custody Form to the COMPANY CONTACT.
3. The COMPANY CONTACT records the date of receipt on the Chain-of-Custody Form in the "Received by" section of the form space and indicates the samples were destroyed ending the chain of possession.
4. The Chain-of-Custody Form is then filed in the appropriate project files.

When samples are disposed of by the Pacific Northwest Laboratory (PNL):

1. If the contract or letter of instruction does not contain provisions for the disposal of samples, PNL personnel will obtain

custody of the samples from the analytical laboratory and will dispose of the samples in accordance with hazardous material shipping procedures.

2. After destruction of samples, PNL personnel responsible for sample destruction return a copy of the Chain-of-Custody Form to the COMPANY CONTACT.
3. The COMPANY CONTACT records the date of receipt of the Chain-of-Custody Form in the "Received by" space next to the Sample Custodian's signature and indicates the samples were destroyed ending the chain of possession.
4. The PROJECT MANAGER shall ensure that Chain-of-Custody Form is then filed in the appropriate project files.

AD-5 GROUND-WATER SAMPLE CHECK-IN PROCEDURE

1.0 APPLICABILITY

This procedure details the methods for establishing the traceability of ground-water samples that require interim storage at the sample storage facility (SSF) before undergoing hazardous chemical and radionuclide analyses. The SSF is located in the confined area within the north side parking lot of the Sigma V Building and consists of an 8- by 20-ft insulated, temperature-controlled shipping container. Access to this trailer is restricted to authorized personnel only. This procedure is intended to be used in conjunction with Procedure AD-2, "Ground-Water Sample Chain-of-Custody Procedure."

2.0 DEFINITIONS

- Custody - a sample is considered to be under a person's custody if it is in any of the following states: 1) in physical possession, 2) in view after it has been taken into possession, 3) secured so no one can tamper with the sample, or 4) secured in an area that is restricted to authorized personnel only.
- RPT - Radiation Protection Technologist.
- Sample Custodian - the person responsible for sample custody at any given time, as cited above.

3.0 RESPONSIBLE STAFF

- RPT
- Technical Staff
- Sample Custodian
- Sample Recipient.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- black permanent-ink pen
- Sample Check-In Form
- list of authorized sample custodians.

4.2 Step-by-Step Instructions

4.2.1 Transferring Custody of Samples

Position Responsible: SAMPLE CUSTODIAN AND SAMPLE RECIPIENT

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Samples shall not be removed from the SSF without permission of either the 1) Sampling and Analysis Coordination Task Leader or 2) the Sampling and Analysis Management Task Leader

FIGURE 1. Sample Check-In Form

1. Before the Chain-of-Custody procedure is initiated, the Sample Custodian will check to ensure the Sample Recipient is on the list posted in the sample receiving area of authorized sample custodians.
2. The Sample Custodian and the sample recipient examine the sample containers and ensure that the samples and the sample seals are intact; the total number of bottles matches the number on the Chain-of-Custody Form; the Sample Analysis Order (SAO) Form accompanies the samples; the information (e.g., Hanford Environmental Information System (HEIS) number) on labels, and Chain-of-Custody Form, are in agreement; and the samples are in contact with the ice.
3. At the time the custody of the samples is transferred, the Sample Custodian signs the Chain-of-Custody Form in the uppermost blank "Relinquished by" space. The signature is witnessed by the Sample Recipient.
4. The Sample Recipient signs the "Received by" line as indicated. The signature is witnessed by the Sample Custodian. Either the Sample Recipient or the Sample Custodian records the date and time of the transfer.
5. After sample custody is transferred and samples have been placed in the SSF, the new custodian shall enter the date, the Sample ID (either a HEIS number or well name, etc.), and Chain-of-Custody number on the Check-In Log (in the staging area of Sigma V), and initial the Log. Any notes of special interest or concern (e.g., sample collection problems, etc.) shall be noted on the Chain-of-Custody Form and the comment column of the Log. A copy of the Chain-of-Custody Form is forwarded to the Sampling and Analysis Coordination Task Leader so sample collection can be documented.

If samples are to be delivered to a Sigma V laboratory for analysis (VOA or Anions), the new custodian is responsible for transferring custody of those samples.

6. If samples were collected by RPTs, the person relinquishing custody of the sample(s) returns the bottom copy of the Chain-of-Custody Form to the RPT Supervisor. When sample(s) are not collected by RPTs, the person relinquishing custody of the sample(s) returns the bottom copy of the Chain-of-Custody Form to the Sampling and Analysis Management Task Leader.
7. The new Sample Custodian places samples into the SSF and ensures the storage unit is locked.

8. A record of archived samples in the SSF is compiled from the copy of the Chain-of-Custody Form retained by the sample collector and transmitted to the RPT Supervisor and any other Chain-of-Custody Forms that are submitted directly to the Sampling and Analysis Management Task Leader. (The RPT Supervisor transmits the copies of Chain-of-Custody Forms that he receives to the Sampling and Analysis Management Task Leader after the collection date has been entered in his records.) (4.2.1.6)

The Archived Sample file will be maintained in 1) a Reflex software directory of the Sampling and Analysis Management Task Leader's computer, 2) back-up on a floppy disk, and 3) a hard copy file. The Sample Check-In Log shall be initialed when the received Chain-of-Custody Forms have been checked against the Log list and entered in the Archived Sample file. This will be the responsibility of the Sample Preparation Technician or a staff person assigned by the Sampling and Analysis Management Task Leader.

9. Only authorized sample recipients have access to the SSF and removal of samples must continue to follow Chain-of-Custody protocol for Relinquished by signature, Received by signature, date and time entries.
10. Archived Samples shall be removed from the SSF only with the permission of the Sampling and Analysis Coordination Task Leader or the Sampling and Analysis Management Task Leader. Removal authorization by the Sampling and Analysis Coordination Task Leader or Sampling and Analysis Management Task Leader will be documented on the Sample Check-In Log by the initials of the authorized individual. When archived samples are removed from the SSF, the Sample Check-In Log will show the date, by whom, and reason for removing samples; the withdrawal date shall be entered in the computer file (refer to Section 4.2.1.8) at the same time.

AD-6 CONTROL MEASURES FOR IDENTIFICATION OF WELLS REQUIRING PURGE-WATER CONTAINMENT

1.0 APPLICABILITY

Because of the migration of the ground-water contaminant plume under the Hanford Site and the addition of new wells to the sampling network, the list of wells requiring purge-water containment must be updated and distributed to project staff on a routine basis. Purge water requiring containment is that water having a specific constituent and constituent concentration at or above the criteria limits identified in WHC-MR-0039, Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington.

This procedure provides guidance on how the list of wells requiring purge-water containment is updated and distributed to key staff.

2.0 DEFINITIONS

- HEIS - Hanford Environmental Information System
- NO-DUMP Well List - List of wells requiring purge-water containment
- "T" Wells - Wells requiring purge-water containment are indicated by the placement of a "T" on each label affixed to sample bottle and on the Field Record Form of the specific well.

3.0 RESPONSIBLE STAFF

- Data Management Task Leader
- Sampling and Analysis Task Leader (Environmental Surveillance Project)
- Sample Analysis Task Leader (Environmental Surveillance Project)
- Sampling and Analysis Coordination Staff
- Sampling and Analysis Management Task Leader (all other Ground-Water Monitoring Projects)
- Radiation Protection Technologist Supervisor
- Radiation Protection Technologist (RPT).

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- copy of HEIS User's Guide
- NO-DUMP Update Computer Program
- Deficiency Report.

4.1.2 Background

On August 21, 1990, WHC-MR-0039, Strategy for Handling and Disposing of Purge-water at the Hanford Site, Washington, was approved by the U.S. Environmental Protection Agency, State of Washington Department of Ecology, and the U.S. Department of Energy, Richland Operations Office. Exhibit 1 identifies the constituents of concern, detection limits, and collection criteria. Table 4 in the Strategy Document identifies wells requiring purge-water containment. That list of wells was generated from analytical data from specific wells sampled and analyzed prior to June 1, 1990. In addition, purge water from all wells located within the 200 West Area, burial grounds, and/or liquid effluent disposal sites requires containment regardless of concentration levels of constituents identified in Exhibit 1. The Strategy Document also directs the list of wells requiring purge-water containment to be updated regularly to include new analytical data from old wells and analytical data from new wells recently added to the monitoring network. To implement this requirement, the NO-DUMP Update Computer Program sorts the data and selects the monitoring wells having constituents measured in ground-water samples exceeding levels identified in Exhibit 1. This update routine identifies wells having constituent concentrations dropping below the criteria level or adds wells having constituent concentrations exceeding the criteria levels.

4.2 Step-by-Step Instructions

4.2.1 Update of NO-DUMP Well List

Position Responsible: DATA MANAGEMENT TASK LEADER

1. On a fiscal year quarterly basis (October, January, April, and July), the NO-DUMP Update Program sorts the most recent radiological and chemical ground-water data in HEIS.
2. The NO-DUMP Update Program generates a list of wells requiring purge-water containment. In addition, the program identifies wells to be deleted from the current NO-DUMP Well List. A well will be deleted from the NO-DUMP List only when four consecutive analytical results for the constituent causing the listing decrease below the criteria concentration. The Data Management Task Leader reviews the list of wells to be deleted from the current NO-DUMP Well List. Any deletions from the NO-DUMP Well List

will have the constituent initially causing the well listing verified by the Data Management Task Leader for accuracy.

3. A copy of the updated NO-DUMP Well List will be forwarded to PNL Document Control.

4.2.2 Distribution of NO-DUMP Well List

Position Responsible: PNL DOCUMENT CONTROL

A Controlled Document Copy of the updated NO-DUMP Well List will be forwarded to the following staff:

Data Management Task Leader
Sampling and Analysis Task Leader
Sample Analysis Task Leader
Sampling and Analysis Coordination Task Leader
Sampling and Analysis Management Task Leader
Sample Collection Task Leader
Senior Project Technical Clerk
Radiation Protection Technologist Supervisor
Radiation Protection Technologist
Technical Support Division - U.S. Department of Energy - Richland
Operations Office
Environmental Engineering Remedial Action Section - Westinghouse
Hanford Company
Ground-Water Well Construction and Remediation Section - Westinghouse
Hanford Company

4.2.3 Implementation of Updated NO-DUMP Well List

Position Responsible: TECHNICAL STAFF/RPT/RPT SUPERVISOR

1. On receipt of the updated NO-DUMP Well List, the staff will replace the outdated list with the updated version and forward the acknowledgment sheet to PNL Document Control.
2. Sampling and Analysis Coordination Staff will implement sampling preparations according to Procedure GC-11, Preparation of Documents and Sample Containers for Ground-Water Sample Collection.

4.2.4 Field Verification of NO-DUMP Wells

Position Responsible: RPT AND RPT SUPERVISOR

1. A copy of the NO-DUMP Well List will be in the possession of each RPT sampling team at all times during ground-water sample collection.
2. Before sampling any well, the RPT sampling team will verify, using the NO-DUMP Well List, if purge-water containment is required. If

a well is misidentified, the "T" is not on the labels and/or Field Record Form, or the "T" is on the labels and/or Field Record Form and should not be, the RPT sampling team will immediately contact the RPT Supervisor and document this action on the Field Record Form for the misidentified well.

3. If there is any doubt about the listing of the well on the NO-DUMP Well List, the purge water shall be contained or the well shall not be sampled until the status of the well is verified by the RPT Supervisor.
4. The RPT Supervisor will contact the Sampling and Analysis and/or Sampling and Analysis Management Task Leader and Data Management Task Leaders about the discrepancy. Contact shall be documented by Contact Memorandum or an Internal Memorandum to file.

4.2.5 Corrections of Deficiency in NO-DUMP Well List

Position Responsible: DATA MANAGEMENT TASK LEADER

1. If the cause of the discrepancy is with the NO-DUMP Well List, the discrepancy shall be determined, remediated, and documented by a memorandum to file or Deficiency Report if appropriate.
2. A corrected version of the NO-DUMP Well List will be forwarded to PNL Document Control for distribution (see Sections 4.2.2 and 4.2.3).
3. If the NO-DUMP Well List is not the cause of the misidentified well, the Sampling and Analysis and/or Sampling and Analysis Management Task Leader must determine the cause, remediate the cause, and document the solution by a memo to file or a Deficiency Report if appropriate.

Constituent	Detn. Limit	Collection Criteria	Units	Basis ¹
1,1,1,2-tetrachlorethane	10.0	50.0	PPB	PQL
1,1,1-trichloroethane	5.0	2000.0	PPB	MCL
1,1,2,2-tetrachloroethane	5.0	24000.0	PPB	CFWTL
1,1,2-trichloroethane	5.0	2000.0	PPB	MCL ²
1,1-dichloroethane	5.0	10.0	PPB	PQL
1,1-dichloroethylene	10.0	70.0	PPB	MCL
1,2,3,4-tetrachlorobenzene	10.0	500.0	PPB	CFWTL
1,2,3,5-tetrachlorobenzene	10.0	500.0	PPB	CFWTL
1,2,3-trichlorobenzene	10.0	500.0	PPB	CFWTL
1,2,3-trichloropropane	10.0	50.0	PPB	PQL
1,2,4,5-tetrachlorobenzene	10.0	100.0	PPB	PQL
1,2,4-trichlorobenzene	10.0	100.0	PPB	PQL
1,2-dibromo-3-chloropropane	10.0	50.0	PPB	PQL
1,2-dibromoethane	10.0	50.0	PPB	PQL
1,2-dichlorobenzene	10.0	500.0	PPB	CFWTL
1,2-dichloroethane	5.0	50.0	PPB	MCL
1,2-dichloropropane	5.0	57000.0	PPB	CFWTL
1,3,5-trichlorobenzene	10.0	500.0	PPB	CFWTL
1,3-dichlorobenzene	10.0	500.0	PPB	CFWTL
1,3-dichloropropene	5.0	2440.0	PPB	CFWTL
1,4-dichloro-2-butene	10.0	50.0	PPB	PQL
1,4-naphthoquinone	10.0	100.0	PPB	PQL
1-naphthylamine	10.0	100.0	PPB	PQL
2,3,4,6-tetrachlorophenol	10.0	100.0	PPB	PQL
2,4,5-T	2.0	20.0	PPB	PQL
2,4,5-TP silvex	2.0	100.0	PPB	MCL
2,4,5-trichlorophenol	10.0	100.0	PPB	PQL
2,4,6-trichlorophenol	10.0	9700.0	PPB	CFWTL
2,4-D	2.0	1000.0	PPB	MCL
2,4-dichlorophenol	10.0	3650.0	PPB	CFWTL
2,4-dimethylphenol	10.0	50.0	PPB	PQL
2,4-dinitrophenol	10.0	500.0	PPB	PQL
2,4-dinitrotoluene	10.0	2300.0	PPB	CFWTL
2,6-dichlorophenol	10.0	100.0	PPB	PQL
2,6-dinitrotoluene	10.0	2300.0	PPB	CFWTL
2-Hexanone	50.0	500.0	PPB	PQL
2-Methylnaphthalene	10.0	100.0	PPB	PQL
2-acetylaminofluorene	10.0	100.0	PPB	PQL
2-chloronaphthalene	10.0	100.0	PPB	PQL
2-chlorophenol	10.0	20000.0	PPB	CFWTL
2-naphthylamine	10.0	100.0	PPB	PQL
2-picoline	10.0	50.0	PPB	PQL
3,3'-dichlorobenzidine	10.0	200.0	PPB	PQL
3,3'-dimethylbenzidine	10.0	100.0	PPB	PQL
3-methylcholanthrene	10.0	100.0	PPB	PQL
4,6-dinitro-o-cresol and salts	10.0	500.0	PPB	PQL
4-Nitroquinoline 1-oxide	10.0	100.0	PPB	PQL
4-aminobiphenyl	10.0	100.0	PPB	PQL
4-bromophenyl phenyl ether	10.0	100.0	PPB	PQL
5-nitro-o-toluidine	10.0	100.0	PPB	PQL
7,12-dimethylbenz[a]anthracene	10.0	100.0	PPB	PQL
Acenaphthalene	10.0	100.0	PPB	PQL
Acenaphthene	10.0	5200.0	PPB	CFWTL
Acetone	10.0	1000.0	PPB	PQL
Acetonitrile	10.0	1000.0	PPB	PQL
Acetophenone	10.0	100.0	PPB	PQL
Acrolein	10.0	210.0	PPB	CFWTL
Acrylonitrile	10.0	26000.0	PPB	CFWTL

EXHIBIT 1. Collection Criteria

Constituent	Detn. Limit	Collection Criteria	Units	Basis ¹
Aldrin	.1	.5	PPB	PQL
Allyl Chloride	100.0	100.0	PPB	PQL ³
Alpha,alpha-dimethylphenethyla	10.0	100.0	PPB	PQL
Alpha-BHC	.1	.5	PPB	PQL
Aniline	10.0	100.0	PPB	PQL
Anthracene	10.0	100.0	PPB	PQL
Antimony, filtered	100.0	16000.0	PPB	CFWTL
Antimony-125	48.0	3000.0	pCi/L	MCL
Aramite	10.0	100.0	PPB	CFWTL
Arochlor 1016	1.0	1.0	PPB	CFWTL ³
Arochlor 1221	1.0	1.0	PPB	CFWTL ³
Arochlor 1232	1.0	1.0	PPB	CFWTL ³
Arochlor 1242	1.0	1.0	PPB	CFWTL ³
Arochlor 1248	1.0	1.0	PPB	CFWTL ³
Arochlor 1254	1.0	1.0	PPB	CFWTL ³
Arochlor 1260	1.0	1.0	PPB	CFWTL ³
Arsenic, filtered	5.0	480.0	PPB	CFWTL
Barium, filtered	6.0	10000.0	PPB	MCL
Benz[a]anthracene	10.0	100.0	PPB	PQL
Benzene	5.0	50.0	PPB	MCL
Benzo(ghi)perylene	10.0	100.0	PPB	PQL
Benzo(k)fluoranthene	10.0	100.0	PPB	PQL
Benzo[a]pyrene	10.0	190.0	PPB	PQL
Benzo[b]fluoranthene	10.0	100.0	PPB	PQL
Benzyl Alcohol	10.0	200.0	PPB	PQL
Beryllium, filtered	5.0	53.0	PPB	CFWTL
Beta-BHC	.1	.5	PPB	PQL
Bis(1-chloro-1-methylethyl)ether	10.0	100.0	PPB	PQL
Bis(2-chloroethoxy) methane	10.0	100.0	PPB	PQL
Bis(2-chloroethyl) ether	10.0	100.0	PPB	PQL
Bis(chloromethyl)ether	5.0	100.0	PPB	PQL
Bromodichloromethane	5.0	10.0	PPB	PQL
Bromoform	5.0	20.0	PPB	PQL
Cadmium, filtered	2.0	11.0	PPB	CFWTL
Carbon disulfide	10.0	50.0	PPB	PQL
Carbon tetrachloride	5.0	50.0	PPB	MCL
Carbon-14	20.0	20000.0	pCi/L	MCL
Cesium-137	20.0	2000.0	pCi/L	MCL
Chlordane	1.0	1.0	PPB	CFWTL ³
Chloride	500.0	250000.0	PPB	MCL
Chlorobenzene	5.0	20.0	PPB	PQL
Chlorobenzene (by ABN)	10.0	20.0	PPB	PQL ³
Chlorobenzilate	300.0	300.0	PPB	PQL ³
Chloroethane	10.0	50.0	PPB	PQL
Chloroform	5.0	1000.0	PPB	MCL
Chromium(VI)	50.0	110.0	PPB	CFWTL
Chromium, filtered	10.0	110.0	PPB	CFWTL ⁴
Chrysene	10.0	100.0	PPB	PQL
Cobalt-60	22.5	1000.0	pCi/L	MCL
Copper, filtered	10.0	120.0	PPB	CFWTL
Cresols	10.0	100.0	PPB	PQL
Cyanide	10.0	52.0	PPB	CFWTL
DDD	.1	1.0	PPB	PQL
DDE	.1	0.5	PPB	PQL
DDT	.1	.1	PPB	CFWTL ³
Delta-BHC	.1	1.0	PPB	PQL
Di-n-propylnitrosamine	10.0	100.0	PPB	PQL

EXHIBIT 1. (contd)

Constituent	Detn. Limit	Collection Criteria	Units	Basis ¹
Dibenz[a,h]anthracene	10.0	100.0	PPB	PQL
Dibenzofuran	10.0	100.0	PPB	PQL
Dibromochloromethane	5.0	10.0	PPB	PQL
Dichlorodifluoromethane	10.0	50.0	PPB	PQL
Dieldrin	.1	.1	PPB	CFWTL ³
Dillate	10.0	100.0	PPB	PQL
Dimethoate	2.0	100.0	PPB	PQL
Dinitrobenzene	10.0	100.0	PPB	PQL
Dinoseb	10.0	10.0	PPB	PQL
Dioxane	500.0	1500.0	PPB	PQL ³
Dioxin	.1	.1	PPB	CFWTL ³
Diphenylamine	10.0	100.0	PPB	PQL
Disulfoton	2.0	20.0	PPB	PQL
Endosulfan I	.1	.6	PPB	CFWTL ³
Endrin	.1	.1	PPB	CFWTL ³
Ethyl benzene	5.0	20.0	PPB	PQL
Ethyl methacrylate	10.0	50.0	PPB	PQL
Ethyl methanesulfonate	10.0	100.0	PPB	PQL
Fluoranthene	10.0	100.0	PPB	PQL
Fluorene	10.0	100.0	PPB	PQL
Fluoride	500.0	20000.0	PPB	MCL
Gross alpha	4.0	150.0	pCi/L	MCL
Gross beta	8.0	500.0	pCi/L	MCL
Heptachlor	.1	.1	PPB	CFWTL ³
Heptachlor epoxide	.1	10.0	PPB	PQL ³
Hexachlorobenzene	10.0	10.0	PPB	PQL ³
Hexachlorobutadiene	10.0	93.0	PPB	CFWTL
Hexachlorocyclopentadiene	10.0	52.0	PPB	CFWTL
Hexachloroethane	10.0	5400.0	PPB	CFWTL
Hexachlorophene	10.0	100.0	PPB	PQL
Hexachloropropene	10.0	100.0	PPB	PQL
Hydrogen sulfide	10.0	20.0	PPB	CFWTL
Indeno(1,2,3-cd)pyrene	10.0	100.0	PPB	PQL
Iodine-129	1.0	10.0	pCi/L	MCL
Iodine-131	20.0	30.0	pCi/L	MCL
Iodomethane	10.0	50.0	PPB	PQL
Iron, filtered	30.0	3000.0	PPB	MCL ³
Isobutyl Alcohol	10000.0	10000.0	PPB	PQL ³
Isodrin	10.0	100.0	PPB	PQL
Isophorone	10.0	100.0	PPB	PQL
Isosafrole	10.0	100.0	PPB	PQL
Kepone	1.0	10.0	PPB	PQL
Lead, filtered	5.0	32.0	PPB	CFWTL
Lindane, gamma-BHC	.1	.8	PPB	CFWTL
Manganese, filtered	5.0	500.0	PPB	MCL
Mercury, filtered	.1	.1	PPB	CFWTL
Methacrylonitrile	10.0	50.0	PPB	PQL
Methapyrilene	10.0	100.0	PPB	PQL
Methoxychlor	3.0	3.0	PPB	CFWTL ³
Methyl bromide	10.0	100.0	PPB	PQL
Methyl chloride	10.0	10.0	PPB	PQL
Methyl ethyl ketone	10.0	100.0	PPB	PQL
Methyl isobutyl ketone	10.0	50.0	PPB	PQL
Methyl methacrylate	10.0	20.0	PPB	PQL
Methyl methanesulfonate	10.0	100.0	PPB	PQL
Methyl parathion	2.0	5.0	PPB	PQL
N-Nitrosodiphenylamine	10.0	100.0	PPB	PQL
N-nitrosodi-n-butylamine	10.0	100.0	PPB	PQL

EXHIBIT 1. (contd)

Constituent	Detn. Limit	Collection Criteria	Units	Basis ¹
N-nitrosodiethylamine	10.0	100.0	PPB	PQL
N-nitrosodimethylamine	10.0	100.0	PPB	PQL
N-nitrosomethylethylamine	10.0	100.0	PPB	PQL
N-nitrosomorpholine	10.0	100.0	PPB	PQL
N-nitrosopiperidine	10.0	100.0	PPB	PQL
Naphthalene	10.0	6200.0	PPB	CFWTL
Nickel, filtered	10.0	1600.0	PPB	CFWTL
Nickel-63	10.0	500.0	pCi/L	MCL
Nitrate	500.0	450000.0	PPB	MCL
Nitrobenzine	10.0	100.0	PPB	PQL
Nitrosopyrrolidine	10.0	100.0	PPB	PQL
0,0,0-triethyl phosphorothioate	10.0	100.0	PPB	PQL
0-toluidine hydrochloride	10.0	100.0	PPB	PQL
P-chloro-m-cresol	10.0	50.0	PPB	PQL
P-chloroaniline	10.0	200.0	PPB	PQL
P-dimethylaminazobenzene	10.0	100.0	PPB	PQL
P-nitroaniline	10.0	500.0	PPB	PQL
Parathion	2.0	2.0	PPB	CFWTL ³
Pcdd's	.0	.1	PPB	PQL
Pcdf's	.0	.1	PPB	PQL
Pentachlorobenzene	10.0	100.0	PPB	PQL
Pentachloroethane	10.0	11000.0	PPB	CFWTL
Pentachloronitrobenzene	10.0	100.0	PPB	PQL
Pentachlorophenol	50.0	130.0	PPB	CFWTL
Phenacetin	10.0	100.0	PPB	PQL
Phenanthrene	10.0	100.0	PPB	PQL
Phenol	10.0	25600.0	PPB	CFWTL
Phenylenediamine	10.0	100.0	PPB	PQL
Phorate	2.0	20.0	PPB	PQL
Phthalic acid esters	10.0	30.0	PPB	CFWTL
Plutonium-238	.1	16.0	pCi/L	DCG
Plutonium-239,40	.1	12.0	pCi/L	DCG
Pronamide	10.0	100.0	PPB	PQL
Propionitrile	5.0	50.0	PPB	PQL
Pyrene	10.0	10.0	PPB	PQL
Pyridine	500.0	500.0	PPB	PQL
Radium	1.0	50.0	pCi/L	MCL
Ruthenium-103	20.0	2000.0	PPB	MCL
Ruthenium-106	172.5	300.0	pCi/L	MCL
Safrol	10.0	100.0	PPB	PQL
Selenium	5.0	100.0	PPB	MCL
Silver, filtered	10.0	10.0	PPB	CFWTL ³
Strontium-89	5.0	200.0	pCi/L	MCL
Strontium-90	5.0	80.0	pCi/L	MCL
Styrene	5.0	10.0	PPB	PQL
Sulfate	500.0	250000.0	PPB	MCL
Sym-trinitrobenzene	10.0	100.0	PPB	PQL
Tech-netium-99	15.0	9000.0	pCi/L	MCL
Tetrachloroethylene	5.0	8400.0	PPB	CFWTL
Tetraethylpyrophosphate	2.0	100.0	PPB	PQL
Thallium	5.0	400.0	PPB	CFWTL
Tin, filtered	30.0	80000.0	PPB	PQL
Toluene	5.0	20.0	PPB	PQL
Toxaphene	1.0	1.0	PPB	CFWTL ³
Trans-1,2-dichloroethylene	5.0	10.0	PPB	PQL
Trichloroethylene	5.0	50.0	PPB	MCL
Trichloromonofluoromethane	10.0	50.0	PPB	PQL
Uranium	.5	400.0	pCi/L	DCG

EXHIBIT 1. (contd)

Constituent	Detn. Limit	Collection Criteria	Units	Basis ¹
Uranium, chemical	.7	590.0	UG/L	DCG
Vanadium, filtered	5.0	400.0	PPB	PQL
Vinyl Acetate	5.0	50.0	PPB	PQL
Vinyl chloride	10.0	20.0	PPB	MCI
Xylene-m	5.0	50.0	PPB	PQL
Xylene-o,p	5.0	50.0	PPB	PQL
Zinc, filtered	5.0	1100.0	PPB	CFWTL
m-Nitroaniline	10.0	500.0	PPB	PQL
o-Nitroaniline	10.0	500.0	PPB	PQL
p-Dichlorobenzene	10.0	500.0	PPB	PQL
p-Nitrophenol	10.0	1500.0	PPB	CFWTL

- (1) The bases for collection criteria are as follows:
MCL - 10X the Maximum Contaminant Level as defined in 40 CFR 141, 40 CFR 143, and EPA 570/9-76-003.
PQL - 10X the Practical Quantitation Limit as listed in Appendix IX of the 40 CFR 264.
CFWTL - 10X the Chronic Freshwater Toxicity Level as defined in EPA 440/5-86-001.
DCG - 10X one-twenty-fifth of the Derived Concentration Guide as listed in DOE Order 5400.5
- (2) Based on 10X MCL for 1,1,1-trichloroethane.
- (3) Criterion is below current detection limit so detection limit is used as criterion.
- (4) All chromium is assumed to be hexavalent.

EXHIBIT 1. (contd)

QC-1 PREPARATION OF QUALITY CONTROL PERFORMANCE EVALUATION STANDARDS FOR GROUND-WATER MONITORING ACTIVITIES

1.0 APPLICABILITY

This procedure is applicable to the preparation of Performance Evaluation Standard samples for chemical analysis applied to ground-water monitoring activities.

2.0 DEFINITIONS

- Performance Evaluation Standard - A solution prepared by a quantitative dilution of a reference material or a neat (ready to use) reference material solution.
- Concentrate - A concentrated reference material (typically ampulized) that is diluted to prepare a Performance Evaluation Standard.
- Laboratory-Pure Water - Type II Reagent Water (ASTM D 1193) having a maximum electrical conductivity (at 25°C) $\leq 1.0 \mu\text{mho/cm}$ or electrical resistivity (at 25°C) $\geq 1.0 \text{M}\Omega\text{cm}$.
- Ammonia-Free Water - Type II Reagent Water (ASTM D 1193 and Standard Methods) that has been obtained by the use of an Ion-Exchange system (e.g., Millipore Milli-Q System).
- Organic-Free Water - Type II Reagent Water (ASTM D 1193 and U.S. EPA SW-846) that has been treated in any of the following ways:
 - by passing water through a carbon filter bed containing about 450 grams of activated carbon (Calgon Corp., Filtrasorb-300 or equivalent)
 - by a water purification system (Millipore Super-Q or equivalent)
 - by boiling water for 15 minutes. Subsequently, while maintaining the temperature at 90°C, bubble a contaminant-free inert gas through the water for 1 hour. While it is still hot, transfer the water to a narrow-mouth screw-cap bottle and seal with a Teflon-lined septum and cap.
- Turbidity-Free Water - Type III Reagent Water (ASTM D 1193) that has a turbidity of 0.05 NTU or less.
- LRB - Laboratory Record Book
- HEIS - Hanford Environmental Information System.

3.0 RESPONSIBLE STAFF

- Technician
- Technical Staff (Quality Control Task Leader or Designee).

4.0 PROCEDURE

4.1 Prerequisites

It is the responsibility of the Technician to follow the requirements for laboratory safety, material handling safety, storage, and disposal when preparing Performance Evaluation Standards.

4.1.1 Equipment

- Laboratory Glassware - Class "A", clean (as per ASTM E 542-85), and calibrated (ASTM E 542-85)
 - volumetric flasks (various volumes)
 - volumetric pipets (various volumes)
 - gas-tight syringes (various volumes)
- Appropriate containers - as specified in Attachment 1 and provided by the sample preparation task.
- 10 N NaOH - Prepare by cautiously dissolving 400 g solid NaOH into 700 mL of laboratory-pure water in a 1000 mL volumetric flask (dissolution of NaOH is highly exothermic). Allow flask to cool. Bring flask to volume and mix well.
- Nitric Acid - Concentrated.

4.2 Step-by-Step Instructions

NOTE: Record all preparation steps in an LRB including calculations, equipment used, source of the concentrate and at least the following additional information: reference material concentrate Chain-of-Custody number, Performance Evaluation Standard order number, expiration date of the concentrate, and documentation of certification of the concentrate to ensure the traceability of the Performance Evaluation Standard. The LRB shall be maintained in accordance with established records management procedures.

NOTE: Prepared Performance Evaluation Standards shall be kept for no longer than necessary prior to submission for analysis. If a delay in submission of 48 hours is encountered, contact the technical staff immediately. The reason for the delay shall be documented on the Performance Evaluation Standard Order form. A determination as to the validity of the standards for submission for analysis shall be made by the technical staff and documented on the Performance Evaluation Standard Order using the following criteria: 1) has the Chain-of-Custody of the

standards been compromised, 2) will the standards still be analyzed within the prescribed maximum holding times.

4.2.1 Use of Performance Evaluation Standard Order Form (Exhibit 1)

NOTE: The Performance Evaluation Standard Order form is used to indicate the desired concentrations and constituents in a performance evaluation standard. Parts of the form are filled out by the Technical Staff, and, upon preparation of the samples, others are filled in by the technician. This document should be photocopied by the technician upon its completion, and the copy kept on file. The signed original will be kept on file by the Quality Control Task leader.

NOTE: The following steps outline instructions for completing the Performance Evaluation Standard Order form (Exhibit 1). Refer to these instructions when filling out the form.

Position Responsible: TECHNICAL STAFF

- A. Indicate Performance Evaluation Standard Order number. This is a sequential number, and a log of Performance Evaluation Standard Orders shall be kept by the Quality Control Task Leader.
- B. Indicate the name of the person requesting preparation of the Performance Evaluation Standard (technical staff member filling out the form).
- C. Fill in the date of the order.
- D. Fill in the name of the project for which the standard(s) are being used.
- E. Fill in the date for which the standard(s) are needed.
- F. Fill in the Work Order number or Work Package number to which the work is to be charged.
- K. Fill in the sample identification number (i.e., HEIS number) of the container into which the standard will be placed. HEIS numbers are obtained from the PNL Sample Preparation Laboratory and should be in agreement with all the accompanying sample documentation (i.e., chain of custody and sample analysis order forms).
- L. Indicate the test(s) that are to be performed on the standard.
- M. Indicate the concentrate to be used in the preparation of the standard.
- N. Indicate the source of the concentrate (e.g., EPA, ERA, NIST, etc.).

(A)

Date (C)

Date Needed _____ (E) _____

_____ (H) Pg. 4

[illegible]

CHECKED BY _____ (X)

SIGNATURE _____ (S)

DATE 10/1/71

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EXHIBIT 1. Performance Evaluation Standard Order

- O. Indicate the inventory number of the concentrate. (Quality Control Standards are individually numbered and kept in an inventory log by the Quality Control Task Leader.)
- P. Indicate the internal Chain-of-Custody number of the concentrate.
- Q. Indicate (by a check mark) that the certification is on file.
- R. Indicate the type of water to be used for the dilution of the concentrate.
 - LP - Laboratory-pure (see Definitions)
 - AF - Ammonia-free (see Definitions)
 - OF - Organic-free (see Definitions)
 - TF - Turbidity-free (see Definitions)
 - TAP - Tap water
 - GW - Ground-water (from a well that has been characterized)
 - NAT - Natural water (from a stream or creek, again, characterized)
 - OTHER - Water from another source (see Notes at right for specification)
 - NONE - No dilution water is to be used
- S. Indicate the amount of the concentrate to be used (and the units).
- T. Indicate the total volume to be made.
- U. Indicate any notes regarding the preparation of the performance evaluation standard.

NOTE: The form is now to be submitted to the technician for preparation of the standards.

Position Responsible: TECHNICIAN

- G. Indicate the LRB number where the records of the preparation of the standard are kept.
- H. Indicate the page number(s) in the LRB where the records of the preparation of the standard are kept.
- I. Immediately upon completion of the preparation of a standard, indicate that the standard has been prepared according to the order by initialing the line of that standard.
- J. After initialing that a standard has been prepared, indicate the date of preparation (mm/dd).
- U. Indicate any pertinent notes or observations made during the preparation.

V. After having prepared all of the materials ordered, type or clearly print the name of the preparer.

W. The preparer is to sign here.

X. The preparer is to date the form here.

Position Responsible: TECHNICAL STAFF

NOTE: Following preparation of the standard(s) and return of the signed form, verify the preparations on the Performance Evaluation Standard Order against the LRB entries for accuracy and completeness. Following this:

Y. Type or clearly print the name of the checker here.

Z. Sign the completed form here.

AA. Date the form, as complete, here.

NOTE: Some concentrates may not be contained in glass ampules. Use safe and appropriate means to open these containers for preparation of the Performance Evaluation Standards.

NOTE: Some preparations (e.g., Cyanide, ICP Metals, AA Metals) require preservative to be added to the flask prior to dilution. These will also have preservative added to the bottles that the prepared standard is dispensed into.

4.2.2 Chlorinated Hydrocarbons; includes: Semi-Volatile Compounds

Position Responsible: TECHNICIAN

1. Stabilize the temperature of the ampule (or container) at room temperature.
2. Open the ampule by snapping off the top at the break area on the neck.
3. Pipet exactly the amount of the concentrate, as specified on the Performance Evaluation Standard Order (Exhibit 1), into a volumetric flask containing 90% of the water (as specified on the Performance Evaluation Standard Order [Exhibit 1]).
4. Bring the flask to volume and mix the sample by inverting the flask 15 to 20 times.
5. Dispense aliquots of performance evaluation standard from flask into appropriate container(s).
6. Until submittal for analysis, refrigerate samples at $4 \pm 2^{\circ}\text{C}$.

4.2.3 Cyanide

Position Responsible: TECHNICIAN

1. Stabilize the temperature of the ampule (or container) at room temperature.
2. Add 90% of the water (as specified on the Performance Evaluation Standard Order [Exhibit 1]) and 2.0 mL/L of 10N NaOH to a volumetric flask.
3. Carefully break open the ampule at the mark on the neck.
4. Pipet the exact amount of the concentrate, as specified on the Performance Evaluation Standard Order (Exhibit 1), into the flask.
5. Bring the flask to volume and mix by inverting the flask 15 to 20 times.
6. Dispense aliquots of performance evaluation standard into appropriate container(s).
7. Until submittal for analysis, refrigerate samples at $4 \pm 2^{\circ}\text{C}$.

4.2.4 Herbicides (Chlorophenoxy pesticide); includes: Chlorinated Herbicides

Position Responsible: TECHNICIAN

1. Stabilize the temperature of the ampule (or container) at room temperature.
2. Into a volumetric flask, add 90% of the water (as specified on the Performance Evaluation Standard Order [Exhibit 1]).
3. Open the ampule by snapping off at the break area on the neck.
4. Pipet the amount of the concentrate, as specified on the Performance Evaluation Standard Order (Exhibit 1).
5. Bring the flask to volume and mix by inverting the flask 15 to 20 times.
6. Dispense aliquots of performance evaluation standard into appropriate container(s).
7. Until submittal for analysis, refrigerate samples at $4 \pm 2^{\circ}\text{C}$.

4.2.5 Minerals; includes: pH, Alkalinity, Fluoride, Chloride, Sulfate, and some ICP Metals

Position Responsible: TECHNICIAN

1. Stabilize the temperature of the ampule (or container) at room temperature.
2. Add 90% of the water (as specified on the Performance Evaluation Standard Order [Exhibit 1]) to a volumetric flask.
3. Carefully break open all ampules at the mark on the neck.
4. Pipet the exact amount of each concentrate, as specified on the Performance Evaluation Standard Order (Exhibit 1), into the flask.
5. Bring the flask to volume and mix by inverting the flask 15 to 20 times.
6. Dispense aliquots of performance evaluation standard into appropriate container(s).
7. Until submittal for analysis, refrigerate samples at $4 \pm 2^{\circ}\text{C}$.

4.2.6 Nitrate/Fluoride

Position Responsible: TECHNICIAN

1. Stabilize the temperature of the ampule (or container) at room temperature.
2. Add 90% of the water (as specified on the Performance Evaluation Standard Order [Exhibit 1]) to a volumetric flask.
3. Carefully break open the ampule at the mark on the neck.
4. Pipet the exact amount of the concentrate, as specified on the Performance Evaluation Standard Order (Exhibit 1), into the flask.
5. Bring the flask to volume and mix by inverting the flask 15 to 20 times.
6. Dispense aliquots of performance evaluation standard into appropriate container(s).
7. Until submittal for analysis, refrigerate samples at $4 \pm 2^{\circ}\text{C}$.

4.2.7 Nutrients; includes: Ammonium, Nitrate, and Phosphate

Position Responsible: TECHNICIAN

1. Stabilize the temperature of the ampule (or container) at room temperature.
 2. Add 90% of the water (as specified on the Performance Evaluation Standard Order [Exhibit 1]) to a volumetric flask.
 3. Carefully break open all ampules at the mark on the neck.
 4. Pipet the exact amount of each concentrate, as specified on the Performance Evaluation Standard Order (Exhibit 1), into the flask.
 5. Bring the flask to volume and mix by inverting the flask 15 to 20 times.
 6. Dispense aliquots of performance evaluation standard into appropriate container(s).
 7. Until submittal for analysis, refrigerate samples at $4 \pm 2^{\circ}\text{C}$.
- 4.2.8 PCBs (Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, Aroclor-1260, Mixed congeners)
- Position Responsible: TECHNICIAN
1. Stabilize the temperature of the ampule (or container) at room temperature.
 2. Into a volumetric flask, add 90% of the water (as specified on Performance Evaluation Standard Order [Exhibit 1]).
 3. Open the ampule by snapping off at the break area on the neck.
 4. Pipet the amount of the concentrate, as specified on the Performance Evaluation Standard Order (Exhibit 1).
 5. Bring the flask to volume and mix by inverting the flask 15 to 20 times.
 6. Dispense aliquots of performance evaluation standard into appropriate container(s).
 7. Until submittal for analysis, refrigerate samples at $4 \pm 2^{\circ}\text{C}$.
- 4.2.9 Pesticides (Chlorinated Hydrocarbon Pest, EP Extract-Pest & Herb, GC/MS Pesticides); includes: Pesticides, Chlorinated Herbicides

Position Responsible: TECHNICIAN

1. Stabilize the temperature of the ampule (or container) at room temperature.

2. Into a volumetric flask, add 90% of the water (as specified on the Performance Evaluation Standard Order [Exhibit 1]).
3. Open the ampule by snapping off at the break area on the neck.
4. Pipet the amount of the concentrate, as specified on the Performance Evaluation Standard Order (Exhibit 1).
5. Bring the flask to volume and mix by inverting the flask 15 to 20 times.
6. Dispense aliquots of performance evaluation standard into appropriate container(s).
7. Until submittal for analysis, refrigerate samples at $4 \pm 2^{\circ}\text{C}$.

4.2.10 pH

Position Responsible: TECHNICIAN

1. Stabilize the temperature of the ampule (or container) at room temperature.
2. Do not dilute the sample concentrate. Carefully open the ampule by snapping off the top at the break area on the neck.
3. Immediately transfer the contents of the ampule (or container) to the appropriate container.
4. Until submittal for analysis, refrigerate samples at $4 \pm 2^{\circ}\text{C}$.

4.2.11 Semi-Volatile Organic Analysis (GC/MS Acids, GC/MS Base/Neutrals, Phenolics, Polynuclear Aromatic Hydrocarbons [PAHs]); includes: Semi-Volatile Organics, Phenol

Position Responsible: TECHNICIAN

1. Stabilize the temperature of the ampule (or container) at room temperature.
2. Into a volumetric flask add 90% of the water (as specified on the Performance Evaluation Standard Order [Exhibit 1]).
3. Open the ampule by snapping off at the break area on the neck.
4. Pipet the amount of the concentrate, as specified on the Performance Evaluation Standard Order (Exhibit 1).
5. Bring the flask to volume and mix by inverting the flask 15 to 20 times.

6. Dispense aliquots of performance evaluation standard into appropriate container(s).

7. Until submittal for analysis, refrigerate samples at $4 \pm 2^{\circ}\text{C}$.

4.2.12 Trace Metals (Atomic Absorption, ICP); includes: ICP Metals, Arsenic; Selenium, Lead, Thallium, and Mercury

Position Responsible: TECHNICIAN

1. Stabilize the temperature of the ampule (or container) at room temperature.

2. Add 90% of the water (as specified on the Performance Evaluation Standard Order [Exhibit 1]) and 4.5 mL/L of concentrated nitric acid to a volumetric flask.

3. Carefully break open the ampule at the mark on the neck.

4. Pipet the exact amount of the concentrate, as specified on the Performance Evaluation Standard Order (Exhibit 1), into the flask.

5. Bring the flask to volume and mix by inverting the flask 15 to 20 times.

6. Dispense aliquots of performance evaluation standard into appropriate container(s).

7. Until submittal for analysis, refrigerate samples at $4 \pm 2^{\circ}\text{C}$.

4.2.13 Turbidity

Position Responsible: TECHNICIAN

1. Stabilize the temperature of the ampule (or container) at room temperature.

2. Shake ampule (or container) thoroughly, then immediately open it by snapping the top off at the break area.

3. Empty the entire contents into a small, clean beaker or flask and gently swirl to mix thoroughly.

4. **DO NOT RINSE THE AMPULE (OR CONTAINER) INTO THE BEAKER OR FLASK.**

5. While still mixing, pipet exactly the amount of the concentrate, as specified on the Performance Evaluation Standard Order (Exhibit 1), into a volumetric flask.

6. Dilute to volume with water (as specified on the Performance Evaluation Standard Order [Exhibit 1]) and mix by inverting the flask 15 to 20 times.

7. Dispense aliquots of performance evaluation standard into appropriate container(s).

8. Until submittal for analysis, refrigerate samples at $4 \pm 2^\circ\text{C}$.

4.2.14 Volatile Organic Analysis (Trihalomethanes, Volatile Organic Contaminants); includes: Volatile Organics GC, Volatile Organics GC/MS

Position Responsible: TECHNICIAN

1. Stabilize the temperature of the ampule (or container) at room temperature.

2. Fill a volumetric flask to volume with water (as specified on the Performance Evaluation Standard Order [Exhibit 1]).

3. Open the ampule by breaking the top off at the break area on the neck.

4. Using a gas-tight syringe or volumetric pipet, immediately withdraw the required volume as specified on the Performance Evaluation Standard Order (Exhibit 1).

5. Immediately after Step 4, inject the concentrate taken from the ampule (or container) directly into the liquid in the expanded area of the volumetric flask.

NOTE: If the sample is injected into the neck area of the flask, poor results may be obtained.

6. Immediately remove the syringe needle or pipet tip and stopper the flask.

7. Mix the sample by inverting the flask three times only.

8. Carefully pour aliquots of performance evaluation standard into appropriate container(s) ensuring that no air is trapped in the container.

9. Until submittal for analysis, refrigerate samples at $4 \pm 2^\circ\text{C}$.

5.0 REFERENCES

- ASTM D 1193, Standard Specifications for Reagent Water (Federal Test Method Standard No. 7916). American Society for Testing and Materials, Philadelphia, Pennsylvania.
- ASTM E 542-85, Standard Practice for Calibration of Volumetric Ware. American Society for Testing and Materials, Philadelphia, Pennsylvania.

- Standard Methods, Standard Methods for the Examination of Water and Wastewater, 13th Ed., 1971, pg. 225.
- EPA. 1986. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. SW-846, Method 8240. U.S. Environmental Protection Agency, Washington, D.C.

ATTACHMENT 1

CONSTITUENT	METHOD	SUGGESTED VOLUME	PRESERVATIVE
ICP Metals	6010	1000 mL (P)	HNO ₃ to pH<2
Arsenic	7060	1000 mL (P)	HNO ₃ to pH<2
Lead	7421	1000 mL (P)	HNO ₃ to pH<2
Mercury	7470 and 7471	500 mL (CG)	HNO ₃ to pH<2
Selenium	7740	1000 mL (P)	HNO ₃ to pH<2
Thallium	7841	1000 mL (P)	HNO ₃ to pH<2
Chloride	ASTM D4327-88 or EPA 600	125 mL (P)	no preservative
Sulfate	ASTM D4327-88 or EPA 600	125 mL (P)	no preservative
Fluoride	ASTM D4327-88 or EPA 600	125 mL (P)	no preservative
Nitrate (preserved)	ASTM D4327-88 or EPA 600	125 mL (P)	H ₂ SO ₄ to pH<2
Phosphate (preserved)	ASTM D4327-88 or EPA 600	125 mL (P)	H ₂ SO ₄ to pH<2
Ammonium	ASTM D-1426-D	500 mL (CG)	H ₂ SO ₄ to pH<2
Cyanide	9010	2 X 1000 mL (P)	NaOH to pH>12
Alkalinity	ASTM D-1067-A or B	250 mL (P)	no preservative
pH	ASTM D-1293	250 mL (P)	no preservative
Turbidity	# 214A	250 mL (CG)	no preservative
Pesticides	8080	4000 mL (GA)	no preservative
Chlorinated Herbicides	8150	4000 mL (GA)	no preservative
Polychlorinated Biphenyls	8080	4000 mL (GA)	no preservative
Volatile Organics GC	8010/8020	3 X 40 mL (GA/S)	HCl to pH<2
Volatile Organics, GC/Mass Spec.	8240	3 X 40 mL (GA/S)	HCl to pH<2
Phenol	8040	2000 mL (GA)	no preservative
Semi-Volatile Org. GC/Mass Spec.	8270	2000 mL (GA)	no preservative
Dioxins	8280	1000 mL (GA)	no preservative
Total Carbon	ASTM D-2579 A or B	250 mL (GA)	no preservative
Total Organic Carbon	9060	250 mL (CG)	H ₂ SO ₄ to pH<2
Total Organic Halides	9020	2 X 250 mL (GA/S)	H ₂ SO ₄ to pH<2

P = Poly
 GA = Glass Amber
 CG = Clear Glass
 GA/S = Glass Amber with a Septum Cap

QC-4 PERFORMANCE EVALUATION STANDARD AND CONCENTRATE RECEIPT, CHAIN-OF-CUSTODY, AND SHIPPING PROCEDURE

1.0 APPLICABILITY

To ensure the integrity of Quality Control (QC) performance evaluation standards, from the time of receipt of the concentrate through data reporting, the history of the custody of each concentrate will be documented according to this procedure. Anyone having custody of QC concentrates must comply with the procedure described below.

2.0 DEFINITIONS

- Concentrate - The material (either a neat standard, or a concentrate) received from a vendor that is used to prepare performance evaluation standards.
- Custody - A concentrate or Performance Evaluation Standard is considered to be under a person's custody if it is in any of the following states: 1) in the person's physical possession, 2) in the person's view after the person has taken possession, 3) secured by the person so that no one can tamper with the sample, or 4) secured by the person in an area that is restricted to authorized personnel.
- Custodian - the person responsible for the custody of a concentrate or standard.
- Sample Recipient - the person receiving custody of a concentrate or standard during a transfer of custody.
- RIDS - Records Inventory Disposition Schedule.
- Standard - A sample prepared from a concentrate.
- I-COC - A Pacific Northwest Laboratory (PNL) Internal Chain-of-Custody form (Attachment 1) available from the QC Task Leader.
- COC - A Pacific Northwest Laboratory (PNL) External Chain-of-Custody form (Attachment 2).

3.0 RESPONSIBLE STAFF

- Custodian
- Sample recipient.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Materials

- Concentrate(s)
- Security tape
- Chain-of-custody forms:
 - a) I-COC for concentrates, and
 - b) COC for prepared standards.

4.2 Step-by-Step Instructions

4.2.1 Receipt of Concentrates or Standards

Position Responsible: CUSTODIAN

1. Record in permanent ink the specified information for each concentrate on an I-COC. Note any peculiarities observed (i.e., a damaged shipping container, etc.). An example of the I-COC form to be used for concentrates is shown in Attachment 1.

NOTE: An active I-COC will be maintained in a file for QC concentrates from the time the concentrates are received until they are used or disposed of (i.e., after their expiration date has been exceeded). Each concentrate must be entered on a separate I-COC form.

2. Place the concentrate(s) into appropriate secure storage. Note on the I-COC where the concentrate(s) are stored, when, and placed there by whom.
3. Send original certification/reports from the supplier to the Process Quality Control Department's Quality Group for inspection/verification.

NOTE: Process Quality Control Department will stamp the original certifications/reports as "approved" and send them back to the custodian. These are quality records and must be maintained in a RIDS file.

4.2.2 Transferring Custody of Performance Evaluation Standards or Concentrates

NOTE: For external COC, use Procedure AD-2, Ground-Water Sample Chain-of-Custody Procedure.

Position Responsible: CUSTODIAN AND SAMPLE RECIPIENT

1. The Sample Recipient examines the containers and ensures that the containers and seals are intact, the total number and type of bottles (or containers) match the number on the I-COC, and that other appropriate conditions are in order. If there is an observed problem with the concentrates, note it in the "Remarks" section of the I-COC and notify the Sample Analysis Task Leader and QC Task Leader of the problem.
2. At the time the custody of the concentrates is transferred, the Custodian signs the I-COC in the uppermost blank "Relinquished by" space. The signature is witnessed by the Sample Recipient.
3. The Sample Recipient signs the "Received by" space on the same line the Custodian signed. The signature is witnessed by the Custodian. Either the Sample Recipient or the Custodian records the date and time of the transfer.

NOTE: The Sample Recipient now becomes the Custodian.

4.2.3 Standard Preparation

Position Responsible: CUSTODIAN

1. Follow the appropriate section of the preparation procedure (Procedure QC-1) to prepare the requested Performance Evaluation Standard(s).
2. Be sure that a COC form (Attachment 2) is included for each set of Performance Evaluation Standards with the Performance Evaluation Standard Order (Procedure QC-1) prior to sample preparation.
3. Be sure any concentrate used is accounted for and note its disposition on the appropriate I-COC.
4. Seal the prepared Performance Evaluation Standard(s) in the sample containers with tamper-proof security tape.
5. Record in writing, by reference (on the I-COC form only), the transfer of custody of the concentrate from the I-COC form to the COC form for the prepared standards that will go to the analytical laboratory. This is done so that the integrity of the prepared standard is not compromised.

4.2.4 Standard Handling and Shipping

Position Responsible: CUSTODIAN

1. For prepared Performance Evaluation Standards, store securely and follow the handling and storage conditions specified in Procedure QC-1.
2. For delivery of prepared Performance Evaluation Standards to the indicated destination, follow the instructions in Procedure AD-2.

4.2.5 Disposal of Samples and Concentrates

1. The analytical laboratory shall dispose of samples following analysis as defined in the contract or a letter of instruction.

When samples are disposed of by the Pacific Northwest Laboratory (PNL):

Position Responsible: CUSTODIAN

1. Samples are disposed of in accordance with established waste management procedures. These procedures are under the direction of the Waste Management and Environmental Compliance Section, Laboratory Safety.
2. Following completion of the chain-of-custody process, the original copy of the I-COC is included in the RIDS file.

5.0 REFERENCES

- Procedure AD-2, "Ground-Water Sample Chain-of-Custody Procedure."
- Procedure QC-1, "Preparation of Quality Control (QC) Performance Evaluation Standards for Ground-Water Monitoring Activities."

ATTACHMENT 1

PNL Internal Chain-of-Custody Form

	PNL INTERNAL CHAIN OF CUSTODY	icoc: QC-														
<p>Company Contact: _____ Telephone: _____</p> <p style="text-align: center;">Date: _____ Time: _____</p> <p>Sample Location: _____</p> <p>Remarks: _____</p> <p>_____</p> <p style="text-align: center;">Aqueous _____ Solid _____ Other _____</p> <p style="text-align: center;">Sample Identification</p> <table style="width: 100%;"> <tr> <td style="width: 50%;"> Source: _____ _____ Standard #: _____ Material: _____ Concentration: _____ Amount: _____ Inventory Log #: QC- _____ Concentrate Prep. Date: _____ Expiration Date: _____ Cert. Received: _____ Date: _____ Cert. File Location: _____ _____ </td> <td style="width: 50%;"> Other: _____ _____ _____ _____ Notes: _____ _____ _____ _____ _____ _____ </td> </tr> </table> <p style="text-align: center;">Chain of Possession</p> <p>Shipper's #: _____</p> <table style="width: 100%; margin-top: 20px;"> <tr> <td style="width: 33%;">Relinquished by _____</td> <td style="width: 33%;">Received by _____</td> <td style="width: 33%;">Date/Time _____</td> </tr> <tr> <td>Relinquished by _____</td> <td>Received by _____</td> <td>Date/Time _____</td> </tr> <tr> <td>Relinquished by _____</td> <td>Received by _____</td> <td>Date/Time _____</td> </tr> <tr> <td>Relinquished by _____</td> <td>Received by _____</td> <td>Date/Time _____</td> </tr> </table>			Source: _____ _____ Standard #: _____ Material: _____ Concentration: _____ Amount: _____ Inventory Log #: QC- _____ Concentrate Prep. Date: _____ Expiration Date: _____ Cert. Received: _____ Date: _____ Cert. File Location: _____ _____	Other: _____ _____ _____ _____ Notes: _____ _____ _____ _____ _____ _____	Relinquished by _____	Received by _____	Date/Time _____	Relinquished by _____	Received by _____	Date/Time _____	Relinquished by _____	Received by _____	Date/Time _____	Relinquished by _____	Received by _____	Date/Time _____
Source: _____ _____ Standard #: _____ Material: _____ Concentration: _____ Amount: _____ Inventory Log #: QC- _____ Concentrate Prep. Date: _____ Expiration Date: _____ Cert. Received: _____ Date: _____ Cert. File Location: _____ _____	Other: _____ _____ _____ _____ Notes: _____ _____ _____ _____ _____ _____															
Relinquished by _____	Received by _____	Date/Time _____														
Relinquished by _____	Received by _____	Date/Time _____														
Relinquished by _____	Received by _____	Date/Time _____														
Relinquished by _____	Received by _____	Date/Time _____														

ATTACHMENT 2

PNL External Chain-of-Custody Form

Battelle <small>Pacific Northwest Laboratories Battelle Memorial Institute 97121-3199, Washington, WA 98112</small>	CHAIN OF CUSTODY	C-of-C: Test User ID: _____																																										
Company Contact: _____ Telephone: _____ Samples Collected by: _____ Date: _____ Time: _____ ID/Sample No.: _____ Ice Chest No.: _____ Field Logbook Page No.: _____ Remarks: _____ Possible Sample Hazard Identification: _____ Destination: _____ Carrier/Waybill No.: _____ Ground-Water _____ Soil _____ Other _____ Shipping container internal temperature _____ Shipping container internal temperature _____ when samples sealed in it _____ when opened in laboratory _____																																												
Sample Identification																																												
<table style="width: 100%; border: none;"> <tr><td style="border: none; width: 50%; height: 20px;"></td><td style="border: none; width: 50%; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> <tr><td style="border: none; height: 20px;"></td><td style="border: none; height: 20px;"></td></tr> </table>																																												
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Disposal Record No.: _____		Date/Initials: _____																																										

BC-1200-345 (12-90)

DM-1 ANALYTICAL DATA HANDLING AND VERIFICATION PROCEDURE

1.0 APPLICABILITY

This procedure establishes a standardized method for the receipt, entry into the PNL data base (HGWDB) and verification of analytical data from United States Testing (UST), the primary analytical laboratory. Data are received from UST in both magnetic media and hard copy form. This procedure also covers data entered into the HGWDB by running an interactive program.

2.0 DEFINITIONS

- HGWDB - the Hanford Ground-Water Data Base.

3.0 RESPONSIBLE STAFF

- Data Handling Task Leader
- Sample Analysis Task Leader
- Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following will be needed when entering and verifying data received on magnetic tape from UST:

- data tape
- data tape listing
- laboratory data sheets
- access to HGWDB project on PNL ZVAX computer
- HGWDB Input File Logbook
- copy of HGWDB User Guide and Maintenance Manual.

The following will be needed when loading and verifying data entered into the data base interactively:

- laboratory data sheets or Field Record Forms
- access to HGWDB project on PNL ZVAX computer
- copy of HGWDB User Guide and Maintenance Manual.

4.1.2 Background Information

Magnetic tapes, two types of data listings, and raw data sheets from UST are delivered to PNL by UST personnel. One of the listings is a summary report, which is used for data review. The other listing is an image of the file as it appears on magnetic tape, which is used for verification of the contents of the tape.

The summary report is reviewed by the Sample Analysis Task Leader for results that are greater than detection limits, blanks that have values above detection limits, or any suspect results. All discrepancies, anomalies, or unusual data shall be investigated, and the resolutions documented.

The data file is copied from UST's magnetic tape to the disk on the ZVAX computer. A preliminary check is done to see that the number of records and the report date are the same as those on the UST tape.

Two programs are run to check the input file and read it into the data base:

The UPDRES (update results) program is used to process the file of UST data into the HGWDB. The program reads the file, checks the file for format errors, and generates a report that lists rejected data. Examples of circumstances that cause rejection of data include improper well or constituent codes, no sample date associated with the analysis value, or receipt of internal UST QC data which are not intended to be included in the PNL data base. The output from the UPDRES program is reviewed by technical staff, and any unexplained rejects are investigated.

The ANATREND (analytical trend) program reads the file generated by UPDRES, does trend checking, and generates a report of results that have been stored in the data base. The trend checking program flags values that are outside 2.09 times the standard deviation of the linear regression curve for each sampling point.

The report generated by ANATREND is used to verify values recorded in the data base against the raw data sheets from UST by a designee of the Sample Analysis Task Leader. This is accomplished by following methods described in American National Standard ANSI/ASQC Z1.4-1981 "Sampling Procedures and Tables for Inspection by Attributes" at an Acceptable Quality Level (AQL) of 1%. Pertinent information from Tables I and IIA from this document are included in Table 1 of this procedure.

4.2 Step-by-Step Instructions

4.2.1 Entering and Verifying Magnetic Tape (Batch) Data

Position Responsible: TECHNICAL STAFF

1. Copy data from tape to a file on the ZVAX. (See Appendix E of HGWDB User Guide and Maintenance Manual.)
2. Change the ANABATCH.COM command file in the HGWDB directory on the ZVAX to show the correct input file name.
3. Submit the ANABATCH.COM file to be processed. (See Sections 3.2.8 and 3.2.9 of HGWDB User Guide and Maintenance Manual.)

TABLE 1. Sampling Plans for Normal Inspection

<u>Lot or Batch Size</u>	<u>Sample Size</u>	<u>Error Acceptance Level</u>	<u>Error Rejection Level</u>
2 - 150	13	0	1
151 - 500	32	1	2
501 - 1,200	80	2	3
1,201 - 3,200	125	3	4
3,200 - 10,000	200	5	6
10,001 - 35,000	315	7	8

Extracted from ANSI/ASQC Z1.4-81, Tables I and II-A

4. Review the UPDRESERR.SAV file (created in the HGWDB directory during processing) for rejected records. Modify and resubmit records that were incorrectly rejected.
5. Determine the number of records that were entered into the data base from the UST data tape. This number is printed at the end of the ANADAT.RPT file (created in the HGWDB directory during processing). This is the Lot or Batch Size.
6. Determine the Sample Size from Table 1 for the Lot or Batch Size.
7. Determine the sampling interval (SI) as the whole number portion of (Lot or Batch Size) Sample Size.
8. Mark every record that corresponds to the SI on a printout of the ANADAT.RPT file. For example, if the SI is 4, mark every fourth record.
9. Check every record marked in step 8 against its laboratory data sheet value and initial each value checked on a printout of ANADAT.RPT.
10. Count the number of checked records that are incorrect in the data base.
11. Determine the Acceptance and Rejection numbers from Table 1 for the Sample Size that has been used.

12. If the number of nonconformances is less than or equal to the Acceptance number, sign and date the ANADAT.RPT listing as accepted and enter the initials of the verifier into the data base for each record from that tape.
13. If the number of errors is greater than or equal to the Rejection number, verify every number in the ANADAT.RPT listing and report the results to the Statistical and Qualitative Data Evaluation Task Leader for further action as outlined in ANSI/ASQC Z1.4-1981.
14. If discrepancies or errors are discovered, bring them to the attention of the Sample Analysis or Data Handling Task Leader (or designee), who shall determine any corrective action. If data are changed in the data base, the new results are automatically included in subsequent ANATREND runs. The most recent value that was changed remains stored in the file in a separate location.

4.2.2 Entering and Verifying Data Entered Interactively

Position Responsible: TECHNICAL STAFF

1. Enter data from laboratory data sheets or Field Record Forms into the data base by running the ANADAT program. (See Section 3.2.3 of HGWDB User Guide and Maintenance Manual.)
2. Check every record against its laboratory data sheet or Field Record Form value and initial each value checked on a printout of ANADAT.RPT. When all records are checked, sign and date the printout.
3. Correct any input errors by running the ANADAT program again and repeat Step 2.

DM-2 WATER LEVEL DATA HANDLING AND VERIFICATION PROCEDURE

1.0 APPLICABILITY

This procedure establishes a standardized method for the entry into the PNL data base (HGWDB) and verification of water level data. Data can be entered interactively or in batch mode (as in the case of data downloaded from a personal computer).

2.0 DEFINITIONS

- HGWDB - the Hanford Ground-Water Data Base.
- PC - personal computer.

3.0 RESPONSIBLE STAFF

- Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following will be needed when entering and verifying water level data entered into the data base:

- copies of field logbook(s)
- access to HGWDB project on PNL ZVAX computer
- copy of HGWDB User Guide and Maintenance Manual.

4.2 Step-by-Step Instructions

4.2.1 Entering and Verifying Data Entered Interactively

Position Responsible: TECHNICAL STAFF

1. Enter water level data from copies of field logbook(s) into the data base by running the HYDDAT program. (See Section 2.2.1 of HGWDB User Guide and Maintenance Manual.)
2. Check each water level value against its field logbook value and initial each value checked on a printout of HYDDAT.RPT (created during data entry). When all records are checked, sign and date the printout.
3. Correct any input errors by running the HYDDAT program again and repeat Step 2.

4.2.2 Entering and Verifying Batch Data

Position Responsible: TECHNICAL STAFF

1. Load the file containing the water level data into the data base by running the HYDLOAD program. (See Section 2.2.3 of HGWDB User Guide and Maintenance Manual.) If data are downloaded from a PC, the file must first be put into the format required by the HYDLOAD program.
2. See Steps 2 to 3 of Section 4.2.1 of this procedure.

GC-1 GROUND-WATER SAMPLE COLLECTION PROCEDURE

1.0 APPLICABILITY

These procedures are intended for use during collection of ground-water samples that will be analyzed for hazardous chemicals and radiological constituents.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Radiation Protection Technologists (RPTs).

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- copy of the safety plan dated June 16, 1989, Revision 2, "Addendum to all PNL Site Safety Plans Concerning Ground-Water Monitoring Activities Conducted on the Hanford Site" applicable to ground-water sampling
- truck-mounted air compressor (equipped with dryer and lubricator) and generator, air hose and power cord
- bailer winch
- HydroStar pneumatic cylinder
- purge hose
- extra discharge line for submersible pump
- stainless steel sampling manifold and back flow preventer
- 2 Teflon bailers
- 2 pH and conductivity meters pH 7 and 10/conduct. sol.
- 2 digital thermometers
- 2 steel measuring tapes (300 ft, 500 ft) and 1 E-tape
- carpenter's chalk
- large plastic bags

- engineer's measuring tape
- Hanford Well Fact Book
- NO DUMP well list/appropriate radiation work procedures
- stopwatch or watch with second hand
- bucket (for measuring flow rate)
- distilled water
- sealed plastic bags
- ice chests with ice
- rubber gloves
- disposable surgical gloves
- towels
- extra sample labels
- sample seals
- copies of Procedures AD-2, AD-6; GC-1, GC-2, GC-3; FA-1, FA-2, FA-3
- sample containers with caps and liners (including extras)
- catch basin (1/2 of 55 gal plastic drum liner)
- box of extra bottles
- Well Services Request (WSR) Forms (Figure 1)
- rubber boots (can be disposable)
- radiation work protection clothes
- radiation detection instruments
- shovel
- wire cutters
- tool bay (with tools)
- miscellaneous stainless steel fitting/Teflon tape

WELL SERVICES REQUEST RESOURCE PROTECTION WELL SERVICES			
COMPLETED BY NOTIFYING ORGANIZATION			
Well Name/No.	Date Identified	Identified By (Printed Name and Signature)	No. _____
DESCRIPTION OF REASON FOR WELL SERVICES REQUEST			
Item 1: _____			

Item 2: _____			

Item 3: _____			

<div style="display: flex; justify-content: space-between;"> <div> Above item(s) prevent sample collection: 1. Yes ☐ No ☐ If yes, sample collection 2. Yes ☐ No ☐ required by: _____ 3. Yes ☐ No ☐ <div style="text-align: center; font-size: small;">Latest Date</div> </div> <div> Notified by _____ Title/Organization _____ Signature/Date _____ </div> </div>			
FORWARD TO: GROUNDWATER WELL SERVICES SECTION, ENVIRONMENTAL DIVISION, WHC			
COMPLETED BY GROUNDWATER WELL SERVICES SECTION			
Notification Received by - Signature/Date: _____		Assigned Priority Levels	
WSR No.: _____ Planning Report No.: _____		Item 1: 1 ☐ 2 ☐ 3 ☐ Item 2: 1 ☐ 2 ☐ 3 ☐ Item 3: 1 ☐ 2 ☐ 3 ☐	
WELL SERVICES PERFORMED			
Item 1: _____			

_____ Printed Name/Signature/Date: _____			
Item 2: _____			

_____ Printed Name/Signature/Date: _____			
Item 3: _____			

_____ Printed Name/Signature/Date: _____			
Closed Out By: _____ Printed Name/Signature/Date: _____			
FOLLOWING CLOSURE OF ALL ITEMS, FORWARD COMPLETED COPY TO NOTIFYING ORGANIZATION.			
DISTRIBUTION: White-Red File Customer Yellow-Group File Pink-Returned to Notifying Organization Green-Returned by Notifying Organization			

FIGURE 1. Well Services Request Form

- blue coveralls
- safety glasses
- hearing protection
- first aid kit
- waterproof markers and black pens
- masking tape
- water for washing hands.

NOTE: Duplicate equipment may be temporarily stored at an easily accessible location.

4.1.2 General Preparation

Read and be familiar with the current safety plan applicable to ground-water sampling.

Before going to the field, test the field equipment (pH/conductivity meter, temperature probe). Load the truck in a secure and safe manner with the necessary supplies. Pick up the sample bottles. Check the Fact Book and "NO DUMP" well list to determine the need for an organic vapor monitor and/or a purge water truck.

When the sample team arrives at the collection site, park the truck near the well for convenience and safe operation of sampling equipment, but downwind. Refer to the NO DUMP well list for determining if containment of purge water and/or the use of an organic vapor monitor are required.

If a well cannot be sampled for any reason, return all sample bottles and paper work to the sample preparation laboratory. Log the well number and the reason for no sample in the "Uncollectible Wells" log book. Fill out a WSR Form and turn it in to the RPT supervisor (Figure 1).

4.1.3 Sampling Precautions

Do not smoke, drink, or eat during sampling, and avoid handling any objects not necessary for performing sampling procedures.

Park downwind of the well being sampled.

Do not sample downwind from sources of volatile organics (e.g., car or generator exhausts, open fuel tanks). These types of equipment could contaminate the sample. If any such sources of contamination are unavoidable, make a note of them on the Field Record Forms (Figure 2).

Leave caps on the sample containers until just before filling. Figure 3 illustrates typical sample labels and provides an explanation key.

Avoid handling the Teflon bottle cap liners. Do not use any liner that falls out of the cap and onto the ground.

Wear disposable or rubber gloves when taking samples and when handling containers, especially those with preservative added. If gloves become soiled replace or wash them. Wear safety glasses when filling sample bottles.

4.2 Step-by-Step Instructions

4.2.1 General Sample Collection Procedure

Position Responsible: RADIATION PROTECTION TECHNOLOGISTS

1. Select the appropriate sampling method by
 - a. determining whether the borehole to be sampled is a well or a piezometer (by comparing diameter). Piezometers are usually 2 in. or less in diameter.
 - b. determining which kind of pump, if any, is in the well (submersible pump, HydroStar pump, or no pump, which requires the use of a bailer). This information is given in the Hanford Well Fact Book. The procedure to follow for each of these types of pump can be found in subsections 4.2.2 through 4.2.4 below. Follow those procedures first, before continuing with step 2 of this general procedure.
2. Once the water begins to flow from the outlet, pump the well for the length of time indicated on the Field Record Form, and until pH, temperature, and specific conductivity stabilize (see Procedures FA-1, "Temperature Measurement Procedure;" FA-2, "Calibration of Conductivity Meter and Measurement of Field Conductivity;" and FA-3, "Calibration of pH Meter and Measurement of Field pH"). If no purge volume or purge time is listed on the Field Record Form, pump for 20 minutes or pump for the time required to remove the purge volume listed in the Hanford Well Fact Book. Pump for the shorter time period for this situation. Check for stabilization of the pH, temperature, and specific conductivity before sampling.

NOTE: If the well pumps dry while purging, a sample can still be obtained by following these steps:

⑪ ⑩ ①
 ⑨ GROUNDWATER ④
 Sponsor: ②
 Lab: ③/
 Sample Size: ⑧
 ⑥ / / ⑦
 Date/Time: ⑫
 Collector: ⑤

 9076 HD007296
 GROUNDWATER ICP
 HNCB Sponsor:
 Lab: /IL
 Sample Size: 500 ML
 07/09/91 Bottle: P
 Date/Time:
 Collector:

 9076 HD007296
 GROUNDWATER 741 ICPMTF
 HNCB Sponsor:
 Lab: /IL
 Sample Size: 500 ML
 07/09/91 Bottle: P
 Date/Time:
 Collector: *** Filter

GROUND-WATER SAMPLE LABEL KEY

The following information is printed on the label by the computer program that creates the label from the sampling schedule:

1. Well Name (e.g., 299-E25-25) or HEIS number.
2. The sponsor code - labels are created from the Hanford Ground-Water Data Base (HGWDB). This field is no longer used but still appears on the labels.
3. The lab code - labels are created from the HGWDB. This field is no longer used but still appears on the labels.
4. The analyses to be performed on the sample by the analytical laboratory.
5. "Filter" - indicates sample should be filtered.
6. The initial date for the sampling period.
7. The type of bottle to be used (e.g., PWC - a plastic bottle with a white cap).
8. Sample Size (e.g., 150 milliliters, 1000 milliliters).
9. The preservative, if used, for the constituent being analyzed.
10. The Chain-of-Custody number.
11. "N" indicates well is a "NO DUMP" well list (i.e., purge water must be contained and not allowed to go into the ground).

The following information is written on the label by the field sampling personnel at the time the sample is collected:

12. The collector's initials, time, and date sampled.

FIGURE 3. Typical Sample Label

- a. Turn the pump off.
- b. Wait for the well to recharge. This recharging period should take about 15 minutes but may take as long as 30 minutes.
- c. Turn the pump back on. If you cannot feel air coming out of the pipe or water does not appear after a few minutes, turn the pump off, wait 30 minutes, and repeat the procedure. If water still fails to appear, report the problem on the Field Record Sheet and a WSR Form and discontinue the sampling effort at that well.

NOTE: Pumping times (shown on Field Record Form) are usually based on voiding three bore volumes of water from the well at a pumping rate of 10 gpm. To calculate an adjusted pumping time based on a field measurement of flow rate:

- a. Divide the size of the container (in gal) by the number of seconds it took to fill. Multiply by 60 to get the new pumping rate (per minute).
 - b. Divide the purge volume given on the Field Record Form by the new pumping rate to determine the adjusted pumping time.
3. Measure the pH, temperature, and specific conductivity of the discharged water at least three times during purging (beginning, middle, and end of the designated purge time), according to the standard procedures for measuring pH and conductivity (Procedures FA-2, "Calibration of Conductivity Meter and Measurement of Field Conductivity" and FA-3, "Calibration of pH Meter and Measurement of Field pH"). The pH will be considered stable when two consecutive measurements agree within 0.1 pH unit. Temperature will be considered stable when two consecutive measurements agree within 1.0°C. Conductivity will be considered stable when two consecutive measurements agree within 10% of each other. If pH, temperature, and conductivity do not stabilize within the listed purging time, repeat the measurements. If necessary, repeat a maximum of four times. If the parameters fail to stabilize, collect the sample and note the problem on Field Record Form.

NOTE: Four additional pH and conductivity readings may be required to meet RCRA requirements. If they are needed the additional readings will be requested on the Field Record Sheet above the Field Measurements section. These four sequential readings are to be made after the pH and conductivity have stabilized. Readings are to be taken on different water samples in rapid succession.

4. Enter time, date, and your last name or initials clearly on all sample labels.

5. Record information, as it becomes available, on the Field Record Form. The information that must be recorded on the Field Record Form is described in Procedure AD-2, "Ground-Water Sample Chain-of-Custody Procedure." Place the names of both members of the sampling team on the Field Record and Chain-of-Custody Forms.
6. Fill the appropriate sample containers starting with unfiltered samples first and filtered samples last.
7. All sample bottles with septum tops, which require zero headspace, are filled first. Unscrew the cap from the sample container, being careful not to touch the lip of the bottle or the inside of the Teflon liner. Also avoid touching the mouth of the discharge line. Reduce the flow rate when filling bottles with septum tops to less than 1 liter/minute. Measure the flow rate with a graduated container before sampling.
8. Fill the sample bottle slowly, placing the outlet tube near the inner side of the sample bottle to prevent trapping any air bubbles. Avoid splashing or agitating the water while the bottle is being filled.

NOTE: For those bottles requiring zero headspace (i.e., those having a septum top), the bottle should be filled completely so that a meniscus forms over the mouth. Cap the bottle immediately, turn it upside down, tap it a few times and check for air bubbles in the sample. If there is a bubble, fill the bottle further, until a bubble-free sample is obtained. On all other sample containers, fill the sample container to the neck of the bottle. These samples (without septum containers) do not have to be checked for air bubbles.

9. Attach the filter assembly and purge the filter according to directions listed in Procedure GC-2, "In-Line Sample Filtration Procedure." If too much pressure is exerted across the filter, the membrane will rupture, usually causing a popping noise. If this happens, replace the filter and begin the filtering procedure again.
10. Survey the sample container with a radiation detection instrument. If the count is greater than 200 c/m, record it on the Field Record Form and use established radiation work procedures. Contact the Environmental Monitoring Supervisor for instructions concerning where the sample is to be taken. Check the statement on the top of the Chain-of-Custody (Figure 4) that requires a yes or no response to the 200 c/m level. If not over 200 c/m, samples delivered per Chain-of-Custody.
11. Attach the security tape on each sample container immediately after filling. Attach the tape in such a way that the sample

<p style="font-size: small; margin-top: 5px;">Pacific Northwest Laboratories Environmental Sciences 19612 1st Avenue NE, Richland, WA 99352</p>	CHAIN OF CUSTODY	C-of-C: Test User ID: _____																														
Company Contact: _____ Telephone: _____ Samples Collected by: _____ Date: _____ Time: _____ ID/Sample No.: _____ Ice Chest No.: _____ Field Logbook Page No.: _____ Remarks: _____ Possible Sample Hazard Identification: _____ Destination: _____ Carrier/Waybill No.: _____ Ground-Water _____ Soil _____ Other _____ Shipping container internal temperature Shipping container internal temperature when samples sealed in it _____ when opened in laboratory _____																																
Sample Identification																																
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Chain of Possession																																
Relinquished by: _____ Relinquished by: _____ Relinquished by: _____ Relinquished by: _____	Received by: _____ Received by: _____ Received by: _____ Received by: _____	Date/Time: _____ Date/Time: _____ Date/Time: _____ Date/Time: _____																														
Disposal Record No.: _____		Date/Initials: _____																														

9C-1200-145 (12-90)

FIGURE 4. Chain-of-Custody Form

cannot be opened without breaking the tape seal. However, do not place the sample seal over the top of the 40-mL VOA vials. Place around the cap and bottle.

12. Place the samples in an insulated container with ice. Be sure the ice is distributed evenly so that all samples are surrounded and in physical contact with ice.
13. Place all nondedicated sampling equipment (e.g., manifolds) that comes into contact with the well water in a plastic bag until the next use.
14. Complete Field Record Forms (see Procedure AD-2, "Ground-Water Sample Chain-of-Custody Procedure").
15. Place the sample cooler in a secure location while driving.
16. Deliver the sample to the appropriate laboratory for analysis as soon as possible, following Chain-of-Custody Procedures (see Procedure AD-2, "Ground-Water Sample Chain-of-Custody Procedure," and Figure 4), and have the person receiving the sample sign the Chain-of-Custody Form. Only authorized personnel shall receive custody of samples. If a sample cannot be delivered to the laboratory the same day, store the sample in a refrigerator ($4^{\circ}\text{C} \pm 2^{\circ}\text{C}$) located inside a locked building or within a secured area. If custody of a sample(s) is transferred to another party, follow the strict Chain-of-Custody procedure signing the relinquishment, date, and time to the new sample custodian who must sign as "Received by." (Sign in the presence of each other.)

NOTE: DO NOT ALLOW SAMPLE BOTTLES TO FREEZE!

4.2.2 Sample Collection Using the Submersible Pump

Position Responsible: RADIATION PROTECTION TECHNOLOGIST

1. Check electrical connection to be assured the pump is properly grounded to casing. If the pump is not properly grounded complete a WSR Form. Do not operate the pump if it is not properly grounded.
2. Take water-level measurements according to Procedure WL-1, "Water-Level Measurement Procedure," and record the value on the Field Record Form.
3. Check to see that the hose bibb for the submersible pump is open. Place the stainless steel sampling manifold on the hose bibb or pump outlet. Be sure a valve is open to allow water to flow freely.

4. Plug the power cord into one of the 230-V outlets on the generator on the truck and into the outlet at the well head.
5. Start the electric generator.
6. Turn the power switch on to begin the pumping process. Do not handle energized power cords. If the pump does not work properly, as indicated by a lack of air flow out the discharge hose or by generator "lug" down, turn the switch off immediately. Wait a few seconds, then turn the switch on and off several times rapidly, finally pausing in the ON position to determine whether the pump has started to function properly. Repeat this several times. If the sample pump still doesn't work, it needs repair. If the breakers or fuses on the generator disengage, an electrical short in the system is indicated and repair is needed. Record problems on the Field Record Form and WSR Form (Figure 1).
7. Once pumping of the well has begun proceed to section 4.2.1 step 2.

4.2.3 Sample Collection Using the HydroStar Pump

Position Responsible: RADIATION PROTECTION TECHNOLOGIST

1. Determine the depth to water (see Procedure WL-1, "Water-Level Measurement Procedure") and record it on the Field Record Form.
2. Attach the pneumatic cylinder assembly to the well head assembly in the following manner:
 - a. Insert the support for the pneumatic cylinder into the column support on the well head assembly (Figure 5). When inserting the cylinder support into the column support on the pump assembly, make sure that at least two holes on the cylinder support overlap with two holes on the column support. If fewer than two holes overlap, fill out Problem Identification Report Form. Align the pumping system in the same manner as described above.
 - b. Pull the cylinder rod down until it is fully extended and has stopped.
 - c. Align the eyelet on the top portion of the turnbolt with the clevis pin hole on the lower portion of the cylinder rod.
 - d. Align the hole on the cylinder support with the column support on the well head so that the turnbolt eyelet and clevis pin hole on the cylinder rod are aligned when the piston is fully extended.

FIGURE 5. Well Head Assembly

- e. Insert the clevis pin through one of the intersecting pairs of holes on the column support and clip a hitch pin into the holes in the small end of the clevis pin.
 - f. Check the alignment on the turnbolt eyelet with the hole on the cylinder rod. On deep wells located in the 200 Areas, the eyelet should be 1/8 to 1/4 inch below the hole on the cylinder rod. Pull the turnbolt assembly up to align with the hole on the cylinder rod.
 - g. Adjust the alignment by rotating the turnbolt clockwise or counterclockwise.
3. Attach stainless steel manifold to the outlet on the discharge tee of the sampling pump. NOTE: Do not collect samples using the purge hose.
 4. Attach the quick-connect on the air supply hose to the unattached end of the control valve on the pneumatic cylinder. The input air pressure should not exceed 120 psi.
 5. Turn on the air supply to the control valve.
 6. To regulate the water-flow rate during sample collection, adjust the throttle control valve (on HydroStar) to obtain the desired flow rate.
 7. Turn on the control valve on the pneumatic cylinder. The piston will begin to operate.
 8. Adjust the stroke rate to no more than 60 per minute. (A stroke is defined as one downward and one upward extension.) The stroke rate of the pneumatic cylinder can be adjusted with the control valve located on the top of the pneumatic cylinder. On deep wells, the stroke rate could be significantly less than 60 per minute.
 9. Once pumping has begun go to section 4.2.1 step 2.
 10. After sampling dismantle the pneumatic pumping assembly by disconnecting the air supply at the pneumatic cylinder and disassembling pneumatic cylinder in reverse order of substeps 2a through 2g above.

4.2.4 Sample Collection Using a Teflon Bailer

Position Responsible: RADIATION PROTECTION TECHNOLOGIST

NOTE: Except where specifically noted, only tritium and nitrate samples should be collected from an unpurged well sampled with a bailer.

1. Unclasp the metal bailer from the winch line and replace it with the Teflon bailer.
2. Disengage the winch clutch and slowly lower the bailer into the water.
3. Engage the winch clutch when the bailer strikes the water surface.
4. Turn on the electric winch and slowly raise the Teflon bailer to the surface.
5. Lower, fill, and empty the bailer at least twice before collecting a sample.
6. Unscrew the cap of the sample container, being careful not to touch the lip of the bottle or the inside of the Teflon liner. Avoid touching the mouth of the Teflon bailer.
7. Unclasp the Teflon bailer.
8. Pour the water from the bailer into the sample container slowly.
9. Obtain sample temperature, pH, and conductivity as described in Procedures FA-1, "Temperature Measurement Procedure;" FA-2, "Calibration of Conductivity Meter and Measurement of Field Conductivity;" and FA-3, "Calibration of pH Meter and Measurement of Field pH;" and record on the Field Record Form. However, a single pH, conductivity, and temperature measurement is adequate.
10. If the ground-water sample is being collected when the water table is encountered during drilling, measurement of pH, conductivity, and temperature is not required.

4.2.5 Collecting Samples from a Piezometer Using the Air-Lift Method

Position Responsible: RADIATION PROTECTION TECHNOLOGIST

NOTE: This method should be used for radioactive constituents only.

Some piezometer tubes are sampled by the air-lift method, in which the sample water is pushed up and out of the well by compressed air. A 1/2-in.-diameter PVC tube has been installed in the wells for this purpose.

1. Connect the compressor hose to the piezometer tube.
2. Open the regulator valve to pressurize the hose and keep the compressor running until water is forced out of the outlet on the side of the piezometer adapter head.
3. Rinse the bucket twice with purge water before filling. Obtain sample temperature, pH, and conductivity as described in

Procedures FA-1, "Temperature Measurement Procedure;" FA-2, "Calibration of Conductivity Meter and Measurement of Field Conductivity;" and FA-3, "Calibration of pH Meter and Measurement of Field pH;" and record on the Field Record Form. However, a single pH, conductivity, and temperature measurement is adequate.

4. Fill the sample bottle from bucket.

4.2.6 Collecting Samples from a Piezometer Using the Bailing Method

NOTE: This method should be used to sample for radioactive constituents only.

Position Responsible: RADIATION PROTECTION TECHNOLOGIST

A few piezometer tubes are sampled by the bailing method. These piezometers do not produce enough water to sample by air lift. The bailer used consists of a flexible rubber tube, 1 in. in diameter and approximately 1.5 to 3 ft long. On one end of the tube, a plug has been inserted and wired in place.

1. Bail the piezometer tube in the same manner as in steps 1 through 9 of subsection 4.2.4 of this procedure.
2. Pour the sample collected into a sampling bottle until the required amount is obtained.
3. Obtain sample temperature, pH, and conductivity as described in Procedures FA-1, "Temperature Measurement Procedure;" FA-2, "Calibration of Conductivity Meter and Measurement of Field Conductivity;" and FA-3, "Calibration of pH Meter and Measurement of Field pH;" and record on the Field Record Form. However, a single pH, conductivity, and temperature measurement is adequate.

4.2.7 Cleaning Sampling Manifolds

Position Responsible: RADIATION PROTECTION TECHNOLOGIST

All sampling manifolds should be cleaned at the end of the day:

1. Rinse sampling manifold with tap water, then distilled water, and place it in a plastic bag.
2. If oil or grease is present on the manifold, wash both the inside and the outside of the manifold with a mild detergent, and rinse twice with warm or hot tap water, then with deionized (DI) or distilled water, and place in a plastic bag.

5.0 REFERENCES

- Procedure AD-2, "Ground-Water Sample Chain-of-Custody Procedure."
- Procedure AD-6, "Control Measures for Identification of Wells Requiring Purge-Water Containment."
- Procedure GC-2, "In-Line Sample Filtration Procedure."
- Procedure GC-3, "Disposal of Purge Water from Monitoring Wells."
- Procedure FA-1, "Temperature Measurement Procedure."
- Procedure FA-2, "Calibration of Conductivity Meter and Measurement of Field Conductivity."
- Procedure FA-3, "Calibration of pH Meter and Measurement of Field pH."

GC-2 IN-LINE SAMPLE FILTRATION PROCEDURE

1.0 APPLICABILITY

This procedure is to be used when filtered ground-water samples are to be collected during routine sample collection from monitoring wells.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Radiation Protection Technologists.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- filters (QED "Sample Pro" Model 8000, 8100, 8200, or equivalent)
- graduated container
- tubing for the filter adapter
- stainless steel manifold (must be used with a submersible pump but is an option with the HydroStar)
- Field Record Form specifying sample volume.

4.2 Step-by-Step Instructions

Follow Procedure GC-1, "Ground-Water Sample Collection Procedure," to prepare the well for ground-water sampling using the bladder, HydroStar, or submersible pump. Collect the filtered sample after all other samples have been collected.

One filter should be sufficient to collect the required sample volume under normal conditions. If a second filter is required, repeat the filter wash procedure described below. If the filters clog too quickly, replace the standard filter (QED Model 8100) with the high capacity model (QED Model 8000) and repeat preparation, Procedure GC-1. Indicate on the Field Record sheet if a high volume filter was required to filter a sample.

4.2.1 Bladder Pump Method

Position Responsible: RADIATION PROTECTION TECHNOLOGISTS

To collect a filtered sample from a well that contains a bladder pump:

1. Set the maximum discharge pressure to 60 psi and turn off the bladder pump controller.
2. Screw the inlet end of the filter assembly (marked inlet) into the threaded adapter, being careful not to touch filter ends to any surface.
3. Turn on bladder pump (check maximum pressure).
4. Filter approximately 500 mL, as a filter wash, into the graduated container.
5. Dispose of the filter wash and fill the sample bottles as specified on the Field Record Form and on the sample bottle labels.
6. Turn off bladder pump, remove the filter assembly, and return the assembly to the sample bottle box for proper disposal at the laboratory.

4.2.2 HydroStar Pump Method

Position Responsible: RADIATION PROTECTION TECHNOLOGIST

To collect a sample from a well that contains a HydroStar pump:

1. Turn off air to the HydroStar pump at the piston assembly.
2. Screw the inlet end of the filter assembly (marked "inlet") into the threaded adapter at the end of the Teflon tubing extending from the HydroStar pump, being careful not to touch filter ends to any surface.
3. Slowly turn on the air until the piston just operates smoothly. This rate should be less than 10 strokes a minute or as slow as possible to maintain water flow. If too much pressure is exerted across the filter, the membrane will rupture, usually resulting in a popping noise. If this happens, replace filter and restart the filtering procedure.
4. Filter approximately 500 mL, as a filter wash, into the graduated container.
5. Dispose of the filter wash and fill the sample bottles as specified on the Field Record Form and on the bottle labels.

6. Turn off the HydroStar pump, remove the filter assembly, and return the filter assembly to the sample bottle box for proper disposal.

4.2.3 Submersible Pump Method

Position Responsible: RADIATION PROTECTION TECHNOLOGIST

This pump should be used to collect a filtered sample only if a stainless steel manifold is used to regulate the water pressure going to the filter apparatus. The manifold must also be capable of maintaining a sufficient water flow to prevent damage to the submersible pump.

To collect a sample from a well that contains a submersible pump:

1. Before turning on the submersible pump, mount the manifold assembly to the well head and the Teflon sampling hose to the manifold.
2. Turn on the submersible pump.
3. Purge the well with the by-pass valve completely open.
4. To collect filtered samples, open by-pass valve completely.
5. Screw the inlet end of filter assembly (marked "inlet") into the threaded adapter at the end of the Teflon tube. Be careful not to touch filter ends to any surface.
6. Slowly close the by-pass valve until a steady flow of water is observed through filter.
7. When a steady flow is achieved, filter approximately 500 mL, as a filter wash, into the graduated container.
8. Dispose of the filter wash and fill the sample bottles as specified on the Field Record Form and on the sample bottle labels.
9. Turn off the submersible pump and remove the filter assembly from the stainless steel manifold.
10. Disconnect the stainless steel manifold from the well head.

11. Return the filter assembly to the sample bottle box for proper disposal at the laboratory.

5.0 REFERENCE

- Procedure GC-1, "Ground-Water Sample Collection Procedure."

GC-3 DISPOSAL OF PURGE WATER FROM MONITORING WELLS

1.0 APPLICABILITY

This procedure is to be used during ground-water sampling, when it has been determined from Procedure GC-1, "Ground-Water Sample Collection Procedure," that purge water from a monitoring well requires containment under the "Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington." (WHC-MR-0039).

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Radiation Protection Technologists
- Other persons collecting samples during special collections (i.e., drilling).

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- 55-gal plastic drum liner (cut off to approximately 24-in. height)
- two 50-ft x 3/4-in. garden hoses or equivalent
- protective gloves (e.g., surgical gloves)
- sampling manifold
- tank truck or storage container
- bucket
- carboy.

4.1.2 General Preparation

Surgical or rubber gloves must be worn when contact with the purge water is possible.

Care must be taken to ensure that water left in the hose is drained into the drum liner for transfer to the tank truck or storage container.

After purge water is disposed of into the tank truck or storage container, the handling, storage, and ultimate disposal of the water becomes the responsibility of Westinghouse Hanford Company waste disposal personnel.

4.2 Step-by-Step Instructions

4.2.1 HydroStar Pump Method

Position Responsible: RADIATION PROTECTION TECHNOLOGIST

1. Place the drum liner as close to the well casing as practical.
2. Connect the purge hose to the sampling manifold on the HydroStar pump and place the discharge end into the tank truck or storage container.
3. When purging is complete and sampling has begun fill all sample bottles over the drum liner so that any spillage will be collected in the drum liner.
4. After sampling, transfer any residual water from the drum liner to a bucket and pour into the tank truck or storage container.

4.2.2 Submersible Pump Method

Position Responsible: RADIATION PROTECTION TECHNOLOGIST

1. Connect the sampling manifold and purge-hose to the submersible pump riser on top of well head.
2. Place the discharge end of the purge hose into a tank truck or storage container.
3. Place the drum liner beneath the valve on the sampling manifold.
4. Begin well purging.
5. When purging is complete, fill all sample bottles over the drum liner so that any spillage will be collected in the drum liner.
6. After sampling, transfer any residual water in the drum liner to a bucket and pour into the tank truck or storage container.

NOTE: During freezing weather drain all lines to prevent frozen transfer line.

4.2.3 Bailer Method

1. Place the drum liner next to the well casing.
2. Deposit bailer rinse water into the drum liner or directly into plastic carboy.
3. Fill sample bottles over the drum liner.

4. Transfer any residual water in the drum liner into a plastic carboy.
5. When convenient, during the day transfer water from the plastic carboy to tank truck or storage container.

GC-4 COLLECTION AND HANDLING OF QUALITY CONTROL SAMPLES

1.0 APPLICABILITY

This procedure applies to the collection and handling of quality control (QC) samples from monitoring wells on the Hanford Site. These QC samples include trip blanks, transport and transfer blanks, intralaboratory and interlaboratory comparison samples, and blind samples.

All QC samples shall be handled and analyzed in the same manner as regular ground-water samples; this includes appropriate holding times. The requirements for blank and duplicate samples apply to all compliance monitoring programs.

2.0 DEFINITIONS

- VOA - Volatile Organic Analysis.
- Type II Reagent Water - Water having a maximum electrical conductivity (at 25°C) $\leq 1.0 \mu\text{mho/cm}$ or electrical resistivity (at 25°C) $\geq 1.0 \text{ M}\Omega\cdot\text{cm}$.
- Sample event (project specific) - describes the scheduled well trips to be made in a given period for a specific project.
- Trip blank - a sample that contains only Type II reagent water [boiled for some analyses including VOA and Total Organic Halides (TOX) analyses] and preservative as required. This blank is a check on bottles and sample preparation. One blank set, which includes all constituents analyzed by a specific project, shall be submitted to each participating laboratory per month. Trip blanks (well code 0899) are filled in the analytical laboratory under the sample preparation task.
- Transport blank - a VOA blank (boiled Type II reagent water) used to check for sample contamination by volatile organic compounds arising from the transportation of samples. The transport blank is not opened in the field. At least one transport blank is collected for each 20 wells sampled, or one per project sample event. The sample number associated with the transport blank is the well number (EMA number) from the well being sampled with a 'Q-0' suffix.
- Transfer blank - a VOA blank (boiled Type II reagent water) used to check for sample contamination by volatile organic compounds arising from conditions encountered during the collection of samples. The transfer blank is filled at the sampling site by pouring Type II reagent water (from a container cleaned to the same protocol as that for the VOA vials) into a VOA vial. At least one transfer blank is

collected for each 20 wells sampled, or one per project sample event. The sample number associated with the transfer blank is the well number (EMA number) from the well being sampled with a 'Q-1' suffix.

- Intralaboratory comparison sample - used to determine repeatability of an analytical measurement (i.e., sampling and analytical variability) on identical samples collected at the same time and location when analyzed by the primary laboratory. NOTE: 'Duplicate' can also indicate triplicate or quadruplicate analyses. Sample numbers associated with 'duplicates' are indicated by a duplicate sample number (e.g., -1, -2, or -3) following the well number (EMA number), e.g., 4975-0 (original sample), 4957-1 (duplicate).
- Interlaboratory comparison sample - used to determine bias in an analytical measurement of identical samples collected at the same time and location when analyzed by an alternate laboratory.
- Blind sample - a sample that contains a concentration of analyte that is known to the supplier, but unknown to the analyzing laboratory. These samples are used to assess accuracy and to monitor the performance of the analytical laboratory.

3.0 RESPONSIBLE STAFF

- Radiation Protection Technologists (RPT)
- Technical Staff (Quality Control Task Leader or Designee).

4.0 PROCEDURE

4.1 Prerequisites

The necessary sampling equipment must be available. A list of equipment required and precautions to take are given. See Procedure GC-1, Ground-Water Sample Collection Procedure.

All appropriate documentation must accompany samples and must be submitted to the laboratory at the time samples are submitted; this includes the Chain-of-Custody forms, Sample Analysis Request (SAR) forms for the primary analytical laboratory, and Request For Analytical Services (RFAS) forms for the alternate laboratory. See Procedures AD-2, Ground-Water Sample Chain-of-Custody Procedure; GC-1, Ground-Water Sample Collection Procedure.

4.2 Step-by-Step Instructions

4.2.1 Trip Blanks

Position Responsible: RADIATION PROTECTION TECHNOLOGISTS OR TECHNICAL STAFF

1. Pick up the blanks at the facility used for sample preparation and transport to the field. Do not open during sampling.
2. Place the blanks into the cooler with the other samples.
3. Deliver samples to the appropriate analytical laboratory.

4.2.2 Transport Blanks

Position Responsible: RADIATION PROTECTION TECHNOLOGISTS

1. Remove the VOA vial from the plastic bag.
2. Place the vial near the well while sampling is taking place but do not open it.
3. Place the vial into the cooler with samples taken from that well.
4. Deliver samples as above.

4.2.3 Transfer Blanks

Position Responsible: TECHNICAL STAFF OR DESIGNEE

1. Obtain a bottle that is cleaned to the same protocol as the VOA vials.
2. Fill the bottle with boiled Type II reagent water.
3. Label the bottle.

Position Responsible: RADIATION PROTECTION TECHNOLOGISTS

NOTE: The transfer blank must be filled at approximately the same time that the VOA sample is taken. The water must be poured carefully, allowing no headspace or entrained bubbles. If bubbles are present, top off the vial with additional boiled Type II reagent water.

4. Fill the transfer blank from the labeled bottle containing the boiled Type II reagent water, performing the transfer near where the field samples are being collected.
5. Place the vial into the cooler with samples taken from that well.

6. Deliver samples as above.

4.2.4 Intralaboratory Comparison Samples (Replicate samples for Duplicate analysis)

Position Responsible: RADIATION PROTECTION TECHNOLOGISTS

1. Collect these samples immediately following collection of the primary samples.
2. Place the sample(s) into the cooler with the primary samples taken from that well.
3. Deliver samples as above.

4.2.5 Interlaboratory Comparison Samples (Alternate Lab Replicate Samples)

Position Responsible: RADIATION PROTECTION TECHNOLOGISTS

NOTE: Every effort will be made to avoid using samples with radioactivity greater than 2 nCi/g as interlaboratory comparison samples.

1. Collect replicate samples.
2. Place the sample(s) into the cooler with the primary samples taken from that well.
3. Deliver samples as above.

4.2.6 Blind Samples

Position Responsible: TECHNICAL STAFF

Blind samples shall be prepared by a designee of the Quality Control Task Leader in accordance with procedures provided. Sample preparation shall be recorded in a numbered laboratory notebook.

Blind samples are identified by well codes assigned to the QC task. Deliver blind samples to appropriate laboratories.

5.0 REFERENCES

- EPA. 1986. Technical Enforcement Guidance Document. OSWER-9950.1, U.S. Environmental Protection Agency, Washington, D.C., Chapter 4.
- EPA. 1979. Handbook for Analytical Quality Control in Water and Wastewater Laboratories. EPA-600/4-79-019, U.S. Environmental Protection Agency, Washington, D.C., Section 2.2, Table 2-2.

- EPA. 1986. Test Methods for Evaluating Solid Waste. SW-846, Vol. II, U.S. Environmental Protection Agency, Washington, D.C.
- Procedure AD-2, "Ground-Water Sample Chain-of-Custody Procedure."
- Procedure GC-1, "Ground-Water Sample Collection Procedure."

GC-7 WELL DEVELOPMENT

1.0 APPLICABILITY

This procedure describes methods and criteria for determining when a monitoring well is suitably developed for the purpose of collecting ground-water samples. The procedure requires that the well be pumped and may be applied any time after a well is completed with screen and sand pack.

The pump and related equipment used in well development are usually installed and maintained by a driller or other subcontractor. If necessary, a tanker truck for collecting purged ground water is supplied by another subcontractor.

2.0 DEFINITIONS

- NTU - Nephelometric turbidity unit.

3.0 RESPONSIBLE STAFF

- Well-Site Geologist
- Project Hydrologist
- Project Manager.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment/Supplies

- turbidimeter
- standards for standardizing turbidimeter
- sample bottles (a dozen are recommended)
- Well Development Log form
- Aquifer Test Data sheet
- marking pen or labels for the sample bottles.

NOTE: Ensure that the turbidimeter has been calibrated in accordance with manufacturer's instructions. Standardize the turbidimeter before using each day or when changing turbidity range, in accordance with manufacturer's instructions. Document the standardization, noting the values of the standard(s) used, in the "comments" section of the Well Development Log form (Figure 1).

Start Date/Time _____
End Date/Time _____
Page _____ of _____

4.2 Step-by-Step Instructions

Position Responsible: WELL SITE GEOLOGIST, PROJECT HYDROLOGIST

4.2.1 General Requirements

1. Record the model and serial number of the instrument used to make the turbidity measurements on the Well Development Log form (Figure 1).

NOTE: Samples are unfiltered, unpreserved, and will not be retained, so labeling may be minimal. The minimum required labeling is the time of collection (or similar unique identifier), which can be written on the bottle with a marking pen.

2. Take measurements of flow rate and depth to water if possible. Record time of measurements and values of flow rate on the Well Development Log form (Figure 1). Record the time in the comments section of that form whenever the pump is started or stopped. Record the time and values of depth to water measurements on an Aquifer Test Data sheet (Figure 2).
3. If purged water is being contained, check the level of the container frequently to ensure that its capacity is not reached. If the container is near capacity, terminate pumping until additional containers are available.

NOTE: If a responsible individual documenting well development (Well Site Geologist or Project Hydrologist) will be absent for an extended period (e.g., overnight) and turbidity has not yet achieved the required criteria, pumping shall be discontinued until such responsible individual is present at the well site.

4.2.2 Collect Well Information

1. Determine depth to water, depth of bottom of well, and depth of pump, and record on Well Development Log form (Figure 1).

4.2.3 Well Development for High-Permeability Material

1. Pump at a flow rate of approximately 5 to 10 gpm.
2. As soon as possible after the pump is started (or flow rate increased), collect a 250-mL unfiltered sample of the water and measure turbidity. Record the time and turbidity measurement results and the person(s) making and recording the measurement on the Well Development Log form (Figure 1).

page _____ of _____

Pumping Well _____

Type of Aquifer Test _____

How W.L.'s Measured _____

Depth of Pump/Airpipe _____

Pump On: date _____ time _____

Pump Off: date _____ time _____

Duration of Aquifer Test _____

FIGURE 2. Aquifer Test Data Sheet

3. Repeat measurements every 15 to 30 min until a general data trend can be determined. Plot the data on a time scale and evaluate the data trend to determine sampling interval. Measurements should be made more frequently when the rate of change is greater, and less frequently when the rate of change is smaller.
4. When turbidity is below 5 NTU, increase flow rate to a sustainable rate. (Flow rate is increased only once during development.)
5. Repeat steps 2 and 3, until turbidity is below 5 NTU. Terminate pumping when turbidity is below 5 NTU.
6. If after plotting the data trend it does not appear that 5 NTU will be achieved after pumping a total of 2,000 gallons, contact the Project Manager for further directions.
7. If the Project Manager concurs that the well will not be developed to the 5-NTU criteria, document the final turbidity measurement on the Well Development Log form (Figure 1), and that the Project Manager concurred with termination of development.

4.2.4 Well Development for Low-Permeability Material

1. Using a small pump, pump at an estimated sustainable flow rate (based on measured or estimated transmissivity and available drawdown).
2. As soon as possible after the pump is started (or flow rate increased), collect a 250-mL unfiltered sample of the water and measure turbidity. Record the time and turbidity measurement results and the person(s) making and recording the measurement on the Well Development Log form (Figure 1).
3. Repeat measurements every 15 to 30 min until a general data trend can be determined. Plot the data on a time scale and evaluate the data trend to determine sampling interval. Measurements should be made more frequently when the rate of change is greater, and less frequently when the rate of change is smaller.
4. When turbidity is below 5 NTU, increase flow rate. (Flow rate is increased only once during development.)
5. Repeat steps 2 and 3, until turbidity is below 5 NTU. Terminate pumping when turbidity is below 5 NTU.
6. When pumping continuously, if the data trend does not indicate that 5 NTU will be achieved after pumping 2,000 gallons, contact the Project Manager for further direction.
7. If pumping cannot be sustained (well pumps dry) at the lowest possible flow rate, continue pumping as long as possible,

measuring collected samples for turbidity. Continue pumping on a cyclic basis, allowing the well to partially recover between pumping cycles. When turbidity is below 5 NTU, terminate pumping. If turbidity will not reach 5 NTU within two days of cyclic pumping, contact the Project Manager for further direction.

8. If the Project Manager concurs that the well will not be developed to the 5-NTU criteria, document the final turbidity measurement on the Well Development Log form (Figure 1), and that the Project Manager concurred with termination of development.

GC-11 PREPARATION OF DOCUMENTS AND SAMPLE CONTAINERS FOR GROUND-WATER SAMPLE COLLECTION

1.0 APPLICABILITY

This procedure outlines the preparation of sample bottles and their accompanying documentation for the collection of ground-water samples from monitoring wells. After sample bottles and documentation preparation, sample collection can be accomplished as described in Procedure GC-1, "Ground-Water Sample Collection Procedure."

2.0 DEFINITIONS

- CCl_4 - Meter reading is required to determine the presence and level of carbon tetrachloride (indicated by Carbon Tet on the Field Record Form).
- Field Record Logbook - Contains Field Record Forms only.
- Label - (see Figure 1).
- PURGE WATER DUMP - Purgewater from well must be contained (indicated by "N" on the label and Field Record Form).
- Project List - Monthly sampling list is created from the information in the Statement of Work (SOW), showing wells to be sampled and any special requirements for sampling.
- Project Log - Printout from Reflex database, listing the Chain-of-Custody number(s), logbook page number, Hanford Environmental Information System (HEIS) number(s), and any indicators for PURGE WATER DUMP and CCl_4 assigned to each well.
- Sample Analysis Order (SAO) - Lists the constituents to be analyzed for; type, size, and number of bottles; and preservative.
- Sample Set - All sample bottles and accompanying documents for a sampling event at a well.
- Sampling Event - Each scheduled sampling.
- Staging Area - Designated area where prepared sample sets are placed for Radiation Protection Technologists (RPTs) to pick up when sample collections are to be made.

3.0 RESPONSIBLE STAFF

- Sampling and Analysis Management Task Leader
- Sampling and Analysis Coordination Task Leader
- Technical Staff

⑪ ⑫ ①
 ⑨ GROUNDWATER ④
 Sponsor: ②
 Lab: ③/
 Sample Size: ⑥
 ⑥ / ⑦
 Date/Time: ⑫
 Collector: ⑤

9076 HQ007296
 HNCB GROUNDWATER ICP
 Sponsor:
 Lab: /IL
 Sample Size: 500 ML
 07/09/91 Bottle: P
 Date/Time:
 Collector:

9076 HQ007296
 HNCB GROUNDWATER 741 ICPMTF
 Sponsor:
 Lab: /IL
 Sample Size: 500 ML
 07/09/91 Bottle: P
 Date/Time:
 Collector: *** Filter

GROUND-WATER SAMPLE LABEL KEY

The following information is printed on the label by the computer program that creates the label from the sampling schedule:

1. Well Name (e.g., 299-E25-25) or HEIS number.
2. The sponsor code - labels are created from the Hanford Ground-Water Data Base (HGWDB). This field is no longer used but still appears on the labels.
3. The lab code - labels are created from the HGWDB. This field is no longer used but still appears on the labels.
4. The analyses to be performed on the sample by the analytical laboratory.
5. "Filter" - indicates sample should be filtered.
6. The initial date for the sampling period.
7. The type of bottle to be used (e.g., PWC - a plastic bottle with a white cap).
8. Sample Size (e.g., 150 milliliters, 1000 milliliters).
9. The preservative, if used, for the constituent being analyzed.
10. The Chain-of-Custody number.
11. "N" indicates well is on the "NO DUMP" well list (i.e., purge water must be contained and not allowed to go into the ground).

The following information is written on the label by the field sampling personnel at the time the sample is collected:

12. The collector's initials, time and date sampled.

FIGURE 1. Typical Sample Label

4.0 PROCEDURE

4.1 Documentation Preparation

Position Responsible: SAMPLING AND ANALYSIS COORDINATION TASK LEADER

1. Authorized sampling schedules are produced from project SOWs, Westinghouse Hanford Company SOW Change Authorizations (Figure 2), Project Management Plans, or by directives from project managers. These schedules are provided by the Sampling and Analysis Management Task Leader. These schedules will include PURGE WATER DUMP ("N") and carbon tetrachloride (*) indicators where relevant.
2. Maintain a file of written authorizations for schedule changes.
3. Produce Project Log and SAOs for each project from the schedules.
4. Assign Chain-of-Custody number(s), HEIS number(s), and Field Record Logbook page for each well to be sampled.
5. Review SAOs and Project Log for each project. Check the Project Log against the schedule, and adjust the SAOs if needed by making additions, deletions, or corrections as indicated on the schedule. Use signature and countersignature on the Document/Label Checklist (Figure 3) to verify the SAOs.
6. Assign preparation of the Chain-of-Custody, Field Record Form, SAO, and labels for each well to be sampled in accordance with Procedure AD-2, "Ground-Water Sample Chain-of-Custody Procedure" and Procedure GC-1, "Ground-Water Sample Collection Procedure."
7. Enter the information from the SAO into the computer, and print the labels.
8. Send the documents and labels cited above for each well scheduled to be sampled to the Sample Preparation Laboratory with a Document/Label Checklist showing the wells to be sampled.

4.2 Document Verification

Position Responsible: TWO STAFF MEMBERS ASSIGNED TO SAMPLING AND ANALYSIS COORDINATION TASK

NOTE: Any staff member assigned to the Sampling and Analysis Coordination Task can perform the first check and sign the Document/Label Checklist. The countersignature must be the Sampling and Analysis Coordination Task Leader or the Sampling and Analysis Management Task Leader or delegated trained authority for Document/Label Checklist.

DOCUMENT/LABEL CHECKLIST

PROJECT: _____

DATE: _____

CHAIN-OF-CUSTODY	Initial/Date	Initial/Date*
Chain-of-Custody Number (Correct Series?)		
Test User ID (Correct?)		
Contract Number (ITAS Only)		
Logbook and Page Number		
Source ID (HEIS Number(s), Well Number)		
Radiation Survey Statement on Form		

WELLS: See below or Attached

FIELD RECORD FORM		
Chain-of-Custody Number(s) (Series Correct?)		
Well Number		
HEIS Number(s)		
Logbook and Page Number		
"N" on Form if PURGE WATER indicates no dumping		
Containment Code Entry		
Comments (Well Fact Book) Carbon Tetrachloride		
Is the Well a Bailer? (Well Fact Book)		
Total Number of Bottles		
Purge Volume (Well Fact Book)		
Last pH (Well Fact Book)		
Four Extra pH & Conductivity (Some RCRA Projects)		

SAMPLE ANALYSIS ORDER (SAO)		
Chain-of-Custody Number (Correct Series?)		
Contract Number Entered/Test User ID?		
Source ID (HEIS Number(s), Well Name)		
Test User ID		
Laboratory Destination Circled?		
Compare Chain-of-Custody, Field Record, and Labels to SAO		

* Indicated either by the Sampling and Analysis Coordination Task Leader, Sampling and Analysis Management Task Leader or delegated trained authority.

FIGURE 3. Document/Label Checklist

<u>LABEL</u>	Initial/Date	Initial/Date*
Does Label have "N" if on NO-DUMP List?		
Is Preservative Correct/Highlighted on Label?		
Correct Number of Labels?		

<u>OTHER</u>		
Any Alternate Laboratory Paperwork		
Security Tape on All Containers and Box or Sealed Plastic Bag for Sample Set		
Copies of Chain-of-Custody, and HEIS/Chain-of-Custody Project Log to S&A Management and S&A Coordination Task Leaders; copy of SAO to S&A Management Task Leader		
Is the HEIS/Chain-of-Custody Project Log Record Copy in the Notebook in Sigma V/1227?		

05/91

* Indicated either by the Sampling and Analysis Coordination Task Leader, Sampling and Analysis Management Task Leader or delegated trained authority.

FIGURE 3. (contd)

1. Use the Document/Label Checklist (see Figure 3) to ensure all information is verified with signature and countersignature. Minor errors (i.e., an omission that can be added) can be corrected on the label or document (initial and date the correction). Major errors require that a label or document be returned to the Sampling and Analysis Coordination Task Leader for correction and replacement. When this occurs, the complete document set must go through the Document/Label Checklist again. Also ensure that purge volume, previous pH reading, and any special documentation (i.e., bailer, specific pumping rate for sampling, special analysis performed outside the contract laboratory) are on the Field Record Form. Documents and prepared bottles do not go to the Staging Area unless the Document/Label Checklist has been completed and verified with signature and countersignature.
2. The Project Log and Document/Label Checklist shall accompany the complete set of documents and labels for each well when ready for the verification process. The first staff member to use the Document/Label Checklist shall enter the identification (either a HEIS number or a well number) of the documents being checked on the Document/Label Checklist or, if all wells from a project are checked at one time, a copy of the Project Log shall be attached to the form.

3. Compare document information for each well to the Project Log. The Project Log identifies the project, the wells, the assigned HEIS numbers, if data are to be entered into the database, Chain-of-Custody numbers, and the Field Record Logbook page numbers for each well. This information is required to check the documents. Use the Project Log and NO-DUMP list to complete the Document/Label Checklist.
4. Verify that the labels agree with the SAOs and SOW schedules.
5. Crosscheck the Chain-of-Custody Form, Field Record Form, and sample label to the SAO.
6. Distribute copies of the SAO for each project to the Sampling and Analysis Management Task Leader.
7. Distribute copies of the Chain-of-Custody Form to project and Sample Coordination files.
8. Distribute copies of the Document/Label Checklist and the Project Log to the Sampling and Analysis Coordination Task Leader and Sampling and Analysis Management Task Leader.

4.3 Sample Bottle Certification

Position Responsible: SAMPLING AND ANALYSIS COORDINATION TASK LEADER

1. Verify that precleaned bottles comply with the Pacific Northwest Laboratory (PNL) quality assurance (QA) items listed on the Purchase Requisition.
2. Segregate the nonverified bottles to preclude inadvertent use. The nonverified bottles are identified by a QA Hold Tag until verification has been confirmed by the QA Document Transmittal Form, showing that documents received from the vendor have been accepted by the PNL Quality Process Department.

4.4 Sample Bottle Preparation

Position Responsible: SAMPLING AND ANALYSIS COORDINATION TASK LEADER

1. Not all sample bottles require preservative. For those that do (see Table 1), add preservative to each bottle in accordance with the constituent or constituent group for which that specific bottle is designated. Lot number of preservative and date opened and date used are to be recorded in a Laboratory Record Book. On the outside of the case of like-preserved bottles indicate the preservative, the date it was added and initials of the preparer. Seal the case with masking tape.

TABLE 1. Sample Bottle Preservation (Primary Laboratory)

CONSTITUENT		SUGGESTED VOLUME	PRESERVATIVE
ICP Metals		500 mL (P)	HNO ₃ to pH<2
Arsenic	separately or in any combination	500 mL (P)	HNO ₃ to pH<2
Lead		500 mL (P)	HNO ₃ to pH<2
Selenium		500 mL (P)	HNO ₃ to pH<2
Thallium		500 mL (P)	HNO ₃ to pH<2
Mercury		125 mL (P)	HNO ₃ to pH<2
Nitrate (preserved)		125 mL (P)	H ₂ SO ₄ to pH<2
Nitrite (preserved)		125 mL (P)	H ₂ SO ₄ to pH<2
Phosphate (preserved)		125 mL (P)	H ₂ SO ₄ to pH<2
Ammonium		500 mL (CG)	H ₂ SO ₄ to pH<2
Cyanide		1000 mL (P)	NaOH to pH>12
Sulfide		500 mL (P)	NaOH/ZnAc to pH>10
Volatile Organics GC	3 X 40 mL (GA/S)	No headspace	HCL to pH<2
Volatile Organics, GC Mass Spec.	3 X 40 mL (GA/S)	No headspace	HCL to pH<2
Total Organic Carbon	2 X 40 mL (GA/S)	No headspace	H ₂ SO ₄ to pH<2
Total Organic Halides	2 X 250 mL (GA/S)	No headspace	H ₂ SO ₄ to pH<2
Total Organic Carbon (quads)	4 X 2 X 40 mL (GA/S)	No headspace	H ₂ SO ₄ to pH<2
Total Organic Halides (quads)	4 X 2 X 250 mL (GA/S)	No headspace	H ₂ SO ₄ to pH<2
(for quad orders, times 4 = 8)			
Alkalinity		250 mL (P)	No Preservative
Conductivity		250 mL (P)	No Preservative
pH		250 mL (P)	No Preservative
Turbidity		250 mL (GA)	No Preservative
Total Dissolved Solids		500 mL (P)	No Preservative
Pesticides and/or PCB	2 X 1000 mL (GA)		No Preservative
Chlorinated Herbicides	2 X 1000 mL (GA)		No Preservative
Phosphorous Pesticides	2 X 1000 mL (GA)		No Preservative
Phenol		1000 mL (GA)	No Preservative
Hydrazine	2 X 250 mL (GA)		2.5mL HCL/Bottle
Semi-Volatile	2 X 1000 mL (GA)		No Preservative
Dioxin	2 X 1000 mL (GA)		No Preservative
Total Carbon	2 X 40 mL (GA/S)	No headspace	No Preservative
Chloride		125 mL (P)	No Preservative
Bromide		125 mL (P)	No Preservative
Fluoride		125 mL (P)	No Preservative
Anions		125 mL (P)	No Preservative
Coliform (membrane filter)		120 mL (P)	Sterile
Coliform (multiple tube ferm.)		120 mL (P)	Sterile
Alpha		1000 mL (P)	HNO ₃ to pH<2
Beta		1000 mL (P)	HNO ₃ to pH<2
Radium		1000 mL (P)	HNO ₃ to pH<2
Uranium		125 mL (P)	HNO ₃ to pH<2
Gamma		1000 mL (P)	HNO ₃ to pH<2
Tritium		125 mL (P)	No Preservative
Technetium		1000 mL (P)	HNO ₃ to pH<2
Iodine 129		4000 mL (P)	No Preservative
Plutonium		1000 mL (P)	HNO ₃ to pH<2
Americium		1000 mL (P)	HNO ₃ to pH<2
Promethium		1000 mL (P)	HNO ₃ to pH<2
Strontium		1000 mL (P)	HNO ₃ to pH<2

P = Poly
 GA = Glass Amber
 CG = Clear Glass
 GA/S = Glass Amber with Septum Cap

EXCEPTIONS: When more than one analysis can be performed from a single container or where special requirements are necessary for alternate laboratories.

4.5 Sample Set Packaging

Position Responsible: SAMPLING AND ANALYSIS MANAGEMENT TASK LEADER/
SAMPLING AND ANALYSIS COORDINATION TASK LEADER

1. Generate the labels for constituent sampling from the appropriate scheduling paperwork.

Position Responsible: SAMPLE AND ANALYSIS COORDINATION TASK LEADER

1. From information on the labels, select the bottles from the appropriate cases of prepared sample bottles.
2. Apply waterproof labels (i.e., Tyvek) to the correct size and type (i.e., clear, amber, septum top) of bottle. If non-waterproof labels are used in place of the waterproof labels, apply clear waterproof tape smoothly over the entire label.
3. Twist the cap to check for tightness.
4. Compare bottle count to the number of sample bottles listed on the Field Record Form. Bottle counts that do not match are compared to the Chain-of-Custody Form and the discrepancy is corrected per the SAO.
5. If filtered samples are required, add a filter (QED Sample Pro Model 8000, 8100, 8200, or equivalent) to the sample set container (see Procedure GC-2, "In-Line Sample Filtration Procedure").
6. Place all documentation in a 1-gal resealable storage bag (include any documents for alternate laboratory). Place documents in the bag so the upper portion of the Field Record Form with the well number is visible to the RPT. Seal the documentation bag.
7. Before sealing the containers of sample sets, verify bottles, analysis requested, well number, and preservative to determine if the set of documents (Chain-of-Custody, SAO, Field Record Form) shows identical information for that well. Any errors identified on the labels or documents should be corrected before well set is completed.
8. Seal the verified container of sample sets with masking tape. Tape the documentation bag to the top of the container. Add security tape over the completed sample set container.
9. Write in large letters and numbers, with permanent marking pen, the well number on the top of the container.
10. If the sample set is small enough, place the sample bottles in a plastic bag. Seal the documents in a 1-gal resealable storage bag (as above). Combine the sample bottles and the documentation in

the first plastic bag, making sure the well number is visible to the RPT. Write the well number on the outer plastic bag with permanent marking pen, and add security tape over the masking tape seal on the bag.

11. File the Project Log.

12. Take sample sets to Staging Area when ready for collection.

4.6 Coordination with Sample Collection

Position Responsible: SAMPLING AND ANALYSIS COORDINATION TASK LEADER

1. Notify Sample Collection RPT Supervisor via electronic mail of the list of wells ready for sample collection.

Position Responsible: RADIATION PROTECTION TECHNOLOGIST SUPERVISOR/
RADIATION PROTECTION TECHNOLOGIST

1. When the RPTs pick up a sample set from the Staging Area, if it is found that the security seal on the documentation, plastic bag, or container is broken, return the entire package to the Sample Preparation Laboratory (Sigma 5, Room 1419).
2. A well set returned to the Sample Preparation Laboratory for reasons stated in Item 1 above will have the offending security seal placed if it was omitted; if it is broken, a replacement container(s) will be placed in the well set.

4.7 Samples Unable to be Collected from Wells

Position Responsible: RADIATION PROTECTION TECHNOLOGIST

1. Return uncollected sample sets to the designated area in the Sample Preparation Laboratory. All unused documentation is to be returned with the uncollected sample set.
2. Record the following information in the designated area on the non-sampled returned wells in the log record in Sample Preparation Laboratory: date, well number, RPT initials, reason not sampled.

Position Responsible: SAMPLING AND ANALYSIS COORDINATION TASK LEADER

1. Notify the Sampling and Analysis Management Task Leader by DSI of any wells unable to be sampled. Copies of this DSI shall be sent to the Project Manager and maintained in an "Unsampled Well" file. The file will be reviewed by the Sample and Analysis Management Task Leader monthly.
2. Record the date, the reason for the sample not being collected, and the staff member's initials on all documents.

3. Return the following paperwork for wells with no samples collected:
 - a. Field Record Form to designated page in Field Record notebook.
 - b. Original Chain-of-Custody Form and accompanying SAO to Sampling and Analysis Management Task Leader and a copy to the file.

NOTE: Chain-of-Custody Log, HEIS Log, and Project Log will have "noncollectible" entered for those assigned well numbers.

4. If the conditions/reasons for which a well is unable to be sampled are changed so that the well can be sampled, the Sampling and Analysis Management Task Leader will re-enter the well number into the sample collection schedule and sampling is resumed. However, if an uncollectible well status has not changed within 90 days from the time the well set was returned to the laboratory, the uncollected well set will be broken down; the documents will be voided; bottles re-cycled or disposed of according to waste compliance. A subsequent sample collection from such a well shall have new documents and a new sample set prepared.

FA-1 TEMPERATURE MEASUREMENT PROCEDURE

1.0 APPLICABILITY

This procedure is to be used during routine ground-water sampling, where temperature measurements are made during well purging and just before actual sample collection. Samples may not be collected until the temperature of the sample stream has stabilized; that is, two consecutive readings must agree within $\pm 1.0^{\circ}\text{C}$. A minimum of three measurements must be made during well purging.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Radiation Protection Technologists.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- Calibrated electronic digital thermometer
- Field Record Form.

NOTE: Before leaving for the field, ensure that the electronic thermometer reads within 1° Centigrade of the NBS calibrated thermometer in the laboratory. If not, adjust (if possible), or replace. Document this calibration check on the Digital Thermometer Calibration Check Log (Figure 1).

4.2 Step-by-Step Instructions

Position Responsible: RADIATION PROTECTION TECHNOLOGIST

1. Switch on the digital thermometer. Make sure that it is set to read in degrees centigrade.
2. Place the probe into the stream of water being discharged by the pump.
3. The temperature is indicated by a digital display, which will normally fluctuate for a few seconds. Wait until fluctuation ceases, then record the time and temperature on the Field Record Form (Figure 2).

Standard Mercury Thermometer Serial Number (S/N) _____

[illegible]

FIGURE 1. Digital Thermometer Calibration Check Log

BC-1500-113 (03,89)

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FA-2 CALIBRATION OF CONDUCTIVITY METER AND MEASUREMENT OF FIELD CONDUCTIVITY

1.0 APPLICABILITY

This procedure is to be used during routine ground-water sampling, where conductivity measurements are made during well purging and just before actual sample collection. Samples may not be collected until the conductivity of the sample stream has stabilized; that is, two consecutive measurements must agree within ± 10 percent. For wells equipped with pumps, a minimum of three measurements must be made during well purging. For wells being sampled by bailer, a single reading is sufficient, and the determination of stabilization will not be done.

The calibration of the instrument used to measure sample conductivity must be verified each day before leaving for the field to collect samples.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Radiation Protection Technologists.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- a field portable conductivity meter with the following specifications:
 - accuracy $\pm 5\%$ of full scale or better
 - resolution, by either digital or analog display, to 1% of full scale or less
 - inclusion of a dip sensor, a cup cell, or a flow-through cell
 - either manual or automatic temperature compensation
- distilled or deionized water

NOTE: Many suitable commercially available conductivity meters exist, and the manufacturer's catalog listing of specifications is acceptable evidence that a given instrument meets the above specifications.

- a standard solution of known conductivity for conductivity meter calibration. For Hanford surface and ground water, a standard solution having a conductivity of from 500 to 1000 $\mu\text{S}/\text{cm}$ is most suitable. The solution must meet the following requirements:
 - The nominal conductance of the solution must be clearly noted on the label of the solution bottle.
 - The temperature dependence of the solution must be clearly noted on the label.
 - The accuracy of the solution must be noted on the label, and the tolerance must be no greater than $\pm 1\%$ relative error.

NOTE: Commercially prepared conductance standard solutions that meet the above requirements are acceptable for this procedure, and the manufacturer's label containing lot number and expiration date is accepted as certification of specifications. Laboratory prepared conductance standards are acceptable, if made using accepted procedures fully described in standard reference works. In this case, the label must also include reference to the procedure used to prepare the solution, the date of preparation, and the name of the preparer.

- if the meter does not include a temperature display readable to at least the nearest 0.5°C , a thermometer accurate to $\pm 1.0^\circ\text{C}$ is required. Any type of thermometer may be used, and the manufacturer's catalog listing of specifications is acceptable evidence of the required accuracy.
- training records for Radiation Protection Technologists who use this procedure must include certification that the user has received instruction in the operation, calibration, and routine care and maintenance of the specific instrument applied in the field measurement of conductivity
- the manufacturer's written instructions for the instrument(s) in use are to accompany and be considered part of this procedure
- Field Record Forms (Figure 1)
- Conductivity Meter Calibration Record (Figure 2).

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Calibration Check for Conductivity Meter

Calibration Std Lot # ----- USE CALIBRATION METHOD LISTED IN PROCEDURE FA-2

Calculated
Value

<u>Observed Value</u>	
AM	PM

Serial No.

Operator

Date _____

[illegible]

FIGURE 2. Conductivity Meter Calibration Record Form

4.2 General Instructions

Position Responsible: RADIATION PROTECTION TECHNOLOGISTS

Because there is a wide variety of commercially available conductivity meters (and thermometers) suitable for use in this procedure, it is not possible to provide detailed operating instructions. In each case, follow the manufacturer's instructions. It is particularly important to strictly observe the manufacturer's recommendations regarding care and storage of the sensing elements, battery charging (where applicable) or battery life, exact calibration procedure, and the environmental extremes under which the instrument is operable. In addition to the manufacturer's instructions, the following steps must be followed:

1. Calibrate the conductivity meter before it is used in the field to measure sample conductivity, and periodically thereafter. Follow the manufacturer's recommendation for the frequency of calibration, and use the calibration standard solution for conductivity described above. A calibration record will be maintained for each instrument and will be on file with the instrument custodian. Check the instrument calibration each day before leaving for the field, and record, sign, and date a log form showing the results. (This ensures that instruments subject to daily use are in operating condition.) If the calibration check shows greater than $\pm 5\%$ error with respect to the standard used, the instrument must be recalibrated.
2. After instrument calibration or calibration check, discard the used portion of the standard solution. Never return it to the solution bottle.

NOTE: Always replace cap to standard solution bottle when calibration is completed.

3. In the field, thoroughly rinse the cell or dip sensor with two portions of the actual sample, and then measure conductance on a third portion. Record the conductance as shown on the meter display, sample temperature, and any other required data on the Field Record Form. After measuring sample conductivity, rinse the probe or cell with distilled or deionized water.

FA-3 CALIBRATION OF pH METER AND MEASUREMENT OF FIELD pH

1.0 APPLICABILITY

Ground-water pH is measured during well purging and just before actual sample collection. Samples may not be collected until the pH of the sample stream has stabilized; that is, two consecutive measurements agree within 0.10 pH units. For wells equipped with pumps, a minimum of three measurements should be made during purging. For wells being sampled by bailer, a single reading is sufficient, and a determination of stabilization will not be done.

The instrument used to measure sample pH in the field must be calibrated each day before leaving for the field to collect samples.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Radiation Protection Technologists.

4.0 PROCEDURE

4.1 Prerequisites

- a field portable pH meter with the following specifications:
 - accuracy ± 0.1 pH unit or better
 - resolution, by either digital or analog display, to 0.01 pH unit or less
 - inclusion of dip electrodes, a cup cell, or a flow-through cell
 - either manual or automatic temperature compensation

NOTE: Many suitable commercially available pH meters exist, and the manufacturer's catalog listing of specifications is acceptable evidence that a given instrument meets the above requirements.

- distilled or deionized water
- standard buffer solutions for pH meter calibration. At least two solutions are required, usually with nominal pH values of 7 and 10. Buffer values of 7 and 10 bracket the normal pH of surface and ground water at the Hanford Site. Other values may be used so long as the sample pH is bracketed. It is best to choose buffers

whose values are near to the sample pH. The buffers must meet the following requirements:

- The temperature dependence of the solution must be clearly noted on the label of the solution bottle.
- The accuracy of the solution must be clearly noted on the label, and the tolerance must be no greater than ± 0.05 pH unit.
- Nominal value, lot number, and expiration date must be clearly noted on the label, and the solutions should be color-coded.

NOTE: Commercially prepared pH buffer solutions are almost always color-coded, with the labels printed in different colors for different nominal pH values, and the solutions tinted the same color as the respective labels. The colors used by different manufacturers are not necessarily the same. The use of color-coded solutions is urged as a convenience, but is not a strict requirement of this procedure.

NOTE: Commercially prepared buffer solutions that meet the above requirements for this prerequisite are acceptable for this procedure, and the manufacturer's label is accepted as certification of specifications. Laboratory prepared buffer solutions may also be used, if made using accepted procedures fully described in standard reference books. In this case, the label must also include reference to the procedure used to prepare the buffers, the date of preparation, and the name of the preparer.

- training records for Radiation Protection Technologists who use this procedure must include certification that the user has received instruction in the operation, calibration, and routine care and maintenance of the specific instrument(s) applied in the field measurement of pH
- the manufacturer's written instructions for the instrument should accompany the instrument into the field
- Field Record Forms (Figure 1)
- pH Meter Calibration Record (Figure 2).

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pH 7 Lot # ----- Calibration Check for pH Meter
pH 10 Lot # ----- USE CALIBRATION PROCEDURES LISTED IN PROCEDURE FA-3

[illegible]

FIGURE 2. pH Meter Calibration Record

4.2 General Instructions

Position Responsible: RADIATION PROTECTION TECHNOLOGISTS

Because there is a wide variety of commercially available pH meters (and thermometers) suitable for use in this procedure, it is not possible to provide detailed operating instructions. In each case, follow the manufacturer's instructions. It is particularly important to strictly observe the manufacturer's recommendations regarding care and storage of the sensing electrodes, battery charging (where applicable) or battery life, exact calibration procedures, and the environmental extremes under which the instrument is operable. In addition to the manufacturer's instruction, the following steps must be followed:

1. Calibrate the pH meter daily before leaving for the field, and log, date, and sign the results of calibration on the pH meter calibration record form (Figure 2).

NOTE: The principal reason for the above step is to ensure that the meter is in operational condition. Also, if this calibration step is performed using the same buffers used in the field, recalibration in the field may be avoided if meter drift is within the limits described below. Always replace cap to standard solution bottle when calibration is complete.

2. Before measuring sample pH in the field, check the meter calibration against both buffer solutions. If the results for both measurements are within 0.05 pH unit of the correct values for the buffers, the meter need not be recalibrated. If not, follow the manufacturer's instructions for meter calibration. It is extremely important to thoroughly rinse the electrodes or cell with distilled or deionized water between measurements of different solutions. This prevents cross-contamination. Never return used buffers to the bottle; discard them instead. Meter calibration must be rechecked upon arrival at each sampling site. Also, it is recommended, but not required, that the meter be fully recalibrated before each sample measurement.
3. Thoroughly rinse the electrode or cell with distilled or deionized water, then dip the electrode in (or fill the cell with) the sample solution. Record the pH (to the nearest 0.01 unit) on the Field Record Form. After measuring sample pH, rinse the electrode with distilled or deionized water.

FA-5 IN SITU SUBTERRANEAN DETERMINATION OF GAMMA EMITTERS BY HIGH-RESOLUTION GAMMA-RAY SPECTROMETRY

1.0 APPLICABILITY

This procedure applies to the in situ measurement of radionuclide concentrations in sediments by the measurement of the intensity of monochromatic photons emitted by those radionuclides. In addition, measurement of the intensity of bremsstrahlung from strontium-90 can be used to quantitatively determine its concentration in situ. Collimators can provide resolution of horizontal strata as thin as 1 cm or angular resolution as small as 0.1 steradian. The detection limit for strontium-90 in normal logging operations with this bremsstrahlung measurement technique is on the order of 10 pCi/g. This technology is also capable of simultaneously measuring the concentration of the six actinide isotopes uranium-235, uranium-238, neptunium-237, plutonium-239, plutonium-241, and americium-241 at levels as low as 10 nCi/g in less than 7 min. The measurement can be made, except for plutonium-241, in less than 15 sec in sediments not contaminated with gamma-emitting fission or activation products. Detection limits for fission/activation products vary from isotope to isotope depending on the energy and branching fraction of their gamma rays but are on the order of 1 pCi/g or less.

2.0 DEFINITIONS

- Bremsstrahlung - Photon radiation emitted when an electron or beta particle is accelerated in the electric field of a nucleus.
- Collimators - High-density radiation absorbers attached to a radiation detector in a manner such that they limit the solid angle through which the radiation can be incident on the detector.
- Data Acquisition System (DAS) - Any arrangement of electronic components capable of receiving and storing electronic signals from the detector; a state-of-the-art DAS would be composed of a small computer, advanced data collection and management system for signal conversion, appropriate pulse amplifying and shaping networks, and software capable of receiving and storing electronic pulses as a function of the energy of the gamma-ray deposited in the detector, data manipulation and reduction, storing header information showing date, time, location, operator, etc., and printing out all results both as hard copy and magnetic media.
- Verified - Standards: a standard that has been, or can be tested against, and shown to reproduce National Institute of Science & Technology and/or International Atomic Energy Agency standards.
Software: a computer code that has been tested and shown to correctly solve mathematical equations and/or perform data processing functions it was designed to perform.

3.0 RESPONSIBLE STAFF

- Project Manager
- Task Manager
- Field Personnel.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Personnel Qualification

Must understand the technical objectives of this procedure and the operation of the equipment. Must be capable of making judgments regarding such operational parameters as length of counting times, adequacy of data, interval spacing within a well, and use and configuration of collimators.

4.1.2 Equipment

- High-resolution intrinsic germanium diode gamma-ray spectrometer in a down-well configuration
- High-density collimators, such as tungsten or lead, for characterizing narrow strata or determining directional orientation of radiocontaminants
- Winch system for raising and lowering the spectrometer in the well
- Depth-measuring device (steel or fiberglass tape) with an accuracy of ± 0.25 in.
- Data acquisition system and peripheral electronics for signal processing
- Power supply - 110 v alternating current
- Radionuclide calibration sources traceable to nationally accepted standards
- Radionuclide control source suitable for monitoring consistency of spectrometer operation (i.e., europium-154).

4.1.3 Safety Precautions

- Germanium spectrometers are operated at liquid nitrogen temperatures (-196°C). Appropriate caution should be exercised when filling the cryostat. Spilling liquid nitrogen on clothing or flesh could result in severe frostbite.

- Winch equipment should be operated with due caution to avoid injuries frequently sustained while using high mechanical-advantage equipment.
- Care should be exercised in handling the heavy collimators to avoid pinching or crushing injuries.

4.2 Step-by-Step Instructions

4.2.1 Calibrating the Detector - General

- In general, it is only necessary to calibrate the spectrometer one time for each well or borehole configuration to be used (i.e., for each different well diameter, casing material, etc.).
- A sealed radioactive "control" source can be used to verify consistency of the spectrometer response from day to day.
- If any changes are made to the detector system that could affect the efficiency, such as physical changes in the germanium crystal or mounting hardware, recalibration is required.

4.2.1.1 Calibrating the Detector for Gamma-Emitting Radionuclides

1. Lower the detector into the calibration zone of a well or borehole with the same type of casing as the unknown wells to be logged, located in well-characterized sediments containing known concentrations of several gamma-ray emitting radionuclides such as the Natural Activities Calibration Facility operated by Pacific Northwest Laboratory (PNL) at the Hanford Site, Washington. Acquire a spectrum for a period of time sufficient to provide statistical accuracy equal to or better than the desired overall accuracy of the results. Because of Poisson statistics, involved in radiation counting, accuracy is directly related to the square-root of the number of counts in the region of interest.
2. Use a well-verified high-resolution gamma-ray spectrum deconvolution code, such as RAYGUN (Hensley et al. 1988), to integrate the photopeak intensities in the spectrum and to generate an efficiency curve as a function of energy based on the known source strength of each gamma ray. Maintain this efficiency function in the computer memory forever, and recall and apply it to the data every time a well with the same physical parameters is examined. Each well type will have its own unique efficiency curve.

4.2.1.2 Calibrating for Strontium-90

1. Acquire a background spectrum in a well or borehole of the same size and casing material as those to be logged in the field situation and located in the same sediments that are to be spiked with a known concentration of strontium-90 or in identical sediments

containing no strontium-90 if the calibration is to be done in a permanent strontium-90 calibration facility.

2. Acquire a spectrum in a well or borehole in a calibration facility containing a known concentration of strontium-90 such as the Natural Activities Calibration Facility operated by PNL (Brodzinski and Nielson 1980; Brodzinski and Hensley 1982).
3. Adjust both the background spectrum and the strontium-90 calibration spectrum to the same energy gain using a verified computer code such as GAINSHF (Arthur and Haggard 1989) and normalize them to the same counting time.
4. Subtract the gain shifted and normalized background spectrum from the strontium-90 calibration spectrum to obtain the resultant strontium-90 bremsstrahlung spectrum. This produces the strontium-90 efficiency factor based on the known strontium-90 source strength (Brodzinski and Nielson 1980; Brodzinski and Hensley 1982; Arthur and Haggard 1989).

4.2.1.3 Generating Standard Reference Library Spectra

1. Acquire background spectra as in section 4.2.1.2.
2. Acquire spectra in a well or borehole in a calibration facility containing a known concentration of a single radioisotope likely to be encountered in field logging operations, such as cobalt-60, ruthenium-106, cesium-134, cesium-137, europium-152, europium-154, and cerium-144.
3. Gainshift all spectra to the same energy calibration as in section 4.2.1.2, step 3.
4. Subtract the time-normalized background spectrum from each of the radioisotopic spectra to obtain a reference library of pure isotopic shape spectra. Maintain this library both on the data acquisition system hard disc and backup the system on floppy disc. All library spectra are to be labeled as the isotope they represent. Additional label information, such as date, time, operator and detector configuration, is presented in the resultant computer file and on the computer printout (Exhibit 1).

4.2.1.4 Documentation of Calibration Activities

All calibration functions are stored, manipulated, documented, and achieved in exactly the same manner as unknown well logging functions described in section 4.2.2 below.

4.2.2 Well Logging

4.2.2.1 Generic Logging Procedures

4.2.2.1.1 Equipment Verification

1. Ensure all equipment is properly connected and operational.
2. Record identification numbers of equipment/systems used in a laboratory record book or field data sheet, etc.
3. Place a plastic sheath around the detector. If the sheath becomes contaminated during logging of well or borehole remove carefully to prevent spread of contamination and discard properly. Replace with new sheath.
4. Acquire a test spectrum using the control source to verify correct operation of all systems.
5. Choose logging parameters to be used (i.e., collimators and spacing if any, logging intervals, and spectrum acquisition time) based on the data requirements defined in the statement of work.

4.2.2.1.2 Generic Logging Procedures

1. Insert configured spectrometer into well or borehole being sampled and lower to measured depth for first spectrum.
2. Acquire spectrum for predetermined time period and lower or raise the detector to the next depth.
3. Label each spectrum to be acquired with the number of the well or borehole and depth interval being sampled.
4. Continue acquiring and labeling spectra at each depth of interest.

4.2.2.2 Determining Background Spectrum

- Acquire a background spectrum in an uncontaminated zone of the well being logged or in a similarly configured well nearby but outside the contaminated zone.

4.2.3 Data Reduction

4.2.3.1 Gamma-Ray Emitting Radionuclides

1. Gainshift all spectra to precisely align the energy scale as in section 4.2.1.2, step 3.
2. Using a gamma-ray spectral deconvolution code, such as RAYGUN, and a photopeak search library containing the requisite data for all

radioisotopes likely to be encountered in the logging operation, determine the absolute concentration of all gamma-ray emitting radionuclides in surrounding sediments based on the measured photopeak intensities and the efficiency curve determined in section 4.2.1.1.

3. Before the data are entered into the data base or transmitted to the Project Manager, the Task Leader shall review, sign, and date the data after the review has been completed.

NOTE: Steps 1 and 2 above are generally part of the data acquisition software such that all gamma-emitting isotopic concentrations are standard output following each logging measurement. An example of the type of data output produced is provided as Exhibit 1. Although this particular example represents data obtained with a different system, the format and content are comparable. The first section contains all header information for each measurement, including operator and well or site information, depth, time, date, etc. The next section is an optional graphic representation of the data. The third section contains the data reduction steps, including documentation of all libraries, background, efficiency curves, etc., used in the analysis. A list of all identifiable photopeaks in the spectrum and their intensity is followed by an assignment of those peaks to the appropriate isotopes and quantification of each isotopic concentration. Next, an upper limit is determined for each isotope in the library that was not identified in the spectral data, followed by a list of all identified photopeaks not assigned to a library isotope. Finally, a summary listing of the concentrations of all isotopes in the library is given. All data are stored and manipulated on the hard disc of the data acquisition system. Backup is always provided by copying to floppy discs for archival storage. As much or as little of the hard copy as is desired can be obtained immediately or retrieved later.

4.2.3.2 Determining Strontium-90

1. After gain adjustment, as in section 4.2.1.2, multiply the background spectrum from section 4.2.2.2 by the ratio of live counting times. Subtract this background spectrum from each of the unknown spectra leaving only manmade radioisotope contributions.
2. Identify each radioisotope contributing to these spectra on the basis of its characteristic full energy photopeaks from the photopeak search library.
3. Call up the corresponding reference spectra from the computer library and normalize on the basis of photopeak intensity.

4. Subtract the identified spectra from the unknown spectra (Brodzinski and Nielson 1980; Brodzinski and Hensley 1982; Arthur and Haggard 1989). The residual unknown spectrum, after subtraction, represents only strontium-90 bremsstrahlung radiation.
5. Compare the residual spectrum to the reference strontium-90 spectrum from section 4.2.1.2 on the basis of intensity to determine the concentration of strontium-90 in the surrounding sediments (Brodzinski and Nielson 1980; Brodzinski and Hensley 1982). If no strontium-90 is present in the matrix, the residual spectrum should appear as a straight line with only a statistical fluctuation of data above and below zero.

5.0 REFERENCES

- Arthur, R. J., and D. L. Haggard. 1989. In-Situ Determination of Radionuclide Levels in Facilities to be Decommissioned Using the Allowable Residual Contamination Level Method. PNL-6974, Pacific Northwest Laboratory, Richland, Washington.
- Brodzinski, R. L. 1981. "In-Situ Subterranean Determination of Actinides by High Resolution Gamma-Ray Spectrometry." In Methods of Low-Level Counting and Spectrometry, Proceedings of a Symposium. IAEA-SM-252/18, International Atomic Energy Agency, Vienna.
- Brodzinski, R. L. 1982. "State-of-the-Art In Situ Determination of Transuranics." Am. Nucl. Soc. Trans. 41:234.
- Brodzinski, R. L., and H. L. Nielson. 1980. "A Well Logging Technique for the In Situ Determination of ⁹⁰Sr." Nucl. Instrm. Methods 173:299.
- Brodzinski, R. L., and W. K. Hensley. 1982. "Well Logging Instrumentation for the In Situ Determination ⁹⁰Sr, Tritium, and Transuranica." In Proceedings of the Fourth Annual Participants' Information Meeting DOE Low-Level Waste Management Program, p. 437. ORNL/NFW-82/18, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
- Hensley, W. K., E. A. Lepel, M. E. Yuly, and K. H. Abel. 1988. "Adaptation and Implementation of the RAYGUN Gamma-Ray Analysis Code on the IBM PC." J. Radioanal. Nucl. Chem. 124:481.
- Nielson, H. L., N. A. Wogman, and R. L. Brodzinski. 1977. "In Situ Subterranean Gamma-Ray Spectroscopy." Nucl. Instrm. Methods 143:385.

EXHIBIT 1.

Barrel: bkg empty drum TID#NONE
 Site: J24 bldg
 Gross Wt= 23.15 kg Files: \DATA\90121801. on 12/18/90

Value returned by magnetic position sensor: 6704 for barrel segment #01
 QUALITY CONTROL SUMMARY at 8: 6:27 on 12/18/90 using ADCAM file: \DATA\90121801.A
 Data for channels 0 --> 4096 Acquisition started at 8: 4: 0 on 18 DEC 90
 MCR # 0 SEG # 1 Real Time = 60.00 sec Live Time = 59.76 sec ==> Dead .07%
 Channel 239.= 238.38 keV Channel 338.= 338.42 keV From file: \DATA\90121801.CAL
 Calibration constants: A= -.8403 keV & B= 1.00313 keV/chan Cnt Rate= 9.03936 cps
 Data from 453.60 gm-NET BARREL: bkg empty drum TID#NONE
 Energy ranges from .14 keV to 4107.98 keV Counts start in 42 = 41.27 keV
 Max count in plot= 18. -- Max channel[47]= 5. -- Gross count= 342.
 Neutron counting time= 60.0 Neutron count= 3182. Rate= 53.033 cps

Value returned by magnetic position sensor: 9708 for barrel segment #02
 QUALITY CONTROL SUMMARY at 8: 7:34 on 12/18/90 using ADCAM file: \DATA\90121801.B
 Data for channels 0 --> 4096 Acquisition started at 8: 6: 0 on 18 DEC 90
 MCR # 0 SEG # 1 Real Time = 60.00 sec Live Time = 59.94 sec ==> Dead .10%
 Channel 239.= 238.38 keV Channel 338.= 338.42 keV From file: \DATA\90121801.CAL
 Calibration constants: A= -.8403 keV & B= 1.00313 keV/chan Cnt Rate= 9.62627 cps
 Data from 453.60 gm-NET BARREL: bkg empty drum TID#NONE
 Energy ranges from .14 keV to 4107.98 keV Counts start in 42 = 41.27 keV
 Max count in plot= 17. -- Max channel[48]= 5. -- Gross count= 577.
 Neutron counting time= 60.0 Neutron count= 2972. Rate= 49.533 cps

Value returned by magnetic position sensor: 12701 for barrel segment #03
 QUALITY CONTROL SUMMARY at 8: 9:20 on 12/18/90 using ADCAM file: \DATA\90121801.C
 Data for channels 0 --> 4096 Acquisition started at 8: 7: 0 on 18 DEC 90
 MCR # 0 SEG # 1 Real Time = 60.00 sec Live Time = 59.98 sec ==> Dead .03%
 Channel 239.= 238.38 keV Channel 338.= 338.42 keV From file: \DATA\90121801.CAL
 Calibration constants: A= -.8403 keV & B= 1.00313 keV/chan Cnt Rate= 9.89328 cps
 Data from 453.60 gm-NET BARREL: bkg empty drum TID#NONE
 Energy ranges from .14 keV to 4107.98 keV Counts start in 42 = 41.27 keV
 Max count in plot= 18. -- Max channel[71]= 6. -- Gross count= 591.
 Neutron counting time= 60.0 Neutron count= 2774. Rate= 46.233 cps

Value returned by magnetic position sensor: 13699 for barrel segment #04
 QUALITY CONTROL SUMMARY at 8:10:47 on 12/18/90 using ADCAM file: \DATA\90121801.D
 Data for channels 0 --> 4096 Acquisition started at 8: 9: 0 on 18 DEC 90
 MCR # 0 SEG # 1 Real Time = 60.00 sec Live Time = 59.96 sec ==> Dead .07%
 Channel 239.= 238.38 keV Channel 338.= 338.42 keV From file: \DATA\90121801.CAL
 Calibration constants: A= -.8403 keV & B= 1.00313 keV/chan Cnt Rate= 12.13811 cps
 Data from 453.60 gm-NET BARREL: bkg empty drum TID#NONE
 Energy ranges from .14 keV to 4107.98 keV Counts start in 42 = 41.27 keV
 Max count in plot= 23. -- Max channel[38]= 6. -- Gross count= 729.
 Neutron counting time= 60.0 Neutron count= 3124. Rate= 52.067 cps

Value returned by magnetic position sensor: 18697 for barrel segment #05
 QUALITY CONTROL SUMMARY at 8:12:14 on 12/18/90 using ADCAM file: \DATA\90121801.E
 Data for channels 0 --> 4096 Acquisition started at 8:10: 0 on 18 DEC 90
 MCR # 0 SEG # 1 Real Time = 60.00 sec Live Time = 59.96 sec ==> Dead .07%
 Channel 239.= 238.38 keV Channel 338.= 338.42 keV From file: \DATA\90121801.CAL
 Calibration constants: A= -.8403 keV & B= 1.00313 keV/chan Cnt Rate= 8.57225 cps
 Data from 453.60 gm-NET BARREL: bkg empty drum TID#NONE
 Energy ranges from .14 keV to 4107.98 keV Counts start in 42 = 41.27 keV
 Max count in plot= 17. -- Max channel[32]= 6. -- Gross count= 302.
 Neutron counting time= 60.0 Neutron count= 2737. Rate= 45.617 cps

Value returned by magnetic position sensor: 21699 for barrel segment #06
 QUALITY CONTROL SUMMARY at 8:13:40 on 12/18/90 using ADCAM file: \DATA\90121801.F

EXHIBIT 1. (contd)

Channel 237.= 238.38 keV Channel 338.= 338.42 keV From file: \DATA\90121801.CAL
Calibration constants: A = -.8603 keV & B = 1.00313 keV/chan Cnt Rate = 7.20721 cps
Data from 433.60 gm-NET BARREL: bkg empty drum TID#NONE
Energy ranges from .14 keV to 4107.98 keV Counts start in 41 = 40.27 keV
Max count in plot = 16. -- Max channel[171] = 5. -- Gross count = 432.
Neutron counting time = 60.0 Neutron count = 2833. Rate = 47.217 cps

Value returned by magnetic position sensor: 24678 for barrel segment #07
QUALITY CONTROL SUMMARY at 8:15: 7 on 12/18/90 using ADCAM file: \DATA\90121801.G
Data for channels 0 --> 4096 Acquisition started at 8:15: 0 on 18 DEC 90
MCR # 0 SEG # 1 Real Time = 60.00 sec Live Time = 59.78 sec ==> Dead .03%
Channel 237.= 238.38 keV Channel 338.= 338.42 keV From file: \DATA\90121801.CAL
Calibration constants: A = -.8603 keV & B = 1.00313 keV/chan Cnt Rate = 8.59619 cps
Data from 433.60 gm-NET BARREL: bkg empty drum TID#NONE
Energy ranges from .14 keV to 4107.98 keV Counts start in 41 = 40.27 keV
Max count in plot = 16. -- Max channel[140] = 6. -- Gross count = 313.
Neutron counting time = 60.0 Neutron count = 2862. Rate = 47.700 cps

Value returned by magnetic position sensor: 27701 for barrel segment #08
QUALITY CONTROL SUMMARY at 8:16:33 on 12/18/90 using ADCAM file: \DATA\90121801.H
Data for channels 0 --> 4096 Acquisition started at 8:16: 0 on 18 DEC 90
MCR # 0 SEG # 1 Real Time = 60.00 sec Live Time = 59.96 sec ==> Dead .07%
Channel 237.= 238.38 keV Channel 338.= 338.42 keV From file: \DATA\90121801.CAL
Calibration constants: A = -.8603 keV & B = 1.00313 keV/chan Cnt Rate = 8.13876 cps
Data from 433.60 gm-NET BARREL: bkg empty drum TID#NONE
Energy ranges from .14 keV to 4107.98 keV Counts start in 44 = 43.28 keV
Max count in plot = 13. -- Max channel[88] = 6. -- Gross count = 488.
Neutron counting time = 60.0 Neutron count = 2726. Rate = 45.433 cps

Value returned by magnetic position sensor: 30701 for barrel segment #09
QUALITY CONTROL SUMMARY at 8:18: 0 on 12/18/90 using ADCAM file: \DATA\90121801.I
Data for channels 0 --> 4096 Acquisition started at 8:16: 0 on 18 DEC 90
MCR # 0 SEG # 1 Real Time = 60.00 sec Live Time = 59.96 sec ==> Dead .07%
Channel 237.= 238.38 keV Channel 338.= 338.42 keV From file: \DATA\90121801.CAL
Calibration constants: A = -.8603 keV & B = 1.00313 keV/chan Cnt Rate = 9.25617 cps
Data from 433.60 gm-NET BARREL: bkg empty drum TID#NONE
Energy ranges from .14 keV to 4107.98 keV Counts start in 41 = 40.27 keV
Max count in plot = 23. -- Max channel[128] = 7. -- Gross count = 333.
Neutron counting time = 60.0 Neutron count = 2760. Rate = 46.000 cps

Value returned by magnetic position sensor: 33703 for barrel segment #10
QUALITY CONTROL SUMMARY at 8:19:20 on 12/18/90 using ADCAM file: \DATA\90121801.J
Data for channels 0 --> 4096 Acquisition started at 8:17: 0 on 18 DEC 90
MCR # 0 SEG # 1 Real Time = 60.00 sec Live Time = 59.96 sec ==> Dead .07%
Channel 237.= 238.38 keV Channel 338.= 338.42 keV From file: \DATA\90121801.CAL
Calibration constants: A = -.8603 keV & B = 1.00313 keV/chan Cnt Rate = 11.19079 cps
Data from 433.60 gm-NET BARREL: bkg empty drum TID#NONE
Energy ranges from .14 keV to 4107.98 keV Counts start in 41 = 40.27 keV
Max count in plot = 22. -- Max channel[36] = 3. -- Gross count = 671.
Neutron counting time = 60.0 Neutron count = 3242. Rate = 54.033 cps

Value returned by magnetic position sensor: 35697 for barrel segment #11
QUALITY CONTROL SUMMARY at 8:23: 3 on 12/18/90 using ADCAM file: \DATA\90121801.K
Data for channels 0 --> 4096 Acquisition started at 8:19: 0 on 18 DEC 90
MCR # 0 SEG # 1 Real Time = 60.00 sec Live Time = 59.96 sec ==> Dead .07%
Channel 237.= 238.38 keV Channel 338.= 338.42 keV From file: \DATA\90121801.CAL
Calibration constants: A = -.8603 keV & B = 1.00313 keV/chan Cnt Rate = 9.20614 cps
Data from 433.60 gm-NET BARREL: bkg empty drum TID#NONE
Energy ranges from .14 keV to 4107.98 keV Counts start in 41 = 40.27 keV
Max count in plot = 17. -- Max channel[97] = 7. -- Gross count = 332.
Neutron counting time = 60.0 Neutron count = 3283. Rate = 54.717 cps

EXHIBIT 1. (contd)

QUALITY CONTROL PLOT plotted at 8:23:16 on 12/18/70 using ADCAM file: \DATA\70121801.
 Data for channels 0 -> 4096 Acquisition started at 8: 4: 0 on 18 DEC 90
 MCR # 0 SEG # 1 Real Time = 660.00 sec Live Time = 639.36 sec ==> Dead .07%
 Channel 239. = 238.58 keV Channel 338. = 338.42 keV From file: \DATA\70121801.CAL
 Calibration constants: A = -.8603 keV & B = 1.00313 keV/chan Cnt Rate = 9.33046 cps
 Data from 433.60 gm-NET BARREL: bkg empty drum TIDNNONE

8 Expanded Peaks

LINEAR PLOT OF data

Energy ranges from .14 keV to 4107.79 keV Counts start in 41 = 40.27 keV
 Max count in plot = 137. -- Max channel[129] = 29. -- Gross count = 6154.
 Neutron counting time = 660.0 Neutron count = 32493. Rate = 49.233 cps

EXHIBIT 1. (contd)

1 Raygun - Portable Version 10-Jan-90

(18-Dec-1990 8:23:27)

Analysis performed by: jdf *[signature]*

Sample: BARREL: bkg empty drum
Weight: 453.60000 gm-NET

TIDHNAME

Count date: 18-Dec-1990 at 8:04:00

Count times: REAL TIME 11.00m (660.00000 seconds)
LIVE TIME 10.98m (659.00000 seconds)

Dea time: .15 percent

Detector: SGS pos H 1 Geometry Factor: 1.000

Efficiencies and shape parameters from file: \DATA\90121801.SGS

Flux normalization factor (1.00E+00) from spectrum header

Spectrum from file : \DATA\90121801.&

Energy calibrations from file: \RDY\CALPK.SGS

Not enough counts in the peak @ 1460.83

K < 2 or Energy range < 300

ECAL aborting

Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gamma /sec	Err % SD	System bkqd
1	1462.5 1459. 1464.	28.	25.	1461.16	4.318E+03	22.5	0.

++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (cans/sec).

WL-1 WATER-LEVEL MEASUREMENT PROCEDURE

1.0 APPLICABILITY

Water-level measurements are taken to determine piezometric head in the aquifer or to determine water-level changes during aquifer testing. Both radiation protection technicians and technical staff perform such measurements. Depth-to-water from the top of the well casing is measured with a steel tape or an electrical water-level indicator. Depth-to-water is subtracted from the surveyed elevation of the top of the well casing to obtain the elevation of the water table.

Graduated steel measuring tapes are more accurate than electrical water-level indicators and so should be used when accurate measurements are required. An electrical water-level indicator can be used to determine the approximate depth-to-water and may be the preferred technique for measuring depth-to-water during periods of rapid water-level change (e.g., during aquifer testing), where cascading water is present, when the inside of the casing is wet, or when oil or similar liquid is present above the surface of the water.

2.0 DEFINITIONS

- Measuring point - the place from which the depth-to-water in a well is measured. It is a point, generally the top of the casing on the north side, which has a known elevation and from which a measuring device can hang freely into the well.

3.0 RESPONSIBLE STAFF

- Project Manager
- Radiation Protection Technologist (RPT)
- Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following equipment will be needed when measuring depth-to-water using a graduated steel tape:

- standardized steel measuring tape with attached stainless steel weight
- carpenter's chalk
- a record of previous water-level measurement in the well [e.g., from copy of Hanford Wells (PNL-5397)], if available

- Field Record Forms, Field Record Book, or Water Level Measurement Form
- towel
- wash bottle containing distilled or deionized water.

A wash bottle with distilled or deionized water is required to decontaminate the portion of the tape that penetrates into the water.

Store and transport steel tapes with care so that damage to the tapes is minimized and tapes are kept free of rust, dirt, and contamination.

The following equipment will be needed when measuring depth-to-water using an electrical water-level indicator:

- electrical water-level indicator
- engineer's measuring tape graduated in hundredths of a foot
- a record of previous water-level measurement in the well [e.g., copy of Hanford Wells (PNL-5397)], if available
- Field Record Forms, Field Record Book, or Water Level Measurement Form
- towel
- wash bottle containing distilled or deionized water.

A wash bottle with distilled or deionized water is required to decontaminate the portion of the tape that penetrates into the water.

Store and transport electrical water-level indicators with care so that damage to the instruments is minimized and the instruments are kept free of rust, dirt, and contamination.

The following safety equipment is required for measuring depth-to-water in wells:

- gloves
- steel-toed shoes
- hard hat when working near drilling or pump setting rigs.

4.1.2 Steel Tape Calibration Requirements

Steel tapes must be standardized before use by comparison with a calibrated steel tape as described in Procedure WL-2, "Procedure for Standardizing Steel Tapes." Verify that the tapes are within their standardization period before use. Standardization status tags (Figure 1) have been attached to the steel tape frame.

Steel Tape Standardization
Last Standardization Date
Next Standardization Date
Standardization performed by
Deviation From Calibrated Tape

FIGURE 1. Steel Tape Standardization Status Tag

4.1.3 Safety Precautions

Select appropriate gloves (e.g., viton, nitrile, or butyl rubber) based on contaminants expected in the well. If contaminants are not expected, leather gloves may be selected for protection.

Leather gloves shall be worn while making depth-to-water measurements with a steel tape, unless otherwise stated in the safety plan. Hard hats are to be worn when making measurements in the vicinity of a drilling or pump setting rig. Steel-toed shoes are to be worn at all times in the field.

4.2 Step-by-Step Instructions

4.2.1 Graduated Steel Tape Method

Position Responsible: RADIATION PROTECTION TECHNOLOGISTS OR
TECHNICAL STAFF

NOTE: If automatic long-term water-level recording equipment is in the well, do not take water-level measurements unless otherwise instructed by the Project Manager. Note this on the Water-Level Measurement Form or in a Field Record Book.

1. Record the

- date (1)
- name of the measuring device (e.g., Lufkin 500-foot steel tape) (2)
- serial number of steel tape (3)
- name of the person taking the measurements and number of the procedure followed (4)
- well number (5)

in the designated space on the Water Level Measurement Form (Figure 2) or in a Field Record Book.

2. Find the elevation of the measuring point and the estimated water level in Hanford Wells (or equivalent), or use an electric tape to find the approximate depth to water.
3. Chalk the 1-foot section of steel tape that is graduated in tenths or hundredths of a foot.
4. Lower the steel tape from the well's measuring point (marked with paint or stamped with an "X" on the top of the casing) to the estimated water level. To avoid splashing at the water surface, lower the tape slowly into the water.
5. Once the estimated water level has been reached, hold the nearest foot mark (held value) against the measuring point on the casing, and without allowing the tape to move any farther into the well, remove the tape from the well.
6. If the water level can be observed on the chalked portion of the tape, read the distance between the zero mark on the tape and the wet line (cut value) to the nearest 0.01 foot. If none of the chalked portion is wet, repeat the procedure, but allow more of the tape to go down the well (i.e., use a greater hold value).

If all of the chalked portion of the tape is wet, dry the tape, rechalk it and repeat the procedure allowing less tape to go down the well (i.e., use a lesser hold value).

Continue adjusting the length of the tape suspended in the well until the water level can be observed on the chalked portion of the tape.

[illegible]

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7. Record the

- held value (6)
- cut value to the nearest 0.01 foot (7)
- time of measurement (8)
- any deviations from the procedure, anomalies, or comments

in the designated space on the Water Level Measurement Form (Figure 2) or in a Field Record book.

8. Calculate and record the depth-to-water on the Water Level Measurement Form.

When using a steel tape with the section marked in tenths or hundredths of a foot between zero and 1 foot on the tape, subtract the wetted portion of the tape (cut value) from the held value.

When using a steel tape with the section marked in tenths or hundredths of a foot below the zero mark on the tape, add the dry length of the graduated foot (cut value) to the held value.

9. Dry the wetted portion of the tape with a towel and repeat the procedure until two depth-to-water measurements agree within 0.02 foot. If two measurements within 0.02 foot cannot be obtained, record the suspected problem on the Field Record Form or Field Record Book.

NOTE: The requirement to obtain a second water level may be waived by the project manager during aquifer testing because the water level in the well may be changing so rapidly that it is not possible to obtain successive measurements within 0.02 foot of each other.

10. When all measurements in a single well are completed, rinse the wetted portion of the tape with distilled or deionized water.

11. Dry the wetted portion of the tape with a towel to prepare it for the next measurement and prevent the tape from rusting. This is required whether the tape has been rinsed or not.

4.2.2 Electrical Water-Level Indicator Method

Position Responsible: RADIATION PROTECTION TECHNOLOGISTS OR TECHNICAL STAFF

Electrical water-level indicators consist of an insulated wire 100 to 1000 feet in length that is graduated in standard increments. A probe, which is attached to the end of the wire, is lowered into the borehole. On contact with the water, the electrical circuit is closed as signaled by an indicator (light or buzzer) at the surface.

NOTE: If automatic long-term water-level recording equipment is in the well, do not take water-level measurements, unless otherwise instructed by the Project Manager. Note this on the Water-Level Measurement Form or in a Field Record Book.

1. Record the

- date (1)
- name of the measuring device (e.g., brand and model of water-level indicator) (2)
- serial number of electrical water-level indicator (3)
- name of the person taking the measurements and number of the procedure followed (4)
- well number (5)

in the designated space on the Water Level Measurement Form (Figure 2) or in a Field Record Book.

2. Turn on the indicator and turn the sensitivity switch to full sensitivity.
3. Push the test button (if the instrument has one) to see if the battery is charged and the buzzer and light are working.

NOTE: An operational check of the indicator can be performed by dipping the probe in a container of water. Indicator light or buzzer should come on.

4. Lower the probe from the measuring point into the well or borehole until the buzzer or the light indicates contact with the water.
5. Mark the wire at the location adjacent to the measuring point.
6. Measure to the nearest 0.01 foot the distance between the mark (cut value) and the nearest graduation mark (held value) on the wire using a measuring tape that is scaled to hundredths of a foot.

7. Record the

- held value (6)
- cut value to the nearest 0.01 foot (7)
- time of measurement (8)
- any deviations from the procedure, anomalies, or comments in the designated space on the Water Level Measurement Form (Figure 2) or in a Field Record Book.

8. Calculate and record the depth-to-water on the Water Level Measurement Form (9), or in a Field Record Book.

If the water level is deeper than the nearest graduation marked on the tape, add the cut value to the held value to obtain the depth to water.

If the water level is shallower than the nearest graduation marked on the tape, subtract the cut value from the held value to obtain the depth to water.

9. Repeat the procedure until two depth-to-water measurements agree within 0.02 foot. If two measurements within 0.02 foot cannot be obtained, record the suspected problem on the Field Record Form or in a Field Record Book.

NOTE: The requirement to obtain a second water level may be waived by the project manager during aquifer testing because the water level in the well may be changing so rapidly that it is not possible to obtain successive measurements within 0.02 foot of each other.

10. When the probe is removed from the well, rinse the probe and the wetted portion of the wire with distilled or deionized water.
11. Dry the probe and the wetted portion of the wire with a towel. This is required whether the tape has been rinsed or not.

4.3 Computations

Position Responsible: RADIATION PROTECTION TECHNOLOGISTS OR TECHNICAL STAFF

The water-level elevation in a well is obtained by subtracting the depth-to-water from the elevation of the measuring point:

Water level = measuring point elevation - depth-to-water

NOTE: Corrections for thermal expansion and tape stretch caused by the suspended weight of the tape and plumb weight are described by Garber and Koopman (1968). Errors resulting from these effects can become significant at high temperatures and for measured depths in excess of 1000 feet.

5.0 REFERENCES

This procedure was developed in accordance with the techniques described in:

- ASTM. 1988. "Standard Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)." D 4750-87, American Society for Testing and Materials, Philadelphia, Pennsylvania.
- EPA. 1986. Resource Conservation and Recovery Act (RCRA) Ground-Water Monitoring Technical Enforcement Guidance Document. National Technical Information Service, Springfield, Virginia.
- USGS. 1977. National Handbook of Recommended Methods for Water Data Acquisition. Office of Water Data Coordination, Reston, Virginia.

Other references used were:

- Garber, M. S., and F. C. Koopman. 1968. Methods of Measuring Water Levels in Deep Wells: U.S. Geological Survey TRWI, Book 8, Chap. A-1. U.S. Government Printing Office, Washington, D.C.
- PNL. 1988. Hanford Wells. PNL-5397, Pacific Northwest Laboratory, Richland, Washington.

WL-2 PROCEDURE FOR STANDARDIZING STEEL TAPES

1.0 APPLICABILITY

This procedure applies to the standardization of steel tapes used to measure water levels. Graduated steel tapes used to measure water levels in wells are compared to steel tapes that have been calibrated by the Hanford Engineering Development Laboratories (HEDL) standards laboratory. Graduated steel tapes cannot be adjusted for deviations from the standard length. Deviations between a calibrated tape and the HEDL laboratory standard and deviations between the calibrated tape and field tapes will be recorded so that field measurements can be corrected to a standard length if required.

2.0 DEFINITIONS

- Calibrated steel tape - a graduated steel tape whose accuracy has been determined by the HEDL standards laboratory and is used only to standardize field tapes.
- Standard steel tape - a graduated steel tape (field tape) that has been standardized against a calibrated steel tape and is used routinely to measure depth to water in a well.
- Field tape - a graduated steel tape that is used routinely to measure depth to water in a well.

3.0 RESPONSIBLE STAFF

- Technical Staff.

4.0 PROCEDURE

One 500-foot steel tape (calibrated steel tape) will be calibrated annually by the HEDL standards laboratory to ± 0.005 foot per 100-foot length of tape. This steel tape is marked "For Standardization Only" and will be used along with this procedure to standardize the steel tapes used in the field. Field tapes will be standardized before initial use and once every 6 months while they are in use.

The 300-foot and 500-foot graduated steel tapes to be used to routinely measure water levels in wells will be compared to a calibrated steel tape in well 699-32-62.

The 200-foot graduated steel tapes to be used to routinely measure water levels in wells will be compared to a calibrated steel tape in well 699-S8-19.

4.1 Prerequisites

4.1.1 Equipment

The following equipment will be needed:

- graduated steel measuring tape that has been calibrated by the HEDL standards laboratory (calibrated steel tape)
- field-use graduated steel tape
- electric water level indicator (optional)
- recent copy of Hanford Wells (PNL-5397)
- two stainless steel weights, of approximately equal weight, one to be attached to each steel tape
- carpenter's chalk
- Water Level Measurement Form
- towel
- wash bottle containing distilled or deionized water.

The following safety equipment is required for standardizing graduated steel tapes:

- leather gloves
- steel-toed shoes.

4.1.2 Safety Precautions

Leather gloves shall be worn while standardizing a steel tape. Steel-toed shoes are to be worn at all times in the field.

4.2 Step-by-Step Instructions

Position Responsible: TECHNICAL STAFF

1. Record the

- date
- calibrated steel tape identifier
- identifier of the steel tape being standardized
- name of the person taking the measurements
- well number

on a Water Level Measurement Form (Figure 1).

2. Attach weights of approximately 8 ounces to the end of the calibrated steel tape and the tape to be calibrated.
3. Find the elevation of the measuring point and the estimated water level in Hanford Wells (or equivalent) or use an electric tape to find the approximate depth to water.

Measured By _____

[illegible]

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4. Chalk the 1-foot section of the calibrated steel tape that is graduated in tenths or hundredths of a foot.
5. Lower the calibrated steel tape from the well's measuring point (marked with paint on the top of the casing) to the estimated water level. To avoid splashing at the water surface, lower the tape slowly into the water.
6. Once the estimated water level has been reached, hold the nearest foot mark (held value) against the measuring point on the casing, and without allowing the tape to move any farther into the well, remove the tape from the well.
7. If the water level can be observed on the chalked portion of the tape, read the distance between the zero mark on the tape and the wet line (cut value) to the nearest 0.01 foot. If none of the chalked portion is wet, repeat the procedure, but allow more of the tape to go down the well (i.e., use a greater held value).

If all of the chalked portion of the tape is wet, dry the tape, rechalk it, and repeat the procedure allowing less tape to go down the well (i.e., use a lesser held value).

Continue adjusting length of tape suspended in the well until the water level can be observed on the chalked portion of the tape.

8. Record the

- held value
- cut value to the nearest 0.01 foot
- time of measurement

on the Water Level Measurement Form (Figure 1).

9. Calculate and record the depth-to-water on the Water Level Measurement Form.

When using a steel tape with the section marked in tenths or hundredths of a foot between zero and 1 foot on the tape, subtract the wetted portion of the tape (cut value) from the held value.

When using a steel tape with the section marked in tenths or hundredths of a foot below the zero mark on the tape, add the dry length of the graduated foot (cut value) to the held value.

10. Dry the wetted portion of the tape and repeat the procedure until two depth-to-water measurements agree within 0.02 foot. If two

measurements within 0.02 foot cannot be obtained, record the suspected problem on the Water Level Measurement Form.

11. Repeat Steps 1 through 10 using the tape to be standardized (field tape).
12. Record the difference between the depth to water measured with the two tapes on the Water Level Measurement Form.
13. When all measurements are completed, rinse the wetted portion of each tape with distilled or deionized water.
14. Dry the wetted portion of each tape with a towel to prepare it for the next measurement and to prevent the tape from rusting.

4.3 Determination of Acceptability of Steel Tapes

Position Responsible: TECHNICAL STAFF

If the field tape deviates in length from the calibrated steel tape by less than 0.10 foot, attach a Standardization tag (Figure 2) to the tape, which indicates the date of standardization, name of the person performing the standardization, and the amount of deviation between the calibrated tape and the field tape. These tapes may be used for making water-level measurements. If the field tape deviates in length from the standard by more than 0.10 foot but less than 0.25 foot, attach a Standardization tag (Figure 2) to the tape. Put an "X" through the top portion of the Standardization tag, write "For Tagging Only" on the bottom of the tag, and sign the tag as shown in Figure 3.

If the field tape deviates in length from the standard tape by more than 0.25 foot, mark the tape "Not Standardized, For Indication Only." Activities for which "Indication Only" tapes can be used will be identified in sampling and analysis plans for projects where they can be used.

5.0 REFERENCES

This procedure was developed in accordance with the techniques described in

- ASTM. 1988. Annual Book of ASTM Standards. Volume 04.08, Standard D 4750-87, American Society for Testing and Materials, Philadelphia, Pennsylvania.
- EPA. 1986. Resource Conservation and Recovery Act (RCRA) Ground-Water Monitoring Technical Enforcement Guidance Document. OSWER 9950.1, U.S. Environmental Protection Agency, Washington, D.C.
- USGS. 1977. National Handbook of Recommended Methods for Water Data Acquisition. Office of Water Data Coordination, Reston, Virginia.

Steel Tape Standardization
Last Standardization Date
Next Standardization Date
Standardization performed by
Deviation From Calibrated Tape

FIGURE 2. Example of a Standardization Tag

Steel Tape Standardization
Last Standardization Date
Next Standardization Date
Standardization performed by
Deviation From Calibrated Tape <i>For Tagging Only</i>

FIGURE 3. Example of a Standardization Tag for Steel
Tapes to be Used for Tagging Only

Other references:

- PNL. 1988. Hanford Wells. PNL-5397, Pacific Northwest Laboratory, Richland, Washington.

WL-3 INSTALLATION, OPERATION, AND REMOVAL OF THE INSTRUMENTATION NORTHWEST DATA LOGGER AND PRESSURE TRANSDUCER WITH AN IBM COMPATIBLE TERMINAL DEVICE

1.0 APPLICABILITY

This procedure applies to personnel installing, operating, or removing Instrumentation Northwest data logging equipment for water-level monitoring. The data logger and pressure transducer are used to automatically measure and record pressure head at a point in a water column at discrete time intervals unattended. The equipment can be used to determine long-term piezometric head in an aquifer or surface water body or determine water-level changes during aquifer testing.

2.0 DEFINITIONS

- Data logger - a field computer that operates a transducer and records the measurements
- Transducer - an electro-mechanical device for measuring water pressure
- Breakout box - a unit that houses the connectors for the RS232C cable and provides a security check for communicating with the data loggers.

3.0 RESPONSIBLE STAFF

- Project Manager
- Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following equipment will be needed when monitoring water levels using an Instrumentation Northwest data logger:

- equipment outlined in Procedure WL-1 for measuring depth-to-water using a graduated standard steel tape and an electric water-level indicator
- Instrumentation Northwest Terra 8/D (downhole version) or Terra 8 data logger, each with a Yuasa 2x6 volt rechargeable battery
- Instrumentation Northwest operation and technical manual

- Instrumentation Northwest pressure transducer with attaching cable and coupling wound on a spool
- pressure transducer cable extensions with attached couplings wound on a spool
- break-out box
- 1 10-pin input to 3 6-pin output pigtail
- RS232C cable
- terminal device with a screen and a keyboard (e.g., portable laptop computer)
- Terrabasic program and data storage disks
- duct tape or clamping device to secure transducer cable
- Equipment Record Form (Figure 1)
- records of previous high and low water-level measurements
- wash bottle containing distilled or deionized water.

NOTE: A wash bottle with distilled or deionized water is required to decontaminate the pressure transducer and the portion of the cable that penetrates the water before installation and following removal of equipment.

NOTE: The 1 10-pin input to 3 6-pin output pigtail is only needed if the Terra 8/D data logger is used. A pigtail is needed for each Terra 8/D unit. The Terra 8 unit does not require a pigtail.

NOTE: The selected full range of the pressure transducer depends on the water-level change expected over the monitoring duration. The water-level change expected should be within the full scale output of the transducer.

4.1.2 Calibration

The pressure monitoring devices must be calibrated by comparison with a national standard. Calibration records shall be maintained by the equipment custodian.

The following equipment shall have calibration documentation that supports the stated requirements.

1. Submersible pressure transducers shall have calibration points of 0, 10%, 30%, 50%, 70%, 90%, and 100% of full-scale range and a

Equipment Record Form for the Installation and Removal of the
Instrumentation Northwest Data Loggers and Pressure Transducers

Initial Check:		
Purpose of Installation:		
Monitored Hydrologic Unit or Water Body:		
Date/Time of Installation:		Procedure Followed:
Data Logger Make/Model:		
Serial No.:	Number of Channels Used:	
Pressure Transducer Make/Model:	Full Scale Range:	Well No.:
	Serial No.:	Depth:
Pressure Transducer Make/Model:	Full Scale Range:	Well No.:
	Serial No.:	Depth:
Description of Data Logger Installation and Well Head Configuration:		
Comments:		
Equipment Installed By		
Date/Time of Equipment Removal:		
Decontamination Procedure (if required):		
Equipment Removed By		

FIGURE 1. Equipment Record Form

maximum point above 100% of full-scale range. The maximum point shall be 3 times the hysteresis (as specified by the manufacturer) above 100% of full-scale range. The calibration run shall increase from 0 to the maximum point, then decrease from the maximum point to 0. This run will be used to determine linearity and hysteresis.

2. The data loggers shall be calibrated at 0, 10%, 30%, 50%, 70%, 90%, and 100% of the full-scale transducer voltage output. These calibration points shall be run at an ambient room temperature of $22 \pm 5^{\circ}\text{C}$. The data logger and pressure transducer may be calibrated together as a dedicated unit or calibrated as separate units, depending on the data collection objective and how the equipment will be used. Three calibration runs shall be conducted for each instrument to determine repeatability.

The data loggers and pressure transducers must be calibrated every 12 months. If the duration of data collection exceeds 12 months, then monthly water-level measurements shall be collected using a standard steel tape during the data collection period. When data collection is completed, the data logger and pressure transducer shall be calibrated.

4.1.3 Safety Precautions

Handle the data logging equipment and terminal device with care, and keep the equipment free of dirt and contamination.

Cable extending from the transducer installation to the data recording equipment at the surface should be arranged to minimize the possibility of tripping. Excess cable should be reeled on a spool or coiled out of the way of the work area. Electrical cords and connections should be protected from vehicular traffic and other equipment and should be inspected and replaced before use if damaged. Electrical connections and recorders should be kept out of water.

The following safety equipment is required for installing or removing water-level monitoring equipment:

- gloves
- steel-toed shoes
- hard hat when working near drilling or pump setting rigs.

4.1.4 Training

Personnel responsible for installing, operating, and removing pressure measurement equipment at monitoring sites must be previously instructed in these matters by experienced staff members and must record the information in accordance with this procedure. Personnel must also be trained in operating the Instrumentation Northwest data loggers. In addition, it is required that personnel read the Instrumentation Northwest operations and technical manual and fully understand use of the equipment before actual field use. Occasionally,

it may be necessary to consult with the equipment manufacturer to obtain updated information regarding improvements to the operations and technical manual if there are problems with equipment operation.

4.2 Step-by-Step Instructions

Position Responsible: TECHNICAL STAFF

4.2.1 Initial Check

The initial check is used only as a guide to prevent potential problems in the field or if there is reason to believe the equipment may not work properly. However, it is strongly recommended that the equipment is tested in the lab before field use. Also, it is recommended that the program configuration is modified in the lab before field use.

Consult the Instrumentation Northwest operations and technical manual if necessary.

1. Check that the terminal device has good batteries or, if rechargeable, is fully charged.
2. Check the main 6x2 volt battery's voltage under a load (i.e., while the system is in "wake" mode).
3. Make sure the Terrabasic program runs free of errors with the program configuration that will be used during field data acquisition. It is recommended that the most updated program version be used.
4. Submerge the probe in a container of clean water to see if the sensor is operating correctly.
5. If the equipment checks show that all equipment is properly functioning, document this on the Equipment Record Form.

4.2.2 Installation

1. Measure and record the water level with a standard steel tape according to Procedure WL-1.
2. Rinse the pressure probe and the portion of the cable that penetrates the water with distilled or deionized water, and lower it to the desired depth. It should be placed below the lowest expected water level, but should not be allowed to exceed its full-scale range. The full-scale range in feet can be determined by multiplying the pressure range by 2.31. For example, 10 psi x 2.31 equals a range of approximately 23 feet.

NOTE: If the pressure transducer or cable extension coupling becomes "hung up" in the well as a result of an existing pump with a pipe column and wiring, do not pull on the cable excessively in an attempt to free the probe. Excessive pulling may strip the transducer from the cable. Contact the Project Manager to have other authorized personnel remove the pipe column to retrieve the transducer.

3. Secure the cable with duct tape or clamping device so that the probe will remain at the desired depth.

NOTE: The Terra 8/D or Terra 8 data logger should be protected from the elements and should not be immersed in water. Make sure that the unit is not positioned in such a manner that will attract a lightning strike. Furthermore, do not place the unit and connecting equipment near high-tension wires or cable carrying high voltage or high current.

The Terra 8 unit (downhole version) may be installed in a 4-in. or greater diameter well if sufficient space is available. If the diameter of the well is greater than 4 in., and the equipment is installed in the well, it is necessary to secure the unit to the wellhead.

4. Record the following on an Equipment Record Form, shown in Figure 1:

- purpose of installation
- well number
- monitored hydrologic unit or water body
- number of procedure followed
- make/model and serial number of data logger
- number of channels used
- make/model, serial number, and full scale range of pressure transducer
- depth of transducer
- name of person installing the equipment
- description of data logger installation and well head configuration
- comments.

NOTE: It is important to record on the Equipment Record Form other pertinent information in the "comments" section of the Equipment Record Form. This information includes the name of the Terrabasic program,

parameters used in the program configuration, and a record of data dumped throughout the duration of data acquisition. The time of data dump and the name of the data file shall be recorded when the data are dumped. The parameters used in the program configuration include the measurement time interval and number of logs per timestamp. Also record any problems encountered while installing or setting up the equipment.

If more than two channels are used, record the information on an additional Equipment Record Form.

4.2.3 Equipment Setup and Operation

The equipment should be configured as shown in Figure 2. For each step below, consult the Instrumentation Northwest operations and technical manual.

NOTE: Steps 7 and 8 are primarily for periodic data dumping during long-term data collection. These steps can be ignored during the initial setup and operation or if enough memory in the data logger is available for the ensuing data collection period.

1. Attach the RS232C cable from the terminal device to the RS232C connector on the breakout box.
2. Attach the 26-pin circular connector from the breakout box to the I/O port on the data logger unit.
3. Attach the transducer cable to the channel port on the Terra 8/D or Terra 8 units. The Terra 8/D requires a 1 10-pin input to 3 6-pin output pigtail.

FIGURE 2. Configuration of Equipment

4. Turn power on to the terminal device.
5. Get into terminal emulation mode.
6. Press the "wake" button on the breakout box. This will illuminate the LED on the breakout box.
7. Save any existing data by dumping it from the data logger to the data disk. Refer to the Instrumentation Northwest operations and technical manual for details on performing this step.
8. After all the data have been saved to disk, then clear the data from memory in the data logger by using the "reset" command. This will allow memory space for the next data collection period.

CAUTION: Use the "reset" command with great care. It destroys all previously collected data stored in the data logger memory. It is highly recommended that all the data saved on disk are loaded and viewed before clearing from the data logger memory. This will ensure that all data stored in the data logger memory have been saved to disk and can be accessed. Step 8 should never be performed without first performing Step 7.

9. Check and, if necessary, reset the time.
10. Make any necessary changes (which were not made during the initial check) to the program configuration and run the program. Correct any program errors.
11. Issue the command to begin data collection.
12. Check to make sure the instrument is operating properly. If the sample interval is greater than 5 seconds, then the LED light on the breakout box will turn off, indicating that the data logger has entered "sleep" mode. This will ensure that the instrument is operating properly. Also, if the program configuration was specified to log time and reading to the terminal screen as well as to memory, then the stored data can be viewed as acquired.

NOTE: If the sample interval is 5 seconds or less, then the data logger will not enter "sleep" mode and the LED will remain illuminated. In this case, the data logger is unable to log the time and reading to the terminal screen, even if it is specified to do so in the program configuration. There is no possible way of ensuring that the instrument is operating properly while collecting data this frequently.

13. Turn power off to computer.
14. Disconnect the RS232C cable from the terminal device.

15. Disconnect the 26-pin circular connector from the I/O port on the data logger unit.

The last two steps are not necessary when monitoring water levels during hydrologic testing until the test is completed, as long as the breakout box and terminal device are protected. The cables can be disconnected at the end of the test after all data have been collected.

4.2.4 Data Conversion

The data loggers apply a conversion of the form $y = mx + b$ to the voltage (ranges from 0 to 5 volts) that appears at the Analog/Digital converter, where m is the multiplier and b is the offset in the configuration section of the program. The conversion factor m depends on the full-scale range of the transducers and can be calculated as follows:

$$m = (\text{full-scale range in psi}) \times (2.31 \text{ ft/psi}) / 5 \text{ volts}$$

For example, m is 2.31 for a 0-5 psi transducer, 4.62 for a 0-10 psi transducer, and 6.93 for a 0-15 psi transducer. This yields hydraulic head in units of feet above the probe, assuming $b = 0$.

Once m has been entered into the program configuration, the offset, b , can be used to correct water levels to elevation and can be calculated as follows:

$b = \text{top of casing elevation} - \text{depth to water} - \text{transducer reading at } b = 0$
for installation in a well and

$b = \text{water surface elevation} - \text{transducer reading at } b = 0$
for installation in a surface water body.

The values for m and b will be recorded automatically on the data output.

4.2.5 Removal

1. Follow Steps 1 through 8 in Section 4.2.3 on equipment setup and operation.

NOTE: Steps 7 and 8 may be performed in the lab or office after all equipment has been removed.

2. Follow Steps 11 through 15 in Section 4.2.3.
3. Remove transducer. If the transducer is in a well with a pump and pipe column, remove the probe slowly to prevent it from being stripped from the cable if it becomes stuck.

4. If the pressure transducer and cable require decontamination, record the decontamination procedure used on the Equipment Record Form.
5. Record the following on the Equipment Record Form:
 - date and time the equipment was removed
 - decontamination procedure (if required)
 - name of person removing the equipment.
6. Measure and record the water level with a standard steel tape according to Procedure WL-1.

5.0 REFERENCES

- Terrascience Systems Ltd. "Operations and Technical Manual, Terra 8 Datalogger." Terrascience Systems Ltd., Vancouver, BC, Canada.
- Procedure WL-1, "Water-Level Measurement Procedure."

WL-4 INSTALLATION, OPERATION, AND REMOVAL OF A DATA LOGGER AND PRESSURE TRANSDUCER

1.0 APPLICABILITY

This procedure applies to the installation, operation, or removal of data logging equipment for water-level monitoring, except for Instrumentation Northwest (INW) Data Logger. INW data loggers are discussed in Procedure WL-3. A data logger and pressure transducer are used to automatically measure and record pressure head at a point in a water column at discrete time intervals unattended. The equipment can be used to determine long-term piezometric head in an aquifer or surface water body or determine water-level changes during aquifer testing.

2.0 DEFINITIONS

- Data logger - a field computer that operates a transducer and records the measurements
- Pressure transducer - an electro-mechanical device for measuring water pressure.

3.0 RESPONSIBLE STAFF

- Project Manager
- Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following equipment will be needed when monitoring water levels using a data logger:

- equipment outlined in Procedure WL-1 for measuring depth-to-water using a graduated standard steel tape and an electric water-level indicator
- data logger with appropriate power device
- data logger's operation and technical manual
- pressure transducer and attaching cable with coupling, if necessary, wound on a spool
- pressure transducer cable extensions, if necessary, with attached couplings wound on a spool
- cable connecting data logger to terminal device, if necessary

- terminal device with a screen and a keyboard (e.g., portable laptop computer), if necessary
- program and data storage disks, if necessary
- housing for protecting data logger from weather conditions, if necessary
- duct tape or clamping device to secure transducer cable
- Equipment Record Form (Figure 1)
- records of previous high and low water-level measurements
- wash bottle containing distilled or deionized water.

NOTE: A wash bottle with distilled or deionized water is required to decontaminate the pressure transducer and the portion of the cable that penetrates the water before installation and following removal of equipment.

NOTE: The selected full range of the pressure transducer depends on the water-level change expected over the monitoring duration. The water-level change expected should be within the full scale output of the transducer.

4.1.2 Calibration

Calibration of new or leased data loggers and transducers is not necessary provided that a calibration certification or calibration report is obtained from the manufacturer or lessor and it is approved by the Process Quality Department. The data loggers and pressure transducers must be calibrated every 12 months. If the duration of data collection exceeds 12 months, then monthly water-level measurements shall be collected using a standard steel tape during the data collection period. The pressure monitoring devices must be calibrated by comparison with a national standard. Calibration records shall be maintained by the equipment custodian.

The following equipment shall have calibration documentation that supports the stated requirements:

1. Submersible pressure transducers shall have, at a minimum, calibration points of 0, 10%, 30%, 50%, 70%, 90%, and 100% of full-scale range and a maximum point above 100% of full-scale range. The maximum point shall be three times the hysteresis (as specified by the manufacturer) above 100% of full-scale range. The calibration run shall increase from 0 to the maximum point,

Equipment Record Form for the Installation and Removal of Data Loggers
and Pressure Transducers

Initial Check:		
Purpose of Installation:		
Monitored Hydrologic Unit or Water Body:		
Date/Time of Installation:		Procedure Followed:
Data Logger Make/Model:		
Serial No.:	Number of Channels Used:	
Pressure Transducer Make/Model:	Full Scale Range:	Well No.:
	Serial No.:	Depth:
Pressure Transducer Make/Model:	Full Scale Range:	Well No.:
	Serial No.:	Depth:
Description of Data Logger Installation and Well Head Configuration:		
Comments:		
Equipment Installed By		
Date/Time of Equipment Removal:		
Decontamination Procedure (if required):		
Equipment Removed By		

FIGURE 1. Equipment Record Form

then decrease from the maximum point to 0. This run will be used to determine linearity and hysteresis.

2. The data loggers shall be calibrated, at a minimum, at 0, 10%, 30%, 50%, 70%, 90%, and 100% of the full-scale transducer voltage output. These calibration points shall be run at an ambient room temperature of $22 \pm 5^{\circ}\text{C}$. The data logger and pressure transducer may be calibrated together as a dedicated unit or calibrated as separate units, depending on the data collection objective and how the equipment will be used. Three calibration runs shall be conducted for each instrument to determine repeatability.

4.1.3 Safety Precautions

Handle the data logging equipment and terminal device with care, and keep the equipment free of dirt and contamination.

Arrange cable extending from the transducer installation to the data recording equipment at the surface to minimize the possibility of tripping. Reel excess cable on a spool or coil it out of the way of the work area. Protect electrical cords and connections from vehicular traffic and other equipment and inspect and replace them before use if damaged. Keep electrical connections and recorders out of water.

The following safety equipment is required for installing or removing water-level monitoring equipment:

- gloves
- steel-toed shoes
- hard hat when working near drilling or pump setting rigs.

4.1.4 Training

Personnel responsible for installing, operating, and removing pressure measurement equipment at monitoring sites must be previously instructed in these matters by experienced staff members and must record the information in accordance with this procedure. Personnel must also be trained in operating the data loggers. In addition, it is required that personnel read the operation and technical manual and fully understand use of the equipment before actual field use.

4.2 Step-by-Step Instructions

Position Responsible: TECHNICAL STAFF

4.2.1 Initial Check

The initial check is used only as a guide to prevent potential problems in the field or if there is reason to believe the equipment may not work properly. However, it is strongly recommended that the equipment be tested in the lab

before field use. If there are problems with equipment operation, it may be necessary to consult with the distributor or manufacturer.

Consult the operation and technical manual if necessary.

1. If necessary, check that the terminal device has good batteries or, if rechargeable, is fully charged.
2. If the system is powered by a battery, check the voltage under a load (i.e., while the system is on), if possible.
3. Check to make sure all cable connections fit together properly.
4. Make sure the program runs free of errors with the program configuration that will be used during field data acquisition. It is recommended that the most updated program version be used.
5. Submerge the probe in a container of clean water to see if the sensor is operating correctly.
6. If the equipment check shows that all equipment is functioning properly, document this on the Equipment Record Form by initial and date.

4.2.2 Installation

1. Measure and record the water level with a standard steel tape according to Procedure WL-1.
2. Lower the pressure probe to the desired depth. It should be placed below the lowest expected water level, but should not be allowed to exceed its full-scale range. The full-scale range in feet can be determined by multiplying the pressure range in psi by 2.31. For example, 10 psi x 2.31 equals a range of approximately 23 ft.

NOTE: If the pressure transducer or cable extension coupling becomes "hung up" in the well as a result of an existing pump with a pipe column and wiring, do not pull on the cable excessively in an attempt to free the probe. Excessive pulling may strip the transducer from the cable. Contact the Project Manager to have other authorized personnel remove the pipe column to retrieve the transducer.

3. Secure the cable with duct tape or a clamping device so that the probe will remain at the desired depth.

NOTE: The data logger should be protected from the elements and should not be immersed in water. Make sure that the unit is not positioned in such a manner that will attract a lightning

strike. Furthermore, do not place the unit and connecting equipment near high-tension wires or cable carrying high voltage or high current.

Some data loggers may be installed in a 4-in. or greater diameter well if sufficient space is available. In this case, it may be necessary to secure the unit to the wellhead.

4. Record the following on an Equipment Record Form, shown in Figure 1:

- date and time of installation
- purpose of installation
- well number
- monitored hydrologic unit or water body
- number and revision of procedure followed for installation
- make/model and serial number of data logger
- number of channels used
- make/model, serial number, and full scale range of pressure transducer
- depth of transducer
- name of person installing the equipment
- description of data logger installation and well head configuration
- comments.

NOTE: It is important to record on the Equipment Record Form other pertinent information in the "comments" section of the Equipment Record Form. This information includes the name of the program, parameters used in the program configuration, and a record of data dumped throughout the duration of data acquisition. The time of data dump and the name of the data file shall be recorded when the data are dumped. Also record any problems encountered while installing or setting up the equipment. If a detailed program is inputted to the data logger by hand, attach to the Equipment Record Form input parameters and their values.

If more than two channels are used, record the information on an additional Equipment Record Form.

4.2.3 Equipment Setup and Operation

Consult the data loggers operation and technical manual for setup and operation.

CAUTION: Most data loggers have a command that destroys all previously collected data stored in the data logger's memory. It is highly recommended that all the data be saved on disk and, if possible, are loaded and viewed before clearing from the data logger memory. This will ensure that all data stored in the data logger memory have been saved to disk and can be accessed.

NOTE: Stored data do not have to be dumped for the initial setup and operation or if enough memory in the data logger is available for the ensuing data collection period. Also, measure and record the water level with a standard steel tape according to Procedure WL-1 each time data are dumped during long-term data collection. In some cases it may not be possible to measure the water level in a well if the data logger is installed in the well head.

4.2.4 Data Conversion

For some data loggers, it may be necessary to apply a conversion of the form

$$y = mx + b$$

to the electronic output signal x , where m is the slope, b the y axis intercept, and y the converted transducer reading. Applying this conversion will allow data to be stored in feet from a referenced datum (e.g., mean sea level). The conversion factor m depends on the full scale range of the transducer. Consult the data logger's operation and technical manual to determine the value for m .

Once m has been determined, the intercept, b , can be used to correct water levels to elevation above mean sea level (MSL). This can be calculated as follows:

for installation in a well,

$$b = \text{transducer elevation} = \text{top of casing elevation} - \text{depth to water} - \text{height of water-level above transducer}$$

and, for installation in a surface water body,

$$b = \text{transducer elevation} = \text{water surface elevation} - \text{height of water level above transducer.}$$

Record the values for m and b on the Equipment Record Form.

4.2.5 Removal

Before removing the transducer, terminate data collection according to the method described in the data logger's operation and technical manual. Do not erase any stored data.

Disconnect equipment according to the method described in the operation and technical manual.

1. Remove transducer. If the transducer is in a well with a pump and pipe column, remove the probe slowly to prevent it from being stripped from the cable if it becomes stuck.
2. If the pressure transducer and cable require decontamination, record the decontamination procedure used on the Equipment Record Form.
3. Record the following on the Equipment Record Form:
 - date and time the equipment was removed
 - name of person removing the equipment.
4. Measure and record the water level with a standard steel tape according to Procedure WL-1.

NOTE: If the pressure transducer and cable are not decontaminated after removal or after returning to the laboratory, a marked tag must be attached to the probe to identify it for decontamination.

5.0 REFERENCES

- Procedure WL-1, "Water-Level Measurement Procedure."
- Procedure WL-3, "Installation, Operation, and Removal of the Instrumentation Northwest Data Logger and Pressure Transducer with an IBM Compatible Terminal Device."

WL-5 PROCEDURE TO DETERMINE THE PRECISION OF ELECTRICAL WATER-LEVEL INDICATORS

1.0 APPLICABILITY

This procedure applies to electrical water-level indicators that will be used to measure depth to water during hydrologic tests in which depth-to-water measurements will be made. The procedure will be followed before such tests are conducted. Depth-to-water measurements are made several times to verify that precision requirements of ± 0.04 foot are met. Standardization of electrical water-level indicators for accuracy is not included in this procedure.

2.0 DEFINITIONS

- Electrical water-level indicator - a device used to measure the depth-to-water surface in a well. A light and/or sound indicates when the water surface is contacted.
- Standard engineer's tape - a measuring tape graduated in feet, tenths of feet, and hundredths of feet.
- Precision - a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions.

3.0 RESPONSIBLE STAFF

- Project Hydrologist
- Well-Site Geologist
- Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following equipment will be needed when verifying electrical water-level indicators:

- electrical water-level indicator
- standard engineer's tape
- Aquifer Test Data sheet (Figure 1).

4.1.2 Safety Precautions

Follow the safety requirements identified in the Health and Safety Plan, if one exists, and refer to safety precautions identified within the appropriate Aquifer Testing (AT) procedures.

Duration of Aquifer Test _____

180

4.2 Step-By-Step Instructions

Position Responsible: PROJECT HYDROLOGIST, WELL-SITE GEOLOGIST, OR
TECHNICAL STAFF

NOTE: The electrical water-level indicator(s) to be used will be verified for precision by lowering the sensor into the well or wells before aquifer testing. The hydraulic head in the well must be in a static condition when the verification measurements are made. The verification measurements for a particular indicator should be made in the same well or wells in which measurements will be made with that indicator during testing.

1. Record the

- date and time
- name of person making measurements
- number of this procedure
- location and well number (or temporary well number)

on the Aquifer Test Data sheet.

2. Turn on the indicator and turn the sensitivity switch to full sensitivity.

3. Push the test button (if the instrument has one) to see if the battery is charged and the buzzer and light are working.

NOTE: An operational check of the indicator can be performed by dipping the probe in a container of water. The indicator light or buzzer should come on.

4. Lower the probe from the measuring point into the well or borehole until the buzzer or light indicates contact with the water. All measurements shall be made in a consistent manner.

5. Mark or hold the wire at the location adjacent to the measuring point (cut value).

6. Measure to the nearest 0.01 foot the distance between the mark (cut value) and the nearest permanent graduation mark (permanent marked value) on the wire using a standard engineer's tape.

7. Record the

- permanent marked value
- cut value to the nearest 0.01 foot
- time of measurement

on the Aquifer Test Data sheet.

8. Calculate and record the depth-to-water on the Aquifer Test Data sheet.

If the water level is deeper than the nearest graduation marked on the tape, add the cut value to the permanent marked value to obtain the depth-to-water.

If the water level is shallower than the nearest graduation marked on the tape, subtract the cut value from the permanent marked value to obtain the depth-to-water.

9. Repeat steps 6 through 8 five times, for a total of six measurements.

4.3 Determination of Acceptability of Electrical Water-Level Indicators

Position Responsible: PROJECT HYDROLOGIST, WELL-SITE GEOLOGIST, OR
TECHNICAL STAFF

If the difference between the smallest and greatest depth-to-water measurements agree within 0.04 foot, the electrical water-level indicator can be used to measure water levels during hydrologic testing. If they do not agree within 0.04 foot, the electrical water-level indicator cannot be used, and the procedure must be repeated until a water-level indicator is found that meets these precision requirements. Record the name and serial number of the electrical water-level indicator chosen for use (meeting the precision requirements) on the Aquifer Test Data sheet.

5.0 REFERENCES

- Procedure WL-1, "Water-Level Measurement Procedure."
- Procedure AT-4, "Well Development Before Hydrologic Testing."
- Procedure AT-5, "Constant Discharge Test."
- Procedure AT-6, "Aquifer Slug Injection and Withdrawal Test."

DO-1 COLLECTION AND DOCUMENTATION OF BOREHOLE SAMPLES AND WELL CONSTRUCTION DATA

1.0 APPLICABILITY

This procedure applies to work performed by well-site geologists monitoring well drilling and well construction activities. It provides standardized methods for the collection and documentation of borehole samples and well construction data. This procedure can be applied independent of the well drilling and construction methods used, but has been written specifically with cable tool methods in mind.

This procedure does not cover construction inspection activities performed by well-site geologists or special requirements needed for handling potentially contaminated borehole samples. These requirements are covered in Procedure DO-4, Contaminated Sediment Sampling.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Project Manager
- Well-Site Geologist(s)
- Senior Technical Reviewer.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- Geologist's Kit (Munsell Color Charts, Grain Size Charts, millimeter scale, hand lens, 10% HCl, etc.)
- sample labels (lithologic and chemical)
- permanent marker (Sharpie)
- sample containers
- plastic bags and moisture cans (for moisture samples)
- sealing tape
- 5-gallon bucket(s)
- applicable forms (Well Completion Summary Report, As-Built Diagram, Daily Borehole Log, and Daily Borehole/Well Completion Log)

- electrical water level indicator (E-tape)
- steel tape
- engineer's tape.

4.1.2 Safety Precautions

The following safety equipment is recommended as a minimum (additional safety equipment may also be required as specified in the project's Health and Safety Plan and/or by the project manager):

- leather gloves
- steel-toed boots
- hard hat
- safety glasses.

4.2 Step-by-Step Instructions

4.2.1 General

Position Responsible: WELL-SITE GEOLOGIST

The well-site geologist records borehole sample descriptions and well construction data daily for each well on an As-Built Diagram (Figure 1), Daily Borehole Log (Figure 2) and Daily Well Completion Log (Figure 3) designating nonapplicable items as "N/A". A Well Completion Summary (Figure 4) is filled out during or after completion of the well and will be stored with the geologist's and driller's logs. Acceptance or rejection of materials or processes used as compared to the specifications are recorded on the Well Inspection Report form discussed in Procedure DO-5, Well Completion Inspection.

1. Use one (more if needed) As-Built Diagram (Figure 1) for each well. Update this form daily. Record the well number, geologist's name, and page number (if more than one form is used). Graphically illustrate and label the well completion details, location and type of samples collected, and pertinent geologic and hydrologic observations. Use an appropriate vertical scale (usually 20 ft per inch) and label the depth in feet.
2. Use at least one Daily Borehole Log (Figure 2) both for each borehole/well and for each day that the borehole is being drilled. Use at least one Daily Borehole/Well Completion Log (Figure 3) both for each borehole/well and for each day that borehole abandonment/well completion activities are being performed. Record the following information on the top of each form:

WELL COMPLETION SUMMARY				
Project _____ Location _____ Drilling Co. _____ Driller _____ Other (companies) _____ Geologist(s) _____ _____ _____		Well No. _____ Temp. Well No. _____ Coordinates _____ Elevation: Casing _____ Brass Marker _____ <div style="text-align: center; font-weight: bold; margin-top: 10px;">DRILLING METHOD</div> Drilling Method(s) _____ Drilling Fluid _____ Other _____		
<div style="text-align: center; font-weight: bold; margin-bottom: 5px;">COMPLETION DATA</div> Drilled Depth _____ Completed Depth _____ Date Started _____ Date Completed _____ Static Water Level/Date _____		<div style="text-align: center; font-weight: bold; margin-bottom: 5px;">OTHER (check if performed)</div> <div style="display: flex; justify-content: space-between;"> <div> _____ Well Abandonment _____ Well Development _____ Aquifer Testing _____ Geophysical Log(s) _____ Lock and Cap </div> <div> _____ Downhole TV Inspection _____ Driller's Logs _____ Pad _____ Guardposts _____ Protective Casing </div> </div>		
SCREEN				
Type	Outer Diameter	Length	Slot Size	Interval
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
TEMPORARY CASING				
Type	Nominal Diameter	Max. Outer Diameter	Interval	
_____	_____	_____	_____	
_____	_____	_____	_____	
_____	_____	_____	_____	
PERMANENT CASING				
Type	Nominal Diameter	Max. Outer Diameter	Interval	
_____	_____	_____	_____	
_____	_____	_____	_____	
ANNULAR SEAL/FILL				
Type	Interval	Quantity	Volume	
_____	_____	_____	_____	
_____	_____	_____	_____	
_____	_____	_____	_____	
_____	_____	_____	_____	
PUMP				
Type	Depth to Inlet	Date Set		
_____	_____	_____		
ACCEPTANCE				
Completed Well: Accept _____		Conditionally Accept _____		
Reject _____				
COMMENTS				

Reviewed by _____ Date _____ Depths are below land surface unless noted.

FIGURE 4. Well Completion Summary

- boring or well number
- sheet number
- location (of boring or well)
- project (name, number, or description)
- logged by (well-site geologist) and date (signed and dated at the end of the day)
- checked by (cognizant manager, task leader, or appointee) and date (signed and dated after check). This consists of an initial check for completeness, legibility, and accuracy, to be conducted on a weekly basis, prior to the formal review.
- lithologic classification scheme (e.g., Folk, Unified Soil, etc.) (Daily Borehole Log only)
- measuring equipment (e.g., steel tape #___), where appropriate
- applicable procedure
- drilling contractor or completion contractor
- driller (and helpers) or completion personnel
- drilling rig model/drilling method (e.g., cable tool BE 22W/hard tool) or completion rig and equipment.

Use the remainder of the Daily Borehole Log for recording sample collection activities and sample descriptions by depth as detailed in Sections 4.2.2 and 4.2.3. Use a convenient scale (such as 1" = 2'). Sign and date each log in the "logged by" space, at the end of each day.

Use the remainder of the Daily Borehole/Well Completion Log for recording borehole abandonment/well completion information by time as detailed in Section 4.2.4. Sign and date each log in the "logged by" space at the end of each day.

Record the following information under the Drilling Comments column on the Daily Borehole Log:

- Borehole Status - record depth to water (D/W) and depth to bottom (D/B) at the start of each shift whenever possible. This is especially critical as the borehole nears the water table until total depth is reached. Note the times these measurements were taken in the time column. Depth to water can be measured by either an electrical tape or a standardized steel tape. Depth to bottom should be measured using a standardized steel tape. Measure at least to the nearest 0.1 ft in feet below land surface.

- Drilling Activities - give a description of all drilling activities including drill rig decontamination, drilling rate and/or blow counts, drill bit type, the use of tool lubricants, down time, initial depth to water, and geophysical logging activities. Record installation of the temporary casing (type, size, depth, and lengths--keep running totals in the casing column). Record the time in the time column.
- If the well-site geologist is relieved by another geologist, this should also be recorded in the Drilling Comments column, and the person's name should be added in the "logged by" space, or a new page could be started.

4.2.2 Sample Collection

Position Responsible: WELL-SITE GEOLOGIST

The least destructive drilling method (i.e., drive-barrel) available to the well driller should be used for advancing the borehole and for recovery of borehole cuttings. Recovery of cuttings for sampling purposes should be performed at least every 5 ft of borehole depth and at significant changes in lithology (as determined by the well-site geologist). Cuttings from each sampled interval shall be collected individually in clean 5-gallon buckets or other suitable containers.

The well-site geologist will perform the following:

1. Observe the recovery of cuttings from each sample interval and record under Drilling Comments of the Daily Borehole Log (Figure 3) any specific conditions that may affect the representativeness of the cuttings. Record the time and method of sample recovery (e.g., drive barrel, split-spoon, dart bailer, flat-bottom bailer, sand-pump bailer).

Ensure that the cuttings from each sample interval are surveyed for hazardous and radioactive contamination. Record the type of instrumentation used and the observed readings.

2. Visually examine the cuttings and determine the moisture content based on the following criteria (ASTM D 2488 Table 3): Dry = absence of moisture, dusty, dry to the touch; Moist = damp but no visible water; Wet = visible free water, usually soil is below water table. If the moisture content of the cuttings is thought to be representative (as determined by the well-site geologist), record the moisture content on the Daily Borehole Log (Figure 3) and immediately collect a moisture sample. Place the sample in a moisture tin; seal it with sealing tape; record the well number, depth, date, time, and initials on the tape with indelible ink. Wrap each moisture sample in at least one plastic bag and seal the bag with sealing tape. Ensure that the moisture sample is also representative of the lithology as these may be sieved as well as analyzed for moisture content.

3. Collect two samples for lithologic analysis from the bucket with a scoop and place in sample containers, ensuring that each sample is representative of the cuttings. Affix a label to each sample container. Record the well number, depth, date, and drill method on the label and on the container's lid with indelible ink. Initial the label. Record the type and number of samples collected, and the drill method used (i.e., "H" for hard tool, "D" for drive barrel).
4. Use the remainder of the cuttings in the bucket for describing the lithology.
5. Preserve and transport the samples according to ASTM D 4220. Any samples collected on the Hanford Site must be released by an RPT before transporting to a laboratory or sample library.
6. Temporarily store the samples in a suitable location (in truck, under work table, etc.) that protects them from temperature extremes and/or from damage or loss. Moisture samples should be kept cool (e.g., ice chest, refrigerator) until the analysis is performed.
7. Permanently store uncontaminated samples from the Hanford Site in the Hanford Geotechnical Sample Library in the 2101-M Building of the 200-East Area.

4.2.3 Sample Description

Position Responsible: WELL-SITE GEOLOGIST

1. Examine and record on the Daily Borehole Log a physical description of the cuttings from the sampled interval. Complete the Daily Borehole Log by depth, using a convenient scale (such as 1" = 2').

The sample description shall be recorded under the Lithologic Description column and shall include the following information:

- a graphic sketch of the geologic materials penetrated, by depth
- the estimated classification (based on Folk's classification scheme, Unified Soil Classification System, etc.) of each material penetrated
- the estimated particle-size distribution (maximum, and range of gravel and sand-size fractions) and sorting
- type of sedimentary structure(s) present
- gross mineralogy
- roundness and shape

- color
- odor
- 10% HCl reaction
- consolidation (compaction and/or cementation)
- changes from previously sampled interval
- other findings.

These descriptions should be made using Last and Liikala (1987) and/or ASTM D 2488 as a guide.

If physical analyses are to be performed by PNL's Soils Laboratory in the Sigma V Building, hand deliver the samples to the Soils Laboratory Coordinator or that person's representative.

4.2.4 Well Construction Documentation (Daily Borehole/Well Completion Log)

Position Responsible: WELL-SITE GEOLOGIST

NOTE: All depth measurements should be in tenths of feet below land surface.

1. Record (in the Casing/Screen column) the type, nominal and maximum outer diameters, length, stickup, and depth of the temporary casings. As the temporary casings are removed, keep a running record of the lengths removed, the stickup, and the depth to the bottom of the temporary casing shoe.
2. Record (in the Comments column) the selected completion interval(s) and the rationale for selection.
3. Record (in the Casing/Screen column) the type (including slot size), maximum outer diameter, length, and depth interval of each section of well screen installed in the well. Keep a running total of the screen length and record the total depth interval for each screened interval (in tenths of feet).

If applicable, record the type and schedule of any perforations, and the respective depth interval(s).

Record the type, nominal and outer diameters, length, stickup, and depth of each section of permanent casing. Record the length of each section and keep a running total. Depth to bottom and depth to water should be measured both before and after the permanent casing is installed as described in Section 4.2.1. The position of the permanent casing should be closely monitored during pull-back of the temporary casing to ensure there is no movement of the permanent casing.

4. Record the type, diameter, length and depth of any packers, and the location/depth of centralizers in the casing/screen column.
5. Record (in the Annular Fill column) the type, quantity, and depth to the backfill, sand pack and/or annular seal materials as they are installed. Record the amount added and the calculated depth. If bentonite slurry, volclay grout, or cement grout is used, the ingredients of each batch that is added to the borehole should be recorded in the Comments column (e.g., number of gallons of water, number of sacks of Portland cement, etc.).

Keep track of the depth to bottom in the annulus versus the depth to the temporary casing shoe. Record this in the Overlap column.

6. Once a specific item has been installed (i.e., well screen, sand pack, etc.), record (in the Comments column) the depth interval and the total quantity and type of material used.
7. Record (in the Comments column) any pertinent information concerning the installation of well head protection items, such as the concrete pad, protective posts, well cap, and well number. Depth to bottom and depth to water should be measured after the concrete pad is poured.
8. Record (in the Comments column) any pertinent information concerning the performance of a downhole visual inspection, or other special work.

4.2.5 Well Completion Summary

Position Responsible: WELL-SITE GEOLOGIST

Use one Well Completion Summary (Figure 4) for each well. This form will be used to enter data into the hydrogeologic data base and to provide a quick reference to the most frequently needed information. Record the following information from the Daily Borehole and Daily Well Completion Logs:

- general project and well information
- drilling method and interval (include whether split-spoon samplers were used on the "other" line)
- completion data (e.g., date drilling started for Date Started and date of pump installation for Date Completed)
- check if the work or materials listed in OTHER were performed or installed
- well screen information
- temporary and permanent casing information

- annular seal/fill information, including any backfill used
- pump information
- acceptance, rejection, or conditional acceptance with the appropriate Non-Conformance Report and/or Design Field Change Number
- any comments pertaining to the use of the well (i.e., if it should be used only for water-level measurements, etc.).

Depths are recorded using the local land surface as the reference datum unless otherwise noted.

4.2.6 Technical Review

Position Responsible: WELL-SITE GEOLOGIST AND SENIOR TECHNICAL REVIEWER

1. Following completion of each well the Well-Site Geologist forwards the

- Daily Borehole Logs
- Daily Borehole/Well Completion Logs
- As-Built Diagram
- Well Completion Summary
- Well Inspection Report (see Procedure DO-5)

to the Senior Technical Reviewer for review.

The following items will be reviewed:

Daily Borehole Logs

Review Items:

- completeness (all blanks completed or marked N/A, all dates or depth intervals accounted for)
- legibility
- addition of percentages to 100%
- geologist signature on each page
- reference to NCRs or DRs
- sample depth, type, and number of samples collected
- reference to sample chain-of-custody numbers (hazardous chemical samples only)

- reference to measuring equipment used.

Daily Borehole/Well Completion Log

Review Items:

- completeness (all blanks completed or marked N/A)
- legibility
- geologist signature(s) on each page
- reference to NCRs or DRs
- reference to measuring equipment used.

As-Built Diagram

Review Items:

- completeness
- legibility
- any deviations from spec. (e.g., design field change, NCR) represented.

Well Completion Summary

Review Items:

- completeness
- legibility
- reference to NCRs or DRs.

Well Inspection Report

Review Items:

- completeness
- legibility
- reference to NCRs or DRs.

2. The Senior Technical Reviewer indicates concurrence by completing, signing and dating the "reviewed by" space on the above forms. After the Daily Borehole Logs and the Daily Borehole/Well Completion Logs have been reviewed, sign-off on only the first page of each set of logs is necessary.

4.2.7 Data Management

Position Responsible: PROJECT MANAGER

1. After completion of the drilling project, the Project Manager will ensure that the original

- Daily Borehole Logs
- Daily Borehole/Well Completion Logs
- As-Built Diagram
- Well Completion/Inspection Report

for each well are copied. The originals will be sent to the geologic and geophysical records manager at PNL's Geosciences Department and a copy will be placed in the Project Files.

5.0 REFERENCES

- ASTM. 1986. "Standard Practice for Description and Identification of Soil (Visual-Manual Procedure)." In Annual Book of ASTM Standards, Volume 04.08. ASTM D 2488-84, American Society for Testing and Materials, Philadelphia, Pennsylvania.
- ASTM. 1986. "Standard Practices for Preserving and Transporting Soil Samples." In Annual Book of ASTM Standards, Volume 04.08. ASTM D 4220-83, American Society for Testing and Materials, Philadelphia, Pennsylvania.
- Last, G. V., and T. L. Liikala. 1987. A Field Guide for Well Site Geologists: Cable Tool Drilling. PNL-6392, Pacific Northwest Laboratory, Richland, Washington.
- Procedure D0-5, "Well Construction Inspection."

DO-2 SPLIT-BARREL SEDIMENT SAMPLING

1.0 APPLICABILITY

Sediment samples are collected for geologic description, determination of physical and hydraulic properties, and/or chemical analyses. This procedure applies to the work performed by well-site geologists during the collection and documentation of sediment samples recovered using split-barrel samplers. This procedure covers both periodic and continuous sampling methods. It should be used in conjunction with Procedure DO-1, Collection and Documentation of Borehole Samples and Well Construction Data.

This procedure does not cover special requirements for handling potentially contaminated borehole samples. These requirements are covered in Procedure DO-4, Contaminated Sediment Sampling.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Well-Site Geologist(s).

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following equipment will be needed to perform this procedure:

- Geologist's Kit (Munsell Color Charts, Grain Size Charts, millimeter scale, hand lens, 10% HCl, etc.)
- sample labels (lithologic and chemical)
- permanent marker (Sharpie)
- sample containers
- plastic bags and moisture cans (for moisture samples)
- sealing tape
- sampling tools (scrapers, scoops, spoons)
- applicable forms (Well Completion Summary Report, As-Built Diagram, Daily Borehole Log, and Daily Borehole/Well Completion Log)
- electrical water-level indicator (E-tape)

- steel tape, with stainless steel weight
- engineer's tape.

For continuous split-barrel sampling the following additional equipment may be needed:

- core boxes
- plastic or metal sleeves
- wooden blocks
- scale (for photography)
- sign board (for photography)
- camera and film.

4.1.2 Safety Precautions

The following safety equipment is recommended as a minimum (additional safety equipment may also be required as specified in the project's Health and Safety Plan and/or by the project manager):

- leather gloves
- steel-toed boots
- hard hat
- safety glasses.

4.2 Step-by-Step Instructions

4.2.1 Generating the Sample

Position Responsible: WELL-SITE GEOLOGIST

1. Instruct the driller to advance the borehole to the desired sample interval (usually every 5 feet and/or at lithologic changes) and make sure the hole has been drilled to a depth below the casing depth. If the continuous core sampling method is being used, skip to step 7 of this subsection.
2. Instruct the driller to clean out the borehole by removing all drill cuttings. Instruct the driller to then lower a clean split-barrel sampler with a catcher ring to the bottom of the clean borehole. If an intact core sample is desired, an internal liner (sleeve) should be used in the sampler. Record the size of the sampler and type of sleeve used. Care should be taken not to drop the sampler down the borehole and onto the soil to be sampled.
3. Instruct the driller to lower the dead weight of the sampler, and/or other drilling tools used to drive the sampler, sampling rods, and hammer (140 lb), onto the bottom of the borehole and to apply a seating blow. Make sure the bottom of the borehole is at the desired depth by measuring the length of the sampler and sampling rods (or drill tools) as they are lowered into the borehole.

If excessive cuttings are encountered, remove the sampler and cuttings, and repeat this step.

4. Mark the sampling rods in three or four successive 0.5 foot (0.15-meter) increments (depending on length of sampler) directly above the top of the auger flights or temporary casing.
5. Instruct the driller to drive the sampler with blows from the 140-pound (63.5-kilogram) hammer in accordance with ASTM D 1586-84 and count the number of blows applied in each 0.5 foot (0.15-meter) increment until either: 1) a total of 50 blows has been applied to any one 0.5 foot increment, 2) a total of 100 blows has been applied, 3) there is no observed advance of the sampler during 10 successive blows, or 4) the sampler is advanced its complete length (1.5 or 2.0 feet). If a different mechanism is used to drive the sampler, record the mechanism used including hammer weight and drop length in the Daily Borehole Log.
6. Record the number of blows required for each 0.5 foot increment or fraction of increment to the nearest 0.1 foot. If the sampler advances below the bottom of the borehole under static weight of the drill rods and hammer, record that on the Daily Borehole Log.
7. Instruct the driller to remove the sampler from the borehole, being careful not to knock the sample out of the sampler. Instruct the driller to carefully remove the sampler from the drill rod.
8. Lay the sampler flat and carefully remove the drive shoe and end cap. Keep the soils retained in the drive shoe for physical samples. If sleeves (liners) are used, immediately indicate the "up" direction on the core sleeves. Indicate well number and depth intervals. Record the interval sampled, the percent recovery (length of sample recovered divided by the length driven), and suspected reason for any core loss, on the Daily Borehole Log.
9. Examine, physically describe, and photograph (optional) the split barrel sample. Record the physical description on the Daily Borehole Log (Figure 1) in accordance with Procedure DO-1, Collection and Documentation of Borehole Samples and Well Construction Data, Section 4.2.3. Make descriptions thorough and record all entries chronologically. Sign and date each log at the end of each day.

NOTE: If the samples are not to be preserved as core, skip to step 14.

10. If sleeves were used, fill any partially filled ends of the sleeves with plastic or other suitable material and seal the ends with end caps and/or tape. Wrap and seal the core in plastic. Note the core interval preserved in the Daily Borehole Log.

11. Indicate the top of the core by drawing arrows pointing up (towards top of core), using a permanent marker. Also, record the starting and ending depths on the core.
12. Place the preserved core in the core box in the same order as the material was retrieved from the ground. Start with the top of the first core in the upper left corner of the core box (Figure 2).
13. When the core box is full, label the top and ends of the box as shown in Figure 2; avoid moving the boxes as much as possible.
14. Sample a portion for particle-size analysis, chemical analysis and/or moisture content. Carefully remove one or more representative portions and place them in suitable containers (moisture tin, canning jars, etc.). If more than one layer of material is present, collect the subsamples by partitioning the sample into lithologically similar subsamples. Take care to exclude any slough in the upper end of the sampler. If the core is to be preserved intact (i.e., a liner is used), collect samples either from the drive shoe or from a drive-barrel sample of the same interval.
15. Label the sample containers with the borehole identification number, the depth interval of the sample or subsample, the date, and the geologist's initials.
16. Protect the samples from extreme temperatures. Preserve and transport the samples according to ASTM D 4220.
17. Scrape the sampler clean of all foreign matter and wash with water or a pre-approved detergent solution. Rinse the sampler clean, wipe dry with a towel, and reassemble.
18. Label samples "Suspect" and/or discard if the location and depth of the sample is lost or unknown, or if the representativeness of the sample is in question.
19. If physical analyses are to be performed by PNL's Soils Laboratory in the Sigma V Building, hand deliver the samples to the Soils Laboratory Coordinator or his representative (after obtaining a radiation release, where necessary). If not, skip this step. When the samples are received, the Soils Laboratory Coordinator or his representative will log the samples into a controlled notebook, along with the date and time they were received. The samples will be logged in and always identified by the borehole number and depth interval as clearly labeled on the sample container.

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FIGURE 2. Examples of Boxed Core

5.0 REFERENCES

- ASTM. 1989. "Standard Method for Penetration Test and Split-barrel Sampling of Soils." In 1989 Annual Book of ASTM Standards, Volume 04.08, ASTM D 1586-84. American Society for Testing and Materials, Philadelphia, Pennsylvania.
- ASTM. 1989. "Practices for Preserving and Transporting Soil Samples." In 1989 Annual Book of ASTM Standards, Volume 04.08, ASTM D 4220. American Society for Testing and Materials, Philadelphia, Pennsylvania.

DO-3 DOCUMENTATION OF SAMPLING PUMP INSTALLATION

1.0 APPLICABILITY

This procedure applies to the documentation of sampling pump installation in ground-water monitoring wells. It may be applied independently of the sample pump type, but has been written focusing on HydroStar sampling pumps.

2.0 DEFINITIONS

- Pump - mechanism used to lift water from the well
- Pump intake - location on the pump that water enters
- Pump piston - cylinder that displaces water in a positive displacement pump
- Riser pipe - pipe connected to pump that conducts water to the top of the well
- Riser pipe coupling - device that connects the lengths of riser pipe
- Operating rod - connecting rod that actuates the pump piston in a positive displacement pump
- Pump landing plate - metal plate located on top of permanent casing on which the riser pipe is secured
- Pump head - assembly located above the pump landing plate
- Screened interval - interval of the monitoring well that contains the screen
- Saturated screened interval - portion of the screened interval that is in contact with the aquifer.

3.0 RESPONSIBLE STAFF

- Project Manager
- Well-Site Geologist.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- steel tape
- carpenter's chalk
- electrical water-level indicator (E-tape)
- engineer's measuring tape graduated in tenths of a foot

- Drill Log Forms
- Sampling Pump Installation Forms
- Well Completion/Inspection Report.

4.1.2 Safety Precautions

The following safety equipment is recommended as a minimum (additional safety equipment may be required in the project's Site Safety Plan and/or by the Project Manager):

- leather gloves
- steel-toed boots
- hard hat
- safety glasses.

The majority of physical hazards associated with sampling pump installation involve the operation of the pump setting rig, including rotating machinery, pinch points, heavy tools, and noise levels. Other physical hazards to be aware of are cold and heat stress. Refer to the Site Safety Plan for other site-specific physical hazards and chemical hazards.

4.2 Step-by-Step Instructions

4.2.1 General

Position Responsible: AUTHORIZED TECHNICAL STAFF

1. Obtain the applicable forms (Figures 1 and 2) and fill in the preliminary information [i.e., location, well number, pump type and model, company, and person(s) installing the pump]. Use the Drill Log Forms for all notes and measurements; use the Pump Installation Form to summarize activities documented on the Drill Log Forms.
2. Measure the depth-to-water (D/W) and the depth-to-bottom (D/B) for the well (see Procedure WL-1). Each measurement should be to the nearest one hundredth of a foot (0.01 ft) and verified by a second measurement that is within two hundredths of a foot (0.02 ft). Measurements should be from the top of the casing or top of the landing plate on the north side; record all measurements and the identification number(s) of the tape(s) that were used to obtain measurements on the Drill Log Form.
3. Inspect and document that the sampling pump, riser pipes, operating rods (if applicable), and couplings are in protective wrappers supplied by the manufacturer or have been adequately wrapped and protected when not in use. All sampling pump materials shall be kept off the ground and on clean plastic sheeting during pump installation; clean cotton gloves shall be worn by the person(s) installing the sampling pump. If steam cleaning is necessary because of inadequate storage, packaging, or handling of the

SAMPLING PUMP INSTALLATION FORM

Project: _____ 1 _____ Well Number: _____ 2 _____
 Pump Type: _____ 3 _____ Pump Model: _____ 4 _____
 Date Installed: _____ 5 _____ Installed by: _____ 6 _____
 Depth-to-Water: _____ 7 _____ Depth-to-Bottom: _____ 8 _____
 Reported Depth-to-Bottom: _____ 9 _____ Date: _____ 10 _____
 Screened Interval: _____ 11 _____ Saturated Screened Interval: _____ 12 _____
 Pump Riser Pipe Description: _____ 13 _____

Additional Comments: _____ 14 _____

Sketch of Pump Installation: _____ 15 _____

Completed By: _____ 22 _____ Date: _____ 23 _____

FIGURE 1. Sampling Pump Installation Form

This form is the preferred method for documenting information. However, alternate methods may be used provided that the content and method of processing is consistent with Procedure DO-3.

materials, record this on the Drill Log Form, and inform the person(s) installing the pump of the situation.

4. Document that the sampling pump was inspected by the person(s) installing the pump. On HydroStar pumps, document that the person(s) installing the pump disassembled the end section and removed the internal pump mechanism. Teflon cups shall be inspected for abrasion and all nuts must be tight. Record that the person(s) installing the pump actuated the piston to ensure that it moved freely before installation in the monitoring well.
5. Record the length of each riser pipe and coupling before installation in the monitoring well. Document whether each joint was wrapped with Teflon tape to prevent unnecessary leakage. Keep a running total of each measurement and the order in which each pipe and coupling were placed in the well on the Drill Log Forms.
6. Calculate and document the location of the sampling pump intake. This location will be calculated by the Authorized Technical Staff member documenting pump installation from measurements obtained in Step 2 and existing well completion information. The sampling pump shall be placed so the pump intake is centered within the saturated screened interval or as designated by the Project Manager.
7. Ensure and document proper landing plate and pump head installation. Record pertinent observations on the Drill Log Form.
8. Check the Drill Log and Pump Installation Forms to ensure the collection and documentation of all necessary information.
9. Document that the well was locked when you departed; if this is not possible, inform the Project Manager in writing.

5.0 REFERENCE

- Procedure WL-1, "Water-Level Measurement Procedure."

ATTACHMENT 1

INSTRUCTIONS FOR COMPLETING SAMPLING PUMP INSTALLATION FORM

1. Enter the project title.
2. Enter the permanent monitoring well number; if one is not available, enter the assigned temporary number.
3. Record the pump type (e.g., positive displacement piston).
4. Record the pump model and serial model (e.g., HydroStar HS-8001).
5. Record the date(s) of pump installation.
6. Record the company and name(s) of person(s) installing the pump.
7. Enter the D/W and the identification number of the tape that was used. Measurements should be from the top of the casing on the north side and should be repeated until two D/W measurements agree within two hundredths of a foot (0.02 ft).
8. Enter the D/B of the well and the identification number of the tape that was used. Measurements should be from the top of the casing on the north side.
9. Record the previously reported D/B; this can be obtained from the Drill Log Form that documented well development or well completion. If the difference between the previously reported D/B and the current D/B is greater than two tenths of a foot (0.2 ft), notify the Project Manager.
10. Record the date of the previously reported D/B.
11. Record the depth of the screened well interval; this may be obtained from the Drill Log Forms or Well Completion/Inspection Report.
12. Calculate and record the saturated screened interval using the D/W obtained in Step 2 of the Step-by-Step Instructions.
13. Record the length and outside diameter (o.d.) of each pipe and coupling in the order which they were placed in the well. Note whether the joints were taped with Teflon tape. This may be a summary of a more detailed description included on the Drill Log Form.
14. Enter a brief description of work conditions during pump installation (i.e., if the sampling pump and pipe were properly protected during installation). This may be a summary of a more detailed description included on the Drill Log Form.

ATTACHMENT 1 (contd)

15. Sketch pump installation; include the following items:
 - outer diameter (o.d.) of riser pipe
 - outer diameter (o.d.) of final casing
 - model of pump
 - measured distance from top of concrete pad to top of casing
 - total measured length of riser pipe, couplings, and pump
 - location of pump intake.
16. Have the person observing the pump installation indicate that the information recorded is complete and accurate by signing the Pump Installation Form.
17. Have the person observing the pump installation enter the date the Pump Installation Form was completed.

DO-4 CONTAMINATED SEDIMENT SAMPLING

1.0 APPLICABILITY

This procedure details the methods for sampling contaminated sediment for radiological and geochemical analysis. The applicability of this procedure shall be identified in the appropriate Sediment Sampling and Analysis Plan and/or the appropriate Health and Safety Plan. This procedure shall be used in conjunction with procedures 1) DO-1, Collection and Documentation of Bore-hole Samples and Well Construction Data; 2) DO-2, Split-Barrel Sediment Sampling; and 3) AD-4, Sediment Sample Chain-of-Custody.

2.0 DEFINITIONS

- Exclusion Zone - Designated area surrounding the drilling operations in which only authorized, trained, and properly attired persons who are working are allowed. Zone shall be designated by ribbon, stakes, or other markers.

3.0 RESPONSIBLE STAFF

- Field Geologist(s).

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- permanent markers
- ice chest with ice (if applicable to sample preservation)
- sampling tools (stainless steel spatulas, scoops)
- designated sample containers
- sample labels
- sample seals
- Chain-of-Custody Forms
- Drill Logs
- designated personal protective equipment
- designated contaminant detection equipment
- designated decontamination equipment
- applicable Sediment Sampling and Analysis Plan
- applicable Health and Safety Plan.

Items listed as designated and applicable are site specific and will be identified in the project's Sediment Sampling and Analysis Plan and/or Health and Safety Plan or by the Project Manager.

4.1.2 Safety Precautions

Sediment samples may pose a hazard to the responsible staff; therefore, the staff shall adhere to the applicable safety precautions outlined in the Health and Safety Plan. The nature of the hazards are physical, chemical, and

radiological. A discussion of each of these hazards is covered in the Health and Safety Plan. This plan outlines the action levels and personal protection equipment required to complete the sampling.

4.1.3 Detection Equipment

Detection equipment (e.g., photoionizer, detection tubes, etc.) identified in the Health and Safety Plan will be used to determine type and, if possible, concentration of sediment contamination. The detection equipment will be calibrated a minimum of once a day or according to the manufacturer's instructions. At each sampling interval, readings with the detection equipment will be taken and recorded on the Drill Logs. In areas where a Radiation Protection Technologist (RPT) is required to be present, the RPT will be responsible for radiological equipment calibration and radiological monitoring. Representative readings made by the RPT will be recorded in the Drill Logs.

4.1.4 Decontamination

Decontamination of the personnel will be carried out according to the Health and Safety Plan. Decontamination of the sampling equipment and the detection equipment will be carried out according to the requirements in the Sediment Sampling and Analysis Plan and/or the drilling specifications. In the event of contradictions, the Sediment Sampling and Analysis Plan takes precedence. An exclusion zone will be set up around the sampling area with a decontamination area at the access point of the exclusion zone. Decontamination activities will be restricted to this area unless an onsite location away from the exclusion zone (i.e., decontamination pad or lab) has been established as the decontamination area. In the case of a decontamination area away from the exclusion zone, the equipment to be decontaminated will be prepared for transport in a manner that eliminates the spread of contamination during transport. Waste products from the decontamination process will be contained and disposed of properly. The type of decontamination process and the verification of waste containment will be recorded on the Drill Logs by the Field Geologist.

4.1.5 Sample Preservation

In accordance with the Sediment Sampling and Analysis Plan, the designated sample bottles, preservation measures, and holding times of samples will be determined before initiating sampling (EPA 1986).

4.2 Step-by-Step Instructions

4.2.1 Sample Collection Technique

Position Responsible: FIELD GEOLOGIST

The sample collection technique will be determined by the sampling method (drive barrel, split spoon sampler, hand tool). See Attachments 1, 2, and 3.

4.2.2 Sample Identification and Transport

Position Responsible: FIELD GEOLOGIST

Sample identification will be recorded on each sample container and on the Drill Logs. Chain-of-Custody Forms will be initiated by the geologist with the appropriate information (see Procedure AD-4, Sediment Sample Chain-of-Custody).

5.0 REFERENCES

- EPA. 1986. Test Methods for Evaluating Solid Waste. SW-846, Third Edition, U.S. Environmental Protection Agency, Washington, D.C.
- Procedure AD-4, "Sediment Sample Chain-of-Custody."
- Procedure DO-1, "Collection and Documentation of Borehole Samples and Well Construction Data."
- Procedure DO-2, "Split-Barrel Sediment Sampling."

ATTACHMENT 1

INSTRUCTIONS FOR SAMPLING CONTAMINATED SEDIMENTS USING A DRIVE BARREL

Position Responsible: FIELD GEOLOGIST

NOTE: Additional instructions to be used in conjunction with these procedural instructions may be included in the Sediment Sampling and Analysis plan.

1. Ensure sample collection equipment has been decontaminated.
2. Instruct the driller to advance the boring to the desired sample interval (usually every 5 feet and/or at lithologic changes).
3. Instruct the driller to remove the sediment-filled drive barrel from the borehole and secure the drive barrel in order to easily remove the sediment for samples. Do not suspend the drive barrel directly over the borehole.
4. If another organization has not been delegated the responsibility for overseeing and monitoring site safety, check the sediment in the drive barrel with the designated detection equipment (e.g., photoionizer, Geiger Meters, Portable Alpha Meters, etc.) to determine type and level of contamination.
5. Note any discoloration, moisture, odor, or unnatural appearances of the sediment and record on the Drill Log.
6. Remove the sediment from the drive barrel using a stainless steel spatula or stainless steel spoon. Remove the sediment from the middle of the drive barrel being careful not to remove sediment that has come in contact with the walls or top of the drive barrel. This will prevent possible cross contamination. Collect the sediment in the sample containers or into a decontaminated stainless steel bucket to fill sample containers away from the drill rig.
7. Handling of the sediment shall be limited to a designated area within the exclusion zone.
8. Clearly mark on the sample containers the date, time, depth, and well number, and initial the label. The sediment analysis and preservative, if any, should be previously labeled. Seal the container with a tamper-proof seal. Initiate the Chain-of-Custody Form.
9. Retain a portion of the sediment for geologic description in accordance with Procedure DO-1, Collection and Documentation of Borehole Samples and Well Construction Data.

ATTACHMENT 1 (contd)

10. Record pertinent information on the Drill Log including depth, date, and time samples were collected; name of sampler; contamination detection; drilling information; and any unusual circumstances or observations. [Reference the procedure(s) used for sample collection.]

ATTACHMENT 2

INSTRUCTIONS FOR SAMPLING CONTAMINATED SEDIMENTS USING A SPLIT BARREL SAMPLER

Position Responsible: FIELD GEOLOGIST

NOTE: Additional instructions to be used in conjunction with these procedural instructions may be included in the Sediment Sampling and Analysis plan.

1. Ensure sample collection equipment has been decontaminated.
2. Instruct the driller to advance the boring to the desired sample interval (usually every 5 feet and/or at lithologic changes).
3. Instruct the driller to remove the sediment-filled split barrel sampler from the borehole, to remove the split barrel sampler from the drill rod, and to lay the split barrel sampler on a clean plastic sheet or table.
4. Instruct the driller to remove the drive shoe and end cap and carefully open the split barrel. Record run length, recovered length, and the percentage of sample recovered on the Drill Log.
5. If another organization has not been delegated the responsibility for overseeing and monitoring site safety, check the sample with the designated detection equipment (photoionizer, Geiger Meters, Portable Alpha Meters, etc.) to determine level of contamination.
6. Note any discoloration, odor, or unnatural appearances of the sediment and record on the Drill Log.
7. Carefully scrape any smeared material (top 1/8-3/8 inch) off the top half of the sample. If this cannot be done without disturbing the sample or a liner is used, disregard this step. Remove the sediment samples from the split barrel sampler with a stainless steel spatula or stainless steel spoon. Remove the sediment from the middle of the split barrel, being careful not to remove sediment that has come in contact with the walls of the split barrel. This will prevent possible cross contamination. Collect the sediment in the appropriate sample containers.
8. Handling of the sediment shall be limited to a designated area within the exclusion zone. Contain and dispose of all sediment spoils properly as designated in the Sediment Sampling and Analysis Plan.
9. Clearly mark on the sample containers the date, time, depth, and well number, and initial the label. The sediment analysis and preservative, if any, should be previously labeled. Seal the

ATTACHMENT 2 (contd)

container with a tamper-proof seal. Initiate the Chain-of-Custody Form in accordance with procedure AD-4, Sediment Sample Chain-of-Custody.

10. Retain a portion of the sediment for geologic description in accordance with Procedure DO-1, Collection and Documentation of Borehole Samples and Well Construction Data.
11. Record pertinent information on the Drill Log including depth, date, and time samples were collected; name of sampler; contamination detection; drilling information; and any unusual circumstances or observations. Record the procedure(s) used for sample collection including date or revision number.

ATTACHMENT 3

INSTRUCTIONS FOR SAMPLING CONTAMINATED SEDIMENTS USING HARD TOOL AND BAILER SAMPLER

Position Responsible: FIELD GEOLOGIST

NOTE: Additional instructions to be used in conjunction with these procedural instructions may be included in the Sediment Sampling and Analysis plan.

1. Ensure sample collection equipment has been decontaminated.
2. Instruct the driller to advance the boring to the desired sample interval (usually every 5 ft and/or at lithologic changes).
3. Instruct the driller to remove the cuttings from the borehole using a bailer and to place them into a stainless steel bucket.
4. If another organization has not been delegated the responsibility for overseeing and monitoring site safety and if contamination is suspected, check the sample in the bucket with the designated detection equipment (e.g., photoionizer, Geiger Meters, Portable Alpha Meters, etc.) to determine the type and level of contamination.
5. Note any discoloration, odor, or unnatural appearances of the sediment and record on the Drill Log.
6. Remove the sediment from the stainless steel bucket with a stainless steel spatula or stainless steel spoon, and collect the sediment in the appropriate sample containers.
7. Handling of the sediment shall be limited to a designated area within the exclusion zone. Contain and dispose of all sediment spoils properly as designated in the Sediment Sampling and Analysis Plan.
8. Clearly mark on the sample containers the date, time, depth, and well number, and initial the label. The sediment analysis and preservative, if any, should be previously labeled. Seal the container with a tamper-proof seal. Place samples for chemical analysis on ice to be kept cold until delivered to the laboratory. Initiate the Chain-of-Custody Form in accordance with procedure AD-4, Sediment Sample Chain-of-Custody.
9. Retain a portion of the sediment for geologic description in accordance with Procedure DO-1, Collection and Documentation of Borehole Samples and Well Construction Data.

ATTACHMENT 3 (contd)

10. Record pertinent information on the Drill Log including depth, date, and time that samples were collected; name of sampler; contamination detection; drilling information; Chain-of-Custody Form number; and any unusual circumstances or observations. Record the procedure(s) used for sample collection including date or revision number.

DO-5 WELL CONSTRUCTION INSPECTION

1.0 APPLICABILITY

This procedure applies to inspection of critical well construction characteristics by well-site geologists. This procedure can be applied independent of the well drilling and construction methods. Inspection of the following areas is specifically excluded from this procedure:

- receiving inspection of procured materials/material certifications
- verification of drillers' licenses/qualifications
- records required by WAC 173-160-050
- welding of temporary or permanent casing.

Nonconformances in well construction materials or workmanship shall be processed using a nonconformance report (NCR) in accordance with PNL administrative procedures and the applicable project QA Plan.

Review of completed inspection documentation generated as a result of this procedure shall be performed in accordance with the requirements for Senior Technical Review specified in Procedure DO-1, Collection and Documentation of Borehole Samples and Well Construction Data.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Well-Site Geologist(s)
- Senior Technical Reviewer
- Project Manager
- PQD Representative.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment/Supplies

- copy of applicable well construction specification including any Engineering Change Notices (ECNs)
- Well Inspection Report forms
- black pens
- steel tape
- engineers tape.

4.1.2 Safety Precautions

The following safety equipment is recommended as a minimum (additional safety equipment may also be required as specified in the project's Health and Safety Plan and/or by the project manager):

- leather gloves
- steel-toed boots
- hard hat
- safety glasses.

4.1.3 Qualification of Inspectors

Prior to performing the inspection functions described in this procedure, the well-site geologist shall complete documented training on this procedure as well as appropriate PNL administrative procedures. The well-site geologist must also attend a briefing on the inspector's responsibilities, documentation of inspections, and actions to take when nonconformances are identified. This briefing will be performed by a member of the PNL Process Quality Department, Quality Control Group, or a designee. Following completion of this training, the well-site geologist will be qualified by the Quality Control Group to perform the inspection function. This qualification shall be documented via a memo to file (or similar means) including a description of the basis for the qualification.

4.2 Step-by-Step Instructions

4.2.1 General

The well-site geologist records well construction inspection results for each well on the Well Inspection Report form (Figure 1) as the information becomes available. An example of a completed Well Inspection Report is shown in Figure 2. The example incorporates the step-by-step instructions presented below.

1. Well Identification/Construction Specification - The temporary well number and permanent well number are entered at the top of the Well Inspection Report form. The specification number, revision, and any Engineering Change Notices (ECNs) that apply to the specification are also entered.
2. Identification of Well-Site Geologist - The name of each well-site geologist performing inspections on the well is listed at the top of the form. If two or more geologists have the same initials, they must initial their names in such a manner to differentiate between them.
3. Inspection Method - Typical inspection methods are pre-printed on the Well Inspection Report form for a number of the inspection topics. If the inspection method is not included or differs from

WELL INSPECTION REPORT							
Well No. _____		Procedure _____		Rev. _____		Specification No. _____	
Geologist(s) _____		ECNs (list) _____		Rev. _____			
CLEANING/DECONTAMINATION							
	Inspection Method	Criteria	Accept	Reject	Date		
Rig/Tools (initial)	Visual/Wipe (optional)						
Temporary Materials	Visual/Wipe (optional)						
Permanent Materials	Visual/Wipe (optional)						
Mtls Brought Onsite Later	Visual/Wipe (optional)						
MATERIAL STORAGE/PACKING							
	Inspection Method	Criteria	Accept	Reject	Date		
Material Storage	Visual						
Material Packing/Seals	Visual						
Other _____							
LUBRICANTS/ADDITIVES/AIDS							
	Inspection Method	Criteria	Accept	Reject	Date		
Lubricants							
Additives/Aids							
DRILLING METHOD							
	Inspection Method	Criteria	Accept	Reject	Date		
Method	Visual						
Drilling Fluid	Visual						
STRAIGHTNESS TEST							
	Inspection Method	Criteria	Accept	Reject	Date		
Well Straightness							
COMPLETION							
	Inspection Method	Criteria	Accept	Reject	Date		
Drilled Depth	Steel Tape #	G-W Mon. Plan					
Completed Depth	Steel Tape #	G-W Mon. Plan					
PERMANENT SCREEN/CASING							
	Inspection Method	Criteria	Accept	Reject	Date		
Screen Type/Slot/Length	Engineers Tape, Visual						
Screened Interval	Steel Tape #						
Casing Type/Size/Length	Engineers Tape, Visual						
Centralizers/Location	Engineers Tape, Visual						
Other _____							
FILTER PACK/ANNULAR SEAL							
	Inspection Method	Criteria	Accept	Reject	Date		
Primary Filter Mtl/Place	Visual/Steel Tape#						
Second Filter Mtl/Place	Visual/Steel Tape#						
Annular Seal Mtl/Place	Visual/Steel Tape#						
Install Annul Seal	Visual/Steel Tape#						
Cement Type/Placement	Visual/Steel Tape#						
Overdrill Seal Method	Visual/Steel Tape#						
WELL PROTECTION							
	Inspection Method	Criteria	Accept	Reject	Date		
Surface Pad Mtl/Place	Visual/Engineers Tape						
Surface Casing Mtl/Place	Visual/Engineers Tape						
Cap/Hasp/Lock	Visual						
WELL SURVEYING/MARKING							
	Inspection Method	Criteria	Accept	Reject	Date		
Well ID Stamped/Correct	Visual						
Well Surveyed/Toler Met	Review Survey Data						
PUMP INSTALLATION							
	Inspection Method	Criteria	Accept	Reject	Date		
Pump Decon/Preparation	Visual						
Installation/Placement	Visual/Engineers Tape						
Pump Operational	Observed Running						

Technical Review Complete _____ Date _____

FIGURE 1. Well Inspection Report

Well No. <u>292-333-90</u> Procedure <u>20-5</u> Rev. <u>1</u>		Specification No. <u>20-5-2-010</u> Rev. <u>1</u>	
Geologist(s) <u>J.F. Smith, S.E. Jones</u>		ECNs (list) <u>124455 124456 124457 124458 124459 124460 124461 124462 124463 124464 124465 124466 124467 124468 124469 124470 124471 124472 124473 124474 124475 124476 124477 124478 124479 124480 124481 124482 124483 124484 124485 124486 124487 124488 124489 124490 124491 124492 124493 124494 124495 124496 124497 124498 124499 124500 124501 124502 124503 124504 124505 124506 124507 124508 124509 124510 124511 124512 124513 124514 124515 124516 124517 124518 124519 124520 124521 124522 124523 124524 124525 124526 124527 124528 124529 124530 124531 124532 124533 124534 124535 124536 124537 124538 124539 124540 124541 124542 124543 124544 124545 124546 124547 124548 124549 124550 124551 124552 124553 124554 124555 124556 124557 124558 124559 124560 124561 124562 124563 124564 124565 124566 124567 124568 124569 124570 124571 124572 124573 124574 124575 124576 124577 124578 124579 124580 124581 124582 124583 124584 124585 124586 124587 124588 124589 124590 124591 124592 124593 124594 124595 124596 124597 124598 124599 124600 124601 124602 124603 124604 124605 124606 124607 124608 124609 124610 124611 124612 124613 124614 124615 124616 124617 124618 124619 124620 124621 124622 124623 124624 124625 124626 124627 124628 124629 124630 124631 124632 124633 124634 124635 124636 124637 124638 124639 124640 124641 124642 124643 124644 124645 124646 124647 124648 124649 124650 124651 124652 124653 124654 124655 124656 124657 124658 124659 124660 124661 124662 124663 124664 124665 124666 124667 124668 124669 124670 124671 124672 124673 124674 124675 124676 124677 124678 124679 124680 124681 124682 124683 124684 124685 124686 124687 124688 124689 124690 124691 124692 124693 124694 124695 124696 124697 124698 124699 124700 124701 124702 124703 124704 124705 124706 124707 124708 124709 124710 124711 124712 124713 124714 124715 124716 124717 124718 124719 124720 124721 124722 124723 124724 124725 124726 124727 124728 124729 124730 124731 124732 124733 124734 124735 124736 124737 124738 124739 124740 124741 124742 124743 124744 124745 124746 124747 124748 124749 124750 124751 124752 124753 124754 124755 124756 124757 124758 124759 124760 124761 124762 124763 124764 124765 124766 124767 124768 124769 124770 124771 124772 124773 124774 124775 124776 124777 124778 124779 124780 124781 124782 124783 124784 124785 124786 124787 124788 124789 124790 124791 124792 124793 124794 124795 124796 124797 124798 124799 124800 124801 124802 124803 124804 124805 124806 124807 124808 124809 124810 124811 124812 124813 124814 124815 124816 124817 124818 124819 124820 124821 124822 124823 124824 124825 124826 124827 124828 124829 124830 124831 124832 124833 124834 124835 124836 124837 124838 124839 124840 124841 124842 124843 124844 124845 124846 124847 124848 124849 124850 124851 124852 124853 124854 124855 124856 124857 124858 124859 124860 124861 124862 124863 124864 124865 124866 124867 124868 124869 124870 124871 124872 124873 124874 124875 124876 124877 124878 124879 124880 124881 124882 124883 124884 124885 124886 124887 124888 124889 124890 124891 124892 124893 124894 124895 124896 124897 124898 124899 124900 124901 124902 124903 124904 124905 124906 124907 124908 124909 124910 124911 124912 124913 124914 124915 124916 124917 124918 124919 124920 124921 124922 124923 124924 124925 124926 124927 124928 124929 124930 124931 124932 124933 124934 124935 124936 124937 124938 124939 124940 124941 124942 124943 124944 124945 124946 124947 124948 124949 124950 124951 124952 124953 124954 124955 124956 124957 124958 124959 124960 124961 124962 124963 124964 124965 124966 124967 124968 124969 124970 124971 124972 124973 124974 124975 124976 124977 124978 124979 124980 124981 124982 124983 124984 124985 124986 124987 124988 124989 124990 124991 124992 124993 124994 124995 124996 124997 124998 124999 125000</u>	
N/A			

Item	Inspection Method	Criteria	Accept	Reject	Date
CLEANING/DECONTAMINATION					
Rig/Tools (initial)	Visual/Wipe (optional)	Spec 7.1.7.6, 124457	T.O.	N/A	1/21/90
Temporary Materials	Visual/Wipe (optional)	Spec 4.1.7.3, 124457	T.O.	N/A	1/21/90
Permanent Materials	Visual/Wipe (optional)	Spec 4.2.3, 124457	T.O.	N/A	1/21/90
Mtls Brought Onsite Later	Visual/Wipe (optional)	Spec 4.1.7.3, 124457	T.O.	N/A	1/21/90
MATERIAL STORAGE/PACKING					
Material Storage	Visual	Spec 7.3	T.O.	N/A	1/21/90
Material Packing/Seals	Visual	Spec 4.2.3, 124457	T.O.	N/A	1/21/90
Other	N/A	N/A	N/A	N/A	N/A
LUBRICANTS/ADDITIVES/AIDS					
Lubricants	Visual	Spec 7.2, 124455	T.O.	N/A	1/21/90
Additives/Aids	Visual	Spec 7.2, 124455	T.O.	N/A	1/21/90
DRILLING METHOD					
Method	Visual	Spec 5.2	T.O.	N/A	1/21/90
Drilling Fluid	Visual	Spec 7.2, 124455	T.O.	N/A	1/21/90
STRAIGHTNESS TEST					
Well Straightness	Spec 4.2.3, 124457	Spec 9.2	T.O.	N/A	1/21/90
COMPLETION					
Drilled Depth	Steel Tape # LUF-097	G-W Mon. Plan	ELP	N/A	2/15/90
Completed Depth	Steel Tape # LUF-097	G-W Mon. Plan	T.O.	N/A	2/25/90
PERMANENT SCREEN/CASING					
Screen Type/Slot/Length	Engineers Tape, Visual	Spec 4.2.1, 4.2.2, 5.3.1	ELP	N/A	2/22/90
Screened Interval	Steel Tape # LUF-097	Spec 5.3.1	ELP	N/A	2/22/90
Casing Type/Size/Length	Engineers Tape, Visual	Spec 4.2.1, 4.2.4, 5.3.1	ELP	N/A	2/22/90
Centralizers/Location	Engineers Tape, Visual	Spec 4.2.5	ELP	N/A	2/22/90
Other	N/A	N/A	N/A	N/A	N/A
FILTER PACK/ANNULAR SEAL					
Primary Filter Mtl/Place	Visual/Steel Tape # LUF-097	Spec 4.2.6, 5.3.1	ELP	N/A	2/22/90
Second Filter Mtl/Place	Visual/Steel Tape # LUF-097	Spec 4.2.6, 5.3.1	ELP	N/A	2/22/90
Annular Seal Mtl/Place	Visual/Steel Tape # LUF-097	Spec 4.2.7, 4.2.8, 5.3.1	J.F.S.	N/A	2/23/90
Install Annul Seal	Visual/Steel Tape # LUF-097	Spec 5.3.1	J.F.S.	N/A	2/23/90
Cement Type/Placement	Visual/Steel Tape # LUF-097	Spec 4.2.9, 4.2.10, 5.3.1	J.F.S.	N/A	2/24/90
Overdrill Seal Method	Visual/Steel Tape # LUF-097	Spec 5.3.3	N/A	N/A	2/24/90
WELL PROTECTION					
Surface Pad Mtl/Place	Visual/Engineers Tape	Spec 4.2.1, 4.2.2, 5.3.1	T.O.	N/A	2/25/90
Surface Casing Mtl/Place	Visual/Engineers Tape	Spec 4.2.2, 5.3.1	T.O.	N/A	2/25/90
Cap/Hasp/Lock	Visual	Spec 4.2.3	T.O.	N/A	2/25/90
WELL SURVEYING/MARKING					
Well ID Stamped/Correct	Visual	Spec 4.2.2	T.O.	N/A	3/5/90
Well Surveyed/Toler Met	Review Survey Data	Spec 7.4, 5.2.1, 5.2.2	T.O.	N/A	2/25/90
PUMP INSTALLATION					
Pump Decon/Preparation	Visual	Spec 4.2.2	ELP	N/A	2/27/90
Installation/Placement	Visual/Engineers Tape	Spec 4.2.2, 5.3.1	ELP	N/A	2/27/90
Pump Operational	Observed Running		ELP	N/A	2/27/90

Technical Review Complete _____ Date _____

FIGURE 2. Example of Completed Well Inspection Report

that on the form, it must be specified by the well-site geologist. If a method of inspection is described in the drilling specification, the method may be by reference only (i.e., see spec., Section 8.3).

4. Inspection Criteria - Reference the section in the specification describing what materials or methods are acceptable for each topic. For example, Section 1.2 of the specification may describe the type of cement grout to be used for the annular seal and Section 4.5 may describe how it is to be installed. In this case the inspection criteria would be "Spec 1.2, 4.5".
5. Measuring and Test Equipment - If measuring and test equipment is used in performing the inspection (e.g., a steel tape used for measuring depth to bottom or placement of materials), reference the ID number of the equipment used. For example, if steel tape number LUF097 was used to measure the completed depth of a well, "LUF097" is entered on the Inspection Method line.
6. Acceptance or Rejection - If the topic being inspected meets the criteria, the inspector initials on the Accept line and enters the date inspected. If the topic being inspected doesn't meet the criteria, the inspector initials the Reject line, enters the date the inspection was performed, initiates a Nonconformance Report (NCR), and references the NCR number next to his/her initials on the Reject line. An example of this situation is shown in Figure 2 for the "Overdrill Seal Method" in the FILTER PACK/ANNULAR SEAL section.
7. Design Field Changes - Pre-planned deviations from the specification that must be made because of prevailing conditions at a specific drill site must be documented using a Design Field Change (DFC) in accordance with Procedure AD-1, Change Control Procedure. If a DFC is used, the DFC number must be referenced when accepting the affected item. For example, Figure 2 shows a reference to DFC No. LLBG-1 on the Accept line for the "Screen Size/Slot/Length" topic in the PERMANENT SCREEN/CASING block. If the deviation was not pre-planned with a DFC issued, the well is in nonconformance with the specification and an NCR must be processed. This would then be classified as a "Reject" on the Well Inspection Report form.
8. Non-Applicable Topics - Mark any blocks or lines "N/A" that are not applicable. For example, if a well is not overdrilled, the topic "Overdrill Seal Method" listed in the FILTER PACK/ANNULAR SEAL section of the form should be marked N/A.

4.2.2 Senior Technical Review

Following completion of the Well Inspection Report, the well-site geologist forwards the report to the senior technical reviewer selected by the project manager or his/her designee for review in accordance with Procedure D0-1, Collection and Documentation of Borehole Samples and Well Construction Data.

DA-1 SIMPLE DATA SUMMARIES

1.0 APPLICABILITY

Ground-water monitoring data collected for RCRA Interim Status Assessment projects will be routinely summarized for reporting to the sponsors and regulators, and nonroutinely analyzed for the assessment of the ground-water regime. This procedure describes the generation of the summaries that are routinely applied to these data. These summaries may also prove useful for other types of ground-water monitoring projects.

It is also anticipated that more sophisticated statistical techniques, such as time series analysis, factor analysis, regression analysis, geostatistics, and other techniques that are appropriate for analyzing the data will be used in the assessment of the ground-water system. However, these will not be applied on a routine basis and are not described in this procedure.

At this time, the routine procedures applied to the data produce summaries described in "Resource Conservation and Recovery Act (RCRA) Ground-Water Monitoring Technical Enforcement Guidance Document" (TEGD) (EPA 1986). These summaries list and summarize the data with simple descriptive statistics calculated using different combinations of the data. They also plot the data for visual review. The steps needed to accomplish this are outlined below in Section 4.0 for generating simple data summaries.

Other planned statistical procedures to be routinely applied are trend tests to identify statistically significant increases in contamination, quality control charts to look for off-normal levels of contamination or outliers, and hypothesis tests for statistical significance of possible contamination. Examples of these methods and others can be found in Ground-Water Monitoring Plans and Statistical Procedures to Detect Leaking at Hazardous Waste Facilities (PNL 1986). However, all of these procedures depend on having a certain amount of historical data. The procedures for applying these methods will be developed as the quantity of data allows and will be included in this procedure as they become available.

2.0 DEFINITIONS

- HGWDB - the Hanford Ground-Water Data Base
- RCRA - the Resource Conservation and Recovery Act
- RCRA Interim Status Ground-Water Assessment - those activities undertaken to satisfy the requirements established in 40 CFR 265.93(d)(3).

3.0 RESPONSIBLE STAFF

- Project Statistician.

4.0 PROCEDURE

The TEGD (EPA 1986) describes certain simple summaries of the ground-water chemical constituent data that the regulators would like available to them when they are reviewing the status of any ground-water monitoring network. This section defines the procedures that are used to generate these suggested summaries.

4.1 Prerequisites

4.1.1 Ground-Water Chemical Constituent Data

The data used as input to the programs discussed in this procedure are maintained in PNL's Hanford Ground-Water Database (HGWDB). These data are entered into the data base using Procedure DM-1, "Analytical Data Handling and Verification Procedure."

4.1.2 Computer Hardware and System Supported Software

All of the programs discussed in this procedure are run on PNL's ZVAX, a VAX-11/780. The latest version of the operating system is VAX/VMS 4.7. System supported software packages used for this procedure are: VAX/DATATRIEVE, Version 4.1, used to extract data from the HGWDB and prepare a card image file for input to summarization programs; and Statistical Analysis System (SAS), Version 5.16, used to read in the data, organize it, summarize it, and generate tables and graphics.

4.1.3 Access to Programs

The programs and data files for each separate project covered by this procedure are maintained on individual project accounts on the ZVAX. The user of these programs must have permission from the Project Statistician to access the project account. Within each project account there is a file called NOTE.BOOK that contains the latest instructions for generating the tables and plots for that project.

4.2 Step-by-Step Instructions

Position Responsible: PROJECT STATISTICIAN

The following steps must be followed to generate the simple EPA summaries.

1. Log on to a personal account on the ZVAX and SET PROJECT to the appropriate project account. Review the NOTE.BOOK file in the project account to ensure that the most recent report generation instructions are being followed for that project. Each project will have the same basic programs except for header information, lists of well names, definition of site-specific constituents, and other possible minor differences.
2. Retrieve the necessary raw data from the HGWDB using the appropriate DATATRIEVE command files by entering "DTR @filename" at a

VMS prompt or by submitting a batch job with a similar statement in it. For example, the following DATATRIEVE command files are used to retrieve raw data for the project overseeing the 183-H Solar Evaporation Basins:

ANA183H.DTR for chemical constituent data (ANADAT relation)
HYD183H.DTR for water level data (HYDDAT relation)
TMP183H.DTR for temperature data (TMPDAT relation).

3. Read the retrieved raw data into SAS and give simple listings by using the appropriate SAS command files by entering "SAS filename" at a VMS prompt or by submitting a batch job with a similar statement in it. For example, the following SAS command files are used for the 183-H Solar Evaporation Basins project:

ANA183H.SAS for the chemical constituent data
HYD183H.SAS for the water level data
TMP183H.SAS for the temperature data.

A review of the output from the program for chemical constituent data is necessary. It contains information that may be needed for updating two programs referenced in the next step: LISTS.SAS and PERIODS.SAS.

4. Prepare chemical constituent data for input to EPA summary programs. The three following SAS command files are not run themselves but are read into other SAS command files referenced below. They contain defining information that is not included in the HGWDB but is used for organizing the data. HOBOKEN.SAS is in its final form, but LISTS.SAS will have to be updated whenever a constituent subset changes. PERIODS.SAS will have to be updated each sample period.

HOBOKEN.SAS identifies data analyzed by UST/Hoboken.
LISTS.SAS defines constituent subsets for the Standard List.
PERIODS.SAS defines the sample periods by dates of sampling.

Once LISTS.SAS and PERIODS.SAS have been appropriately updated, run the following program by entering "SAS ABOVE DL" at the VMS prompt or by submitting a batch job with a similar statement in it. This program separates the data into two SAS datasets for further processing. One, called BELOWDL, is the most basic summary of the data and is used as input to TABLE60.SAS in the next section. The other dataset is called ABOVE DL. It contains all the raw data for each constituent that had at least one value reported as being above the detection limit and is used as input to all the other simple summary programs.

ABOVE DL.SAS separates ANA183H into BELOWDL and ABOVE DL.

5. The following programs actually produce the output that is reported to the sponsors and regulators. Each program is run by

entering "SAS filename" at the VMS prompt or submitting a batch job with a similar statement in it.

- TABLE60.SAS - summary for all constituents (total, above detection limit)
- TABLE61.SAS - raw data listing per constituent greater than detection limit
- TABLE62.SAS - simple statistical summaries by constituent
- TABLE63.SAS - simple statistical summaries by constituent and well
- TABLE64.SAS - simple summaries by constituent, well, and sample date
- TABLE65.SAS - simple summary by ranking descriptive statistics
- PLOT183H.SAS - does time plots of constituents.

TABLE60.SAS is not mentioned in the TEGD, but has proven useful in data presentation because it identifies constituents that have not been detected and constituents that have exceeded Drinking Water Standards. TABLE61.SAS is a program for listing raw data, but in a more compact format than presented in the TEGD. TABLE62.SAS through TABLE65.SAS present the data as shown in Tables 6.2 through 6.5 of the TEGD.

5.0 REFERENCES

- PNL. 1986. Ground-Water Monitoring Plans and Statistical Procedures to Detect Leaking at Hazardous Waste Facilities. PNL-5754, Pacific Northwest Laboratory, Richland, Washington.
- EPA. 1986. Resource Conservation and Recovery Act (RCRA) Ground-Water Monitoring Technical Enforcement Guidance Document. OSWER 9950.1, U.S. Environmental Protection Agency, Washington, D.C.

DA-2 GROUND-WATER ANALYTICAL DATA CONSISTENCY REVIEW

1.0 APPLICABILITY

This procedure is to be used for performing consistency reviews of the ground-water analytical data that are entered into the Hanford Environmental Information System (HEIS). The method of review at this time is qualitative and is based on the experience of the reviewers. Methods for documenting these reviews are included.

The data consistency review process described herein applies to internal consistency, historical consistency, and situational consistency.

2.0 DEFINITIONS

- Data Inconsistencies - Constituent values that do not qualitatively fit or are inconsistent with historical or situational patterns.
- General Data Reviews - Ongoing reviews of site-wide ground-water data on computerized lists.
- Hanford Environmental Information System (HEIS) - A site-wide data base of soil, atmospheric, ground-water, geologic, and biologic historical information.
- Historical Consistency - A data review based on comparison of the current data with historical values from the same well.
- Internal Consistency - A data review based on checking constituent value interrelationships with other gross indicators, such as alpha, beta, total organic halides, and ion concentrations.
- Sampling Period - The period of ground-water sampling for a particular project, designated by the date that sampling begins and the date that sampling ends.
- Situational Consistency - A data review that accounts for particular situations, such as location (e.g., nearby wells, wells downgradient from a plume, effects from changing river levels, etc.).

3.0 RESPONSIBLE STAFF

- Data Evaluation/Review Task Leader.
- Data Evaluation/Review Team - Qualified personnel appointed by the Task Leader to review individual projects.
- Technical Staff.

4.0 PROCEDURE

4.1 General Information

Obtain summary information for review from data generated by the laboratory. This computerized report includes:

- amount of incoming data
- collection dates of the data
- wells from which the data were gathered
- projects involved
- modifications that were made to the data by the laboratory.

4.2 Step-by-Step Instructions

Position Responsible: DATA EVALUATION/REVIEW TASK LEADER OR ASSIGNED TECHNICAL STAFF

1. Perform General Data Reviews for each type of computerized report or listing weekly to identify any data inconsistencies (i.e., internal, historical, or situational).
2. Note data inconsistencies in the margin of the computerized report.
3. Where data inconsistencies cannot be explained by the reviewer, initiate a Request for Data Review (RDR).
4. Document project identification, sampling period, reviewer, collection date, report date, duplicate number, well number, constituent, value(s), comments, whether an RDR was generated, and the review date on a Data Consistency Review Sheet (Attachment 1).
5. Notify the Project Manager via memo if changes from previous listings are discovered during the review, and reference the RDR number if an RDR has been generated.
6. Sign and date the computerized report following the review.
7. Maintain the report and a copy of any related correspondence (i.e., memo, RDR) in a location designated by the Data Evaluation/Review Task Leader.

ATTACHMENT 1.

DATA CONSISTENCY REVIEW SHEET

Project Identification: _____

Sampling Period - From: _____ To: _____

Reviewer: _____

[illegible]

GL-1 GEOPHYSICAL WELL LOGGING VAN OPERATING PROCEDURE

1.0 APPLICABILITY

This procedure describes the operation of the Geophysical Well Logging Van. Geophysical borehole logging consists of lowering probes and a television camera down boreholes and recording at the surface a continuous instrumental response to the subsurface material. In an attempt to standardize log responses, a log will be made from each probe every 3 months in reference well 399-5-2. If a probe malfunctions during logging, the probe will be run in the reference well after repair to ensure proper response.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging cable and winch system
- electronic surface equipment that transmits and receives information from the probes
- AC power source
- sensing probes: temperature, three- and four-arm calipers, gamma ray, neutron-epithermal neutron (neutron), gamma-gamma (density), spontaneous-potential resistivity (SP&R), flowmeter, fluid resistivity, gradiometer (magnetic), fluid sampler, sonic bond, and TV camera
- chart recorder
- rig-up chains, cable, and sheaves
- radioactive sources
- tool box
- calibration equipment
- logbook
- hard hats

- leather gloves
- steel-toed shoes
- 2 ABC fire extinguishers.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field
- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or
- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.1.3 Safety

Operation of the geophysical logging van can be hazardous when work is connected with a drilling rig. Hard hat, gloves, and safety shoes must be worn when work is connected with drilling rigs.

Special care should be taken before connecting and disconnecting the probes from the cable head to make sure the electrical current has been shut off. Failure to follow this safeguard may result in electrical shock.

Two 10-pound ABC fire extinguishers must be carried in the logging van at all times.

Review Job Safety Analysis on Operation of the Downhole Television System, Operation of the Geophysical Logging System and Operation of Government Vehicles.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

4.2.1 Setting Up the Equipment

1. In preparation for geophysical logging or television logging, park the logging van no closer than 60 feet from the well head. This will allow the cable to spool evenly on the drums.

2. Place a sheave over the center of the well casing.
3. Extend the cable with the attached camera or geophysical probe from the winch to the sheave at the well, such that the camera lens or probe sensing element is even with the well measuring point.
4. Set the mechanical registers on the cable drums and the electronic register on the TV monitor to zero.

4.2.2 Operating the Truck Hydraulic System

1. Start the truck engine to build up pressure in the air tank.
2. After air pressure has built to about 70 pounds, depress the truck clutch peddle and engage the power take off lever. Release the clutch and turn truck ignition off. Make sure the truck transmission is in neutral and the emergency brake is set.
3. Both cable drums run off of the same hydraulic pump. In order to switch from one to the other, valves mounted on the geophysical cable drum must be changed. To operate the TV cable drum, move both valves toward that drum. To operate the geophysical cable drum, move both valves toward that drum.
4. Check to be sure that the fuse switch on the operators panel is in the ON position. The switch must be in this position to allow power to go to the panel switches.
5. Start the truck engine from the operators panel and run at idle speed - 600 to 700 RPM. Observe the tachometer.
6. With the UP-DOWN hydraulic control lever in neutral, shift the transmission into the desired gear. Leave the transmission in neutral when operating the TV cable drum.
7. When lowering equipment into the hole, place the UP-DOWN hydraulic control lever in the DOWN position and adjust the speed with the adjustable flow regulator valve on the front of the operators panel and the truck throttle control.
8. Observe the tachometer and hydraulic pressure gauge on the operators panel. Do not exceed 3,000 RPM and 1,500 PSI when operating the geophysical drum and 1,000 RPM and 1,500 PSI when operating the TV cable drum.
9. During warm weather, open the door to the hydraulic fluid reservoir so air will circulate and cool the fluid.

4.2.3 Operating the AC Electrical System

1. Before starting the generator open the doors to the generator compartments and leave them open while the generator is in operation. Failure to do this may result in overheating and damage to the generator.
2. Before starting, check the oil.
3. Observe the control panel for the proper voltage and cycles output from the generator. Voltage should be 115V plus or minus 5V. Cycles should be 60Hz plus or minus 2Hz.
4. If one generator is overloaded, start the other generator and divide the load by switching on the control panel.

4.2.4 Calibrating the Probes

1. Calibrate all probes in accordance with instructions set forth in Procedures GL-2 through GL-15. Calibrate geophysical probes before and after the log is made. This double check of the calibration accounts for any drift or malfunction in the system. Note calibration actions on the original geophysical logs. This notation shall comprise documentation of the calibration.
2. Before placing the probe in the well make sure it is clean. If not, wipe it down with a clean cloth to prevent cross contamination between wells.
3. Run a 30-foot repeat section of the log to check on a probe's repeatability. If logs have been run previously in a well, a 30-foot overlap will be run to check for repeatability.

4.2.5 Logging the Well

All geophysical logs, with the exception of temperature and fluid resistivity, are made by lowering the probes to the bottom of the hole and logging up. Television logging is done while going into the hole. The correct speed is determined by observing the monitor and adjusting the control valve to suit the observers. Review Procedures GL-2 through GL-15 for step-by-step instructions.

4.2.6 Cleaning After Logging

1. When logging is completed, wipe clean the probes and camera and store securely in the logging van to avoid damage during transport.
2. Store the radioactive sources in their containers and place in the logging van for return to the radioactive source storage room.

3. Record on the log all information regarding well identification, depth, type of log, well diameter, water level, date, interval logged, instrument scale used, time constant, logging speed, procedure number, probe serial number, and calibration equipment numbers. Have the person operating the equipment sign the log. Remark on any problems encountered during logging or anything that could affect equipment response.

5.0 REFERENCES

- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."
- Procedure GL-11, "Magnetic Probe Procedure."
- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."
- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-2 TEMPERATURE PROBE PROCEDURE

1.0 APPLICABILITY

This procedure describes borehole temperature logging. Temperature logging provides for fluid level location, formation temperature measurements, cement top determination, fluid entry detection, injection profiling, and detection of casing leaks. All temperature logging is performed while lowering the tool into the well, minimizing the effect of the tool and cable on the ambient temperature. Maximum logging speed is 40 feet per minute. Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules specifications
- SRP - solid state recorder panel
- LPM - line power module
- RMM - flowmeter module.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- NIMS Bin Panel
- logging truck, reel, and cable
- AC generator
- temperature probe
- line power module
- ratemeter module
- chart recorder
- well sheave
- certified thermometer
- container of water for calibrating.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field

- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or
- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

4.2.1 Setting up and Calibrating Equipment

1. Turn the power ON-OFF switch to ON.
2. Turn the SRP main power switch to ON.
3. Turn the LPM CURRENT-VOLTAGE switch to CURRENT.
4. Move the LPM CURRENT ADJUST to 0.
5. Set the LPM instrument power switch to POSITIVE.
6. Turn the LPM CURRENT ADJUST control to 50 milliamps.
7. Set the RMM MODE switch to LINE.
8. Set the RMM CPS switch to 500.
9. Set the RMM TC switch to .01.
10. Set the RMM RECORDER OUTPUT to 1000.
11. Set the RMM POSITIVE-NEGATIVE switch to POSITIVE.
12. Set the RMM REVERSE-NORMAL switch to NORMAL.
13. Use recorder amplifier #2 for temperature measurements. Set ZERO at 490 and SPAN at 248. This will give a temperature range of 20° across the chart in °C. The probe is calibrated from 10° to 70°C.
14. Place the probe in a container of water. Use a certified thermometer to read the water temperature. Record this on the chart.
15. Use the RMM SUPPRESSION control to set the pen to a desired position on the chart. Example: the temperature span is set for 10° to 30°C across the chart and water temperature is 20°C. The pen would be set at the center of the chart paper. If the temperature

reaches 30°C while logging, stop and reset the pen to the left edge of the chart paper using the RMM SUPPRESSION control, making the span now read 30° to 50°C.

16. Place tool in the well and set to proper measuring point. Tool zero is at the bottom of the probe.
17. Set the UP-DOWN direction switch on the SRP in the down position and log going into the hole. Typical logging speed is 30 feet per minute.
18. When the bottom of the hole is reached, log back up 30 feet for system check. Temperature may vary slightly because the water was disturbed on the way down.
19. Bring the probe to the surface and recheck the calibration by placing the probe in the water container and reading the temperature with the certified thermometer. Record this on the chart; also record the serial number of the thermometer on the chart. If the temperature is off by over 0.3 of a degree, recalibrate and rerun the log. Record this on the chart; also record the serial number of the certified thermometer on the chart.
20. Review log for errors and fill in the log heading as discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedures.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."

- Procedure GL-10, "Flowmeter Probe Procedure."
- Procedure GL-11, "Magnetic Probe Procedure."
- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."
- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-3 CALIPER PROBE PROCEDURE

1.0 APPLICABILITY

This procedure describes borehole caliper logging. Caliper logging is used to determine hole and casing diameter, and locate caved zones, casing, and the absence of casing. The caliper tool is provided with different length caliper arms, depending on the diameter of the hole to be measured. The 6-inch arms extend to 18 inches and the 18-inch arms extend to 32 inches. The maximum logging speed is 50 feet per minute. Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules
- SRP - solid state recorder panel
- LPM - line power module
- RMM - rate meter module.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- NIMS Bin Panel
- chart recorder
- line power module
- rate meter module
- caliper probe
- caliper probe calibrator
- well sheave.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field
- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized

technical staff member will decide when a staff member in training is qualified to operate the equipment, or

- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

4.2.1 Attaching Tool and Opening Arms

1. Set the NBP power ON-OFF switch to ON.
2. Set the SRP main power switch to ON.
3. Attach caliper tool to the cable head.
4. Set the LPM CURRENT-VOLTAGE switch to VOLTAGE.
5. Set the LPM HIGH-NORMAL switch to HIGH.
6. Set the LPM NEG-OFF-POS switch to NEGATIVE.
7. Adjust LPM CURRENT ADJUST control to 200 volts.
8. Switch CURRENT-VOLTAGE switch to CURRENT (meter will read full scale). Arms will open fully in 20 to 30 seconds. Current will drop to 0.
9. Set the LPM NEG-OFF-POS switch to OFF.
10. Set the LPM CURRENT ADJUST to 0.

4.2.2 Setting up and Calibrating

1. Set the LMP NEG-OFF-POS switch to POSITIVE.
2. Adjust LPM current to read 60 milliamps.
3. Set the RMM mode switch to LINE.
4. Set the RMM POSITIVE-NEGATIVE switch to POSITIVE on tool #C-001, and NEGATIVE on tool #C-002.
5. Set the RMM REVERSE-NORMAL switch to NORMAL.
6. Set the RMM TC switch to 1.

7. Set the RMM CPS switch to 100 for tool #C-001 and 500 for tool #C-002.
8. Switch on a recorder amplifier.
9. Depress the ZERO switch on the RMM and adjust the pen to a desired position on the chart using the recorder amplifier zero potentiometer.
10. Close the caliper arms by placing the calibrator over the arms.
11. Bring the recorder pen to zero by using the SUPPRESSION control on the RMM.
12. Remove the calibrator, letting the arms open to maximum.
13. Use the recorder amplifier span control to adjust the desired span on the chart.
14. Repeat steps 11 through 13 until desired span has been set.
15. Place calibrator on caliper arms.
16. Record calibration settings on the chart. The short arms will measure from 2 to 17.75 inches. The long arms will measure from 2 to 32 inches.

4.2.3 Preparing to Log

1. Set the RMM mode switch to OFF.
2. Set the LPM NEG-OFF-POS switch to POSITIVE.
3. Set the LPM CURRENT-VOLTAGE switch to VOLTAGE.
4. Adjust LMP current adjust to 200 volts.
5. Set the LPM CURRENT-VOLTAGE switch to CURRENT. Caliper motor will run for 20 to 30 seconds closing the arms and the current will drop to 0.
6. Set the LPM NEG-OFF-POS switch to OFF.
7. Place probe in well and set to proper measuring point. Tool zero is at tips of tool arms.

4.2.4 Logging the Hole

1. Run tool into well to deepest known casing size.
2. Open arms and, using SUPPRESSION control, set pen to match casing size to calibration.

3. Close arms, proceed to bottom of hole.
4. Place the SRP transmission lever to the UP position.
5. Open the arms and log up. Maximum logging speed is 50 feet per minute.
6. Log back into known casing size to make sure instruments have not drifted.
7. For system check, rerun a 30-foot section, or if well has been logged before, overlap a 30-foot section of previous log.
8. Close the arms and bring the probe to the surface.
9. Review the log for errors. Fill in the log heading as discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."
- Procedure GL-11, "Magnetic Probe Procedure."
- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."

- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-4 SONIC PROBE PROCEDURE

1.0 APPLICABILITY

This procedure describes borehole sonic bond logging. Sonic logging provides an indication of formation density, quality of the casing bond to the formation, and grout or cement voids in the well. The sonic probe must be operated in a liquid-filled hole and the maximum logging speed is 60 feet per minute. Safety precautions during logging are described in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules specifications
- SRP - solid state recorder panel
- Scope - oscilloscope
- SBM - sonic bond module
- PA - pipe amplitude
- FA - formation amplitude.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- NIMS Bin Panel
- chart recorder
- line power module
- sonic bond module
- sonic bond probe
- oscilloscope
- probe centralizers
- well sheave.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field

- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or
- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

NOTE: Sonic logs should always be run with centralized tools where hole size permits. This is to ensure a near-constant travel time through the borehole and symmetrical response from all quadrants with no destructive interference of sound reaching the receiver because of unequal radial travel time paths between the tool and the borehole wall.

4.2.1 Attaching Probe to Cable Head and Applying Power

1. Set the NBP power ON-OFF switch to ON.
2. Set the SRP main power switch to ON.
3. Set the SBM power switch to ON.
4. Set the scope ON-OFF switch to ON.
5. Set the LPM NEG-OFF-POS switch to POSITIVE. Adjust current control fully clockwise. Current should read 60 to 65 milliamps. Voltage should read 300 volts. A clicking sound should be coming from the transmitter.
6. Place probe in well and set to proper measuring point. Probe zero is at bottom of probe.

4.2.2 Setting up the Scope

1. Set channel 1 to 0.5 V/cm and sweep time to 50 μ sec/cm. When logging use 1 V/cm and 0.1 μ sec/cm.

4.2.3 Setting up the SBM

1. Set dials to zero position.
2. Set LOG-ZERO to LOG.
3. Set LOG-FT ZERO to LOG.

4. Set scope A-B to A. Position A shows complete oscilloscope pattern and position B shows only the gated interval.
5. Set PA-FA to PA. For cement bond logging and logging inside the casing, use PA. For open hole logging, use FA.
6. Adjust SYNC control to obtain a scope trace. Adjust until trace appears and advance 1/2 division.

4.2.4 Calibrating the Equipment

To calibrate the amplitude curve:

1. Lower the tool into the well and stop it at a point in the well which is in fluid, in free pipe, and between casing collars. In cases where no free casing can be found in the well, return the logging tool to the surface and adjust travel time and amplitude to that observed with the tool in a water-filled aluminum tube.
2. Adjust SBM SIGNAL dial for 1/2 to 1 volt; that is, adjust amplitude for the first positive return signal to 1/2 to 1 volt. One vertical division on the scope screen equals 1/2 volt because the sensitivity is set on 0.5 volt/cm or 0.5 volt/chart division.
3. As the SYNC is turned up, a trace will appear on the scope. The SIGNAL should be increased and then increase the SYNC again until the proper trace is seen on the scope. An example is shown below.

Enclosed block is first positive return signal

4. Note position of the first positive return signal on the scope screen (the part of the trace adjusted for 1/2 or 1 volt). Switch SCOPE selector switch on SBM to B position.
5. Adjust the gate DELAY control until the left edge of the gate is aligned with the left edge of the first positive return signal. It may be necessary to turn the GATE width control up as needed to properly position the left edge of the gate to the left side of the first positive return signal.
6. Adjust the GATE width control until the right edge of the gate is aligned with the right edge of the first positive return signal. The gated interval should look like this:

If the gate is properly positioned when the SCOPE switch is changed from A to B, the "gated interval" will lie perfectly on the first positive return signal. If it doesn't, readjust the GATE and DELAY controls.

7. Turn on the recorder pen #2. Switch LOG-ZERO switch to ZERO position. Adjust pen with recorder zero control to left side of left chart.
8. Switch LOG-ZERO switch to LOG position. Adjust OUTPUT control on SBM to move pen to center of left chart. Switch back and forth from LOG to ZERO to position pen properly. Leave switch on LOG position when dials have been set up.

4.2.5 Setting Up a Formation Time Curve

1. Turn FT TRIGGER on SBM to obtain flags on scope trace.

2. Adjust FT TRIGGER until the bottom of the first flag is even with the baseline of the scope trace.
3. Switch LOG-FT ZERO switch to ZERO.
4. Turn on recorder pen #3. Position it to the right side of the right chart using the recorder zero control.
5. Switch LOG-FT ZERO switch to LOG.
6. Adjust the FT OUTPUT control to indicate 58 μ sec, 11-3/5 chart divisions to the left. (5 μ sec = 1 chart division.)
7. With the recorder zero control, move the pen to the right to suppress 40 μ sec (8 chart divisions). The pen should be 3-3/5 chart divisions from the right side. This adjustment makes the right side of the chart 40 μ sec and the left side 140 μ sec.
8. Turn CLAMP full clockwise to position 10.
9. Turn FT TRIGGER to zero. Turn CLAMP counterclockwise to set pen two chart divisions from left side of chart.

10. Readjust FT TRIGGER as in step 1 to obtain flags. Pen #3 should return to 3 3/5 chart divisions from the right side of the chart paper. Position bottom of first flag even with the baseline.

4.2.6 Running the Log

1. Lower tool to desired depth.
2. Place the SRP transmission lever in the UP position.
3. Log up. Maximum logging speed is 40 feet per minute.
4. For system check, rerun a 30-foot section, or if the well has been logged before, overlap a 30-foot section of previous log.
5. Return the probe to the place of setup and check for drift. If the curve is off by 10%, recalibrate and rerun the log.
6. Review the log for errors. Fill in the log heading as discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."
- Procedure GL-11, "Magnetic Probe Procedure."

- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."
- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-5 NEUTRON PROBE PROCEDURE

1.0 APPLICABILITY

This procedure describes borehole neutron logging. The neutron logging system provides a means for determining formation hydrogen content, moisture content, and porosity. Maximum logging speed is 25 feet per minute. Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedures.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules specifications
- SRP - solid state recorder panel
- LPM - line power module
- RMM - rate meter module.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- NIMS Bin Panel
- chart recorder
- line power module
- rate meter module
- neutron probe
- 3-Ci ²⁴¹Am Be source
- well sheave
- 50-mCi ²⁴¹Am Be calibration source.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field
- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the

supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or

- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

4.2.1 Setting Up the Equipment

1. Attach a 3-Ci Am Be source to the probe and the probe to the cable head.
2. Switch on the NBP and SRP power.
3. Set the RMM MODE switch to LINE.
4. Turn the RMM SUPPRESSION and RECORDER OUTPUT control fully clockwise.
5. Set the RMM TC switch to 2.
6. Set the RMM POSITIVE-NEGATIVE polarity switch to POSITIVE.
7. Set the RMM REVERSE-NORMAL switch to NORMAL.
8. Set the LPM CURRENT-VOLTAGE switch to CURRENT.
9. Set the LPM NEG-OFF-POS switch to POSITIVE.
10. Turn the LPM CURRENT ADJUST to 70 milliamps.

4.2.2 Calibrating the Equipment

1. Set the RMM MODE switch to CAL 100.
2. Set the RMM CPS switch to 100.
3. Switch SRP recorder amplifier to ON.
4. Depress ZERO on the RMM and hold in.
5. Adjust recorder amplifier ZERO to position pen to its preselected zero point on the chart.
6. Release the ZERO on the RMM.

7. Adjust the recorder amplifier SPAN control to the desired position on the chart. Record this span on the chart.
8. Set the RMM MODE switch to LINE.
9. Set the RMM CPS switch to 500.
10. With the probe resting on a dry surface at least 3 feet above the ground, take a 1-minute background count and record this on the chart. Use the time drive to advance the recorder chart.
11. Place the 50-mCi ^{241}Am Be neutron calibrator at the proper position on the probe and take a 1-minute count. Record this on the chart.

4.2.3 Logging

1. Place the probe in the well and set to proper measuring point. Probe zero is at the detector tube.
2. Change CPS switch to 1000 or 5000.
3. Lower the probe to bottom of the hole.
4. Place the SRP transmission lever in the UP position.
5. Run the log. Maximum logging speed is 25 feet per minute. Rerun a 30-foot section for system check, or if well has been logged before, overlap a 30-foot section of the previous log.

4.2.4 Checking the Calibration

1. Repeat steps 9, 10, and 11 from Section 4.2.2.
2. Record the span on the chart.
3. If the count rate does not match the calibration background and source count by 20 counts per second, the probe has malfunctioned and the log should not be used.
4. Review the log for errors and fill in the heading as discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."

- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."
- Procedure GL-11, "Magnetic Probe Procedure."
- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."
- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-6 BULK DENSITY PROBE PROCEDURE

1.0 APPLICABILITY

This procedure describes borehole bulk density logging. The bulk density logging system provides continuous recording of bulk density of materials surrounding the borehole. Maximum logging speed is 25 feet per minute. Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules specifications
- SRP - solid state recorder panel
- LPM - line power module
- RMM - rate meter module.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- NIMS Bin Panel
- chart recorder
- line power module
- rate meter module
- density probe
- 125-mCi ¹³⁷Cs source
- well sheave.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field
- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or

- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

4.2.1 Setting up the Equipment

1. Attach probe to cable head and the 125-mCi ^{137}Cs source to the probe.
2. Place probe in well and set to proper measuring point. Probe zero is at the detector, 3.7 feet from top of cable head spring.
3. Set the NBP and SRP power switches to ON.
4. Set the RMM NORMAL-REVERSE switch to REVERSE.
5. Set the RMM MODE switch to LINE.
6. Turn the RMM SUPPRESSION and RECORDER OUTPUT control fully clockwise.
7. Set the RMM TC switch to 3.
8. Set the RMM POSITIVE-NEGATIVE switch to NEGATIVE.
9. Set the LPM NEG-OFF-POS switch to POSITIVE.
10. Turn the LPM CURRENT ADJUST to 70 milliamps.
11. Set the RMM MODE switch to 100 CAL.
12. Set the RMM CPS switch to 100.
13. Switch a recorder amplifier to ON.
14. Depress the zero on the RMM and hold in.
15. Adjust the recorder amplifier on the SRP to ZERO to position pen to its preselected position on the right side of the chart.
16. Release zero on the RMM.
17. Adjust recorder SPAN control on the SRP to desired position on the left side of the chart. Record this span on the chart.
18. Set the RMM MODE switch to LINE.

19. Set the RMM CPS switch to 500.

4.2.2 Running the Log

1. Lower probe to bottom of the hole.
2. Place SRP transmission lever in the UP position.
3. Run the log. Maximum logging speed is 25 feet per minute.
4. Rerun a 30-foot section for system check, or if well has been logged before, overlap a 30-foot section of previous log.
5. Check the span and record it on the chart.
6. Review the log for errors and fill in the heading as discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."
- Procedure GL-11, "Magnetic Probe Procedure."
- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."

- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-7 GAMMA RAY PROBE PROCEDURE

1.0 APPLICABILITY

This procedure describes borehole gamma ray logging. Gamma ray logs are used for the determination of lithology and measurement of natural and induced gamma radiation. Gamma ray logs may be recorded in cased or uncased wells, fluid-filled or dry. Maximum logging speed is 20 feet per minute. Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules
- SRP - solid state recorder panel
- LPM - line power module
- RMM - rate meter module.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- NIMS Bin Panel
- chart recorder
- line power module
- rate meter module
- gamma ray probe
- well sheave
- 0.02-mCi ²²⁶Ra calibration source.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field
- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the

supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or

- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

4.2.1 Setting up Equipment

1. SET NBP and SRP switches to ON.
2. Turn the RMM SUPPRESSION and RECORDER OUTPUT controls fully clockwise.
3. Set the RMM TC switch to 3.
4. Set the RMM POSITIVE-NEGATIVE polarity switch to NEGATIVE.
5. Set the RMM REVERSE-NORMAL switch to NORMAL.
6. Set the LPM CURRENT-VOLTAGE switch to CURRENT.
7. Set the LPM INSTRUMENT POWER switch to POSITIVE.
8. Set the LPM CURRENT ADJUST to 75 milliamps for probe No. NG-001. For probe No. CG-27A97 use 60 milliamps.

4.2.2 Calibrating the Equipment

1. Set the RMM CPS switch to 100.
2. Set the RMM switch to CAL 100. RMM CPS meter should read 100 cps at this point.
3. Switch a recorder amplifier on the SRP to ON.
4. Depress the zero on the RMM and hold in.
5. Adjust recorder ZERO on the SRP to position pen to its preselected position on the chart.
6. Release the zero on the RMM.
7. Adjust the SPAN control on the SRP to position the pen to a desired position on the chart.

8. Record this span on the chart.
9. Set the RMM MODE switch to LINE.
10. Set the RMM CPS switch to 500.
11. Record gamma ray background in air, at least 50 feet away from any radioactive source.
12. Record the probe response to the .02-mCi ^{226}Ra source placed perpendicular to the probe and 42 inches from the detector. Make sure the source is pointing toward the top of the probe.

4.2.3 Logging

1. Place probe in the well and set depth to proper measuring point. Probe zero is at the counting tube.
2. Proceed to the bottom of the hole.
3. Place the SRP transmission lever in the UP position.
4. Log up. Log at 15 feet per minute.
5. For system check, rerun a 30-foot section, or if the well has been logged before, overlap a 30-foot section of the previously logged section.

4.2.4 Checking Calibration

1. Record gamma ray background in air, at least 50 feet away from any radioactive source.
2. Record the probe response to the .02-mCi ^{226}Ra source.
3. Record the span.
4. If the calibration check does not match the calibration count rate by 25 counts per minute, the probe has malfunctioned and the log should not be used.
5. Review the log for errors; fill in the heading as discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."

- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."
- Procedure GL-11, "Magnetic Probe Procedure."
- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."
- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-7A GROSS GAMMA-RAY LOGGING PROCEDURE - Work Requests from Westinghouse Hanford Company

1.0 APPLICABILITY

This procedure describes borehole gross gamma-ray logging performed for Westinghouse Hanford Company. Gamma-ray logs are used to help determine the subsurface lithology. Gamma-ray logs may be recorded in water-filled or dry wells that are uncased or cased with a single steel casing.

Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

Field calibration and operation instructions presented here conform as much as possible to American Petroleum Institute Standards (API 1974), as well as accepted uranium industry standards for gross-count gamma-ray logging (see IAEA 1982).

Responsibilities of Westinghouse Hanford Company staff presented in this procedure are included for information only.

2.0 DEFINITIONS

- analog gamma-ray logging system: a logging system that detects gamma rays and produces an electrical signal that is proportional to the rate at which gamma rays are detected
- correction factor: a numerical factor that is applied to logging measurements made under nonstandard conditions to derive the equivalent measurement that would have been made under standard conditions
- gamma-ray detector: an instrument which contains an active material within which photons interact, and an electronics package that converts signals (e.g., light or electric charge) from the photon interactions into recordable electronic signals
- gamma-ray probe: a probe designed to respond to gamma-ray intensity in a borehole or well
- gross-gamma-ray probe: a gamma-ray probe for which the electronic signal output is a sum of all detected radiation in the measurement time interval. Signal outputs are not sorted according to the energies of the photons that produced them.
- probe: the logging tool, i.e., the portion of the logging system, exclusive of the cable, that contains measurement instrumentation which is lowered into the borehole or well

- probe factor: a numerical constant, determined by measurements at a standard calibration model, and used for the direct conversion of logging system responses into standard units of measure
- well logging: the process of recording measurements in a borehole or well, as a function of depth.

3.0 RESPONSIBLE STAFF

- authorized technical staff.

NOTE: Approval of persons assigned to this position to perform gross gamma-ray logging for Westinghouse Hanford Company is required by the Manager, Geosciences Group, Environmental Engineering and Technology Function, Westinghouse Hanford Company.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source (generator or other)
- NIMS Bin Panel
- line-power module
- rate-meter module model RMM208, serial No. 185 or 182
- gamma-ray probe No. CG27A97
- well sheave
- 0.02-mCi ²²⁶Ra calibration source No. RA20S-204
- calibration source holder.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the gross-gamma geophysical well logging equipment in accordance with this procedure if they have the following qualifications, training, and approvals:

- (a) Associates degree in electronics, measurement systems, or mechanical engineering technology, or 5 years' direct experience with electronic measurement systems.
- (b) Background in geology, geotechnical engineering, or geophysics from 2 years of formal college education or 5 years of direct work experience.
- (c) Completion of a documented Training Assignment requiring the technical staff to complete a 24-hour training course in borehole geophysical logging theory and practice.

- (d) Completion of a documented Training Assignment requiring the technical staff to read the applicable PNL and Westinghouse Hanford Company procedures before going into the field.
- (e) Completion of a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or
- (f) The cognizant line manager waives the documented training requirements in (e) above and authorizes the technical staff based on previous experience. Such a waiver shall be documented by memo or similar means and state the basis for the waiver.
- (g) Approval by the Manager, Geosciences Group, Environmental Engineering and Technology Function, Westinghouse Hanford Company.

4.1.3 Other Prerequisites

The Westinghouse Hanford Company logging witness must be present for all of the work, including the set-up and pre- and post-survey calibrations.

The logging technician shall work closely with the Westinghouse Hanford Company logging witness to be certain that the witness has full knowledge of the details of each logging run.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

NOTE: Copies of the attached log header are to be used to record pertinent information for each logging session.

4.2.1 Setting up Equipment

1. Start the generators and turn on the NIMS bin power and each of the individual module power switches.
2. Be certain that the rate meter SUPPRESSION and RECORDER OUTPUT switches are set to the "10" position.
3. Set the rate meter POSITIVE-NEGATIVE polarity switch to NEGATIVE.
4. Set the rate meter REVERSE-NORMAL switch to NORMAL.
5. Set the line power module CURRENT-VOLTAGE switch to CURRENT.
6. Set the line power module INSTRUMENT POWER switch to POSITIVE.
7. Set the line power module CURRENT ADJUST to 60 milliamps for use with probe No. CG-27A97.

8. While the equipment is in the warm-up period, fill in log-header information.
 - (a) Record base-calibration reference and date on the log header. The date must be less than 1 year old to be valid.
 - (b) If a particular data field is not applicable to a particular logging session, so indicate by writing N/A in that field.
 - (c) Make all log header information and markings on the chart paper, including recorder pen markings, with waterproof, nonerasable ink. Line out corrections with a single line, and place with the correct entry next to the incorrect one. Initial and date the correction.
 - (d) Tape the log header sheets to the original log on completion of the logging session.
 - (e) Upon completion of the logging session, the original log becomes the responsibility of Westinghouse Hanford Company's logging witness, who must add any information to the log header that was not available at the time of logging, such as casing elevation or borehole survey coordinates.

A 2-page log header (attached) (a well information page and a logging information page) will be attached to all gross-gamma-ray logs. This is the pertinent information for qualifying the log.

NOTE: Deviations from specified requirements or special instructions should be handled in the following manner.

Critical deviations would be deviations from the procedure having to do with calibrations, data acquisition rates, equipment operations, or mode of operation that would have a significant impact on the quality of the data. These deviations are allowed if prior consent is obtained from Westinghouse Hanford Company's logging geophysicist. That consent can be verbal if time is of the essence, but written approval for the deviation is preferred.

For any deviations, a follow-up letter must be prepared by the Westinghouse Hanford Company logging witness to be sent to the Westinghouse Hanford Company logging geophysicist. That letter must describe the deviation, identify any possible impacts on the quality of the data, justify the reasoning for the deviation, indicate whether the deviation is a critical or noncritical deviation, and identify how approval for the deviation was obtained.

Any deviations shall be clearly identified on the log header in the comments section with a short note describing the deviation.

NOTE: A depth or elevation datum must be established during set up (usually the top of the casing) and recorded on the log header. This datum must be preserved long enough for a survey to be completed to determine the

datum elevation. (It is the responsibility of the logging field witness to ensure that the datum is preserved until it is surveyed).

1. Record the datum elevation if available, the ground-surface elevation and the approximate difference in elevation from that of the datum to that of the ground surface.
2. If water is present, determine the water level to within ± 0.1 foot as measured from the established elevation datum and record on the log header.
3. Obtain a sample of the water with a hand bailer, measure the water temperature with a hand-held thermometer, and record it on the log header. If the water appears cloudy and laden with suspended particles, note that on the log header.

4.2.2 Calibrating the Equipment

Position Responsible: AUTHORIZED TECHNICAL STAFF

A base calibration of the equipment is required once a year at a minimum. This calibration must be reviewed and approved by Westinghouse Hanford Company logging geophysicists. It should be similar to that reported in Brodeur and Koizumi (1989), and it should include an instrumentation calibration, a dead-time measurement, a primary source calibration, and a field source correlation.

After equipment warm up, perform a pre-survey calibration.

1. Set the rate meter output scale to 5000 CPS with a time constant of 1 second and the mode switch on "input."
2. Run a shielded cable from the output of the pulse generator to the input on the rate meter.
3. Set the pulse generator to produce 5000 counts per second.
4. Place the chart recorder on line with the vertical axis set on a time base with a chart speed of at least 1 inch per minute.
5. Press the rate meter "zero" contact switch and zero the chart recorder by adjusting the recorder zero knob.
6. Release the zero switch and adjust the chart recorder span so that the pen corresponds to the 10th major division on the chart paper.
7. Record at least 30 seconds of the zero output and 1 minute of the full-scale output.
8. Label the chart record as "Pre-survey instrumentation calibration."

NOTE: Once the chart recorder is set, the zero and span dials shall not be changed for the entire logging session.

After the above pre-survey calibration, perform a pre-survey field source calibration.

1. Place the gamma probe in a pipe clamp or suspend it so that it is at least 2 feet away from any solid matter.
2. Place the field calibration source in the source holder and place the holder in position 1 (see Figure 1) on the probe.
3. Switch the rate meter mode to "Line," allow the chart recorder to settle and record at least 1 minute of the gamma activity.
4. Place the source holder in position 2 (see Figure 1) and record 1 minute of the gamma activity (change the rate meter output settings if necessary to prevent chart saturation).
5. Remove the source holder, set the rate meter output to the lowest scale, and take a background reading for at least 1 minute. The probe must be left in the same position as in the position 1 and 2 calibration. (NOTE: It will be required to increase the time constant to at least 2 seconds in order to suppress statistical noise during the background measurement.)
6. Label the chart record as "Pre-survey field calibration" and label the individual traces as "position 1," "position 2," and "background."

NOTE: Because the linearity of the rate meter and chart recorder are established during the base calibration, it is not necessary to readjust the chart recorder zero and span when changing rate-meter output scales.

7. Determine the "position 1," "position 2," and "background"-activity values from the chart records and write them on the log header under the logging information section. The "position 1" and "position 2" data are converted to equivalent uranium concentration (eU) by applying the following formula:

$$C1 = (A1 - B0) * PF$$

$$C2 = (A2 - B0) * PF$$

where C1 = eU concentration for position 1
C2 = eU concentration for position 2
A1 = recorded activity in position 1
A2 = recorded activity in position 2
B0 = recorded background activity
PF = probe factor determined in base calibration.

FIGURE 1. Field Calibration Source Holder Diagram

C1 and C2 must agree with the base calibration field-source correlation values to within 8%. If the data do not correlate, the instrumentation is considered suspect and must be repaired.

4.2.3 Logging

If there is water in the borehole, the gross-gamma tool shall be operated in an eccentric position in the borehole, i.e., pressed against one side of the borehole casing. This requires a bowspring to be attached to the tool before the tool is lowered into the borehole. The bowspring must be appropriately emplaced on the probe so that the most sensitive part of the probe faces the borehole wall.

1. Correlate the center of the sodium iodide crystal inside the probe with the established depth datum for the particular borehole being logged. The AUTHORIZED TECHNICAL STAFF, with the logging witness's concurrence, will determine how best to do this. Make certain that the chart record and depth indicator correspond appropriately.

NOTE: If a sheave is placed at the top of the borehole on the well casing, the logging cable should be marked with a permanent mark at an established point above the tool scribe mark (5 feet or so). That mark shall be used for depth correlations. (The logging operation will begin and end at the specified depth rather than zero depth.)

2. Place the probe in the well and set the depth to the proper measuring point. Probe zero is at the center of the NaI crystal.
3. Lower the tool to the bottom of the hole.
4. Set the chart recorder so that the vertical gradations correspond to the depth shown on the depth indicator.
5. Lock the chart-recorder gear drive into place on the gear that produces a vertical chart scale of 1 inch per 10 feet, or 1 division per foot. (Place the SRP transmission lever in the UP position.)
6. Set the rate meter output scale to 500 CPS.
7. Set the rate meter time constant at 1 second for logging at 10 feet per minute or at 2 seconds for logging at 5 feet per minute. At no time should the data acquisition interval exceed 2 inches.

NOTE: The data acquisition interval is approximated by multiplying the logging speed by the time constant.

8. Log the borehole at the appropriate logging speed.

9. Write depth values on the log every 20 feet and record all of the logging information on the log header.
10. Upon reaching the top of the borehole, the chart-recorded depth indication must be checked against the borehole datum. Record the difference between these two depth measurements on the log and label as "depth error."
11. For system check, rerun a 30-foot section, or if the well has been logged before using this procedure, overlap a 30-foot section of that log. Label the rerun section on the log.

4.2.4 Reruns (as necessary)

Any zones along the borehole where the first log run produces an area where the chart record output was saturated must be rerun. These reruns should be recorded separately on the chart above the first run. The rerun zones shall completely include the previously saturated zones as well as 20 feet above and below the saturated zones when possible.

1. Lower probe to proper depth.
2. Set the rate meter output scale to the next higher scale.
3. Align the chart recorder and engage the gear drive.
4. Log the hole at a time constant and logging speed prescribed in Section 4.2.3.
5. If the instrument is still saturated, continue runs with the rate meter output set at each higher scale until a nonsaturated record is obtained or a peak of 14,500 CPS is reached. Rerun scales must be consecutive.

All reruns must use the same data acquisition interval (about 2 inches) as in the original run, unless compelling evidence exists to suggest changing this. Such evidence must be shown as a chart paper response and be included on the log. A note should be provided in the "notes" section.

The depth must be indexed to the borehole as in the original run (Section 4.2.3). A depth-error indication must be provided on the log at completion of all of the reruns.

All rerun chart scale information, chart speeds, time constants, and rerun depth increments must be recorded on page 2 of the log header at the time the rerun is made. Rerun recordings must also be labeled as "rerun 1, rerun 2, ... " on the chart record.

4.2.5 Checking Calibration (post-survey calibration)

The post-survey calibration is precisely the same as the pre-survey calibration. The reader is referred to Section 4.2.2 of this procedure for a detailed description.

1. Perform a post-survey calibration as prescribed in Section 4.2.2.
2. Convert the post-survey calibration data to equivalent uranium units and compare to the pre-survey calibration data. If the difference is greater than 8%, the instrumentation is suspect and the logging should be redone.

4.2.6 Logging-Records Disposition

The final task for logging the borehole is to check the log header to make certain that all of the log header information is filled out and correct and that all charts from the chart recorder are correctly and appropriately labeled.

1. Attach the log header to the log.
2. If everything is correct and any abnormalities are recorded in the comment sections of the log header, the logging witness signs the log header signifying Westinghouse Hanford Company's acceptance of the log.
3. The log is given to the Westinghouse Hanford Company logging witness, who handles it according to Westinghouse Hanford Company protocols.

The logging witness must make arrangements to have the depth datum surveyed and obtain the survey information for later inclusion on the log header.

5.0 REFERENCES

- ANSI. 1980. American National Standard Calibration and Usage of Sodium Iodide Detector Systems. ANSI N4212-1980, American National Standards Institute, New York.
- API. 1974. Recommended Practice for Standard Calibration and Format for Nuclear Logs. RP 33, Third Edition, American Petroleum Institute, Dallas, Texas.
- Brodeur, J. R., and Koizumi. 1989. Base Calibration of Pacific Northwest Laboratory's Gross Gamma Borehole Geophysical Logging System. WHC-EP-0246, Westinghouse Hanford Company, Richland, Washington.

- IAEA. 1982. Borehole Logging for Uranium Exploration. IAEA Technical Reports Series, No. 212, International Atomic Energy Agency, Vienna, Austria.

ATTACHMENT 1 EXAMPLE OF PAGE ONE OF THE LOG HEADER

<h1 style="margin: 0;">WESTINGHOUSE</h1> <h1 style="margin: 0;">HANFORD COMPANY</h1>	
WELL NUMBER _____ AREA _____	
DATE _____	
LOG RUN _____ LOG TYPE _____	
SURVEY COORDINATES _____ N _____ E	
ELEVATION DATUM _____ ELEVATION _____	
LOG MEASURED FROM _____	
LOCATION DESCRIPTION _____	
GROUND SURFACE ELEVATION _____	
SURFACE TEMPERATURE _____ WEATHER _____	
BOREHOLE INFORMATION	
DRILLER _____	
DRILL RIG TYPE _____	BIT TYPE/DIAMETER _____
BOREHOLE DIAMETER(S)/DEPTH _____	
DEPTH DRILLER _____	DEPTH LOGGER _____
LIQUID LEVEL _____	LIQUID APPEARANCE _____
TEMPERATURE _____	
CASING RECORD	
TYPE _____	INTERVAL _____
TYPE _____	INTERVAL _____
TYPE _____	INTERVAL _____
TYPE _____	INTERVAL _____
WELL SCREEN INTERVAL: _____	
COMMENTS: _____	

ATTACHMENT 1 (contd)

EXAMPLE OF PAGE TWO OF THE LOG HEADER

EQUIPMENT DATA			
LOGGING COMPANY			
OPERATOR(S)			
EQUIPMENT BRAND		EQUIPMENT TYPE	
TOOL TYPE		BASE CALIBRATION DATE	
SERIAL NO.		CALIBRATION REFERENCE	
CALIBRATION / PROBE FACTOR			
DEAD TIME		WARM UP TIME	
LOGGING INFORMATION			
LOG INTERVAL FROM		TO	
RERUNS			
PRE SURVEY CALIBRATION		POSITION 1	POSITION 2 BACKGROUND
LOGGING SPEED			
START TIME		COMPLETION TIME	
CHART SPEED(S), FT/IN.			
CHART RECORDER HORIZONTAL SCALE, CPS/IN.			
RERUN SCALES, CPS/IN.			
TIME CONSTANT(S)			
POST SURVEY CALIBRATION		POSITION 1	POSITION 2 BACKGROUND
PERCENT CHANGE		POSITION 1	POSITION 2
COMMENTS			
WITNESSED AND VERIFIED BY:			

GL-7B ANNUAL CALIBRATION OF PACIFIC NORTHWEST LABORATORY'S GROSS GAMMA GEOPHYSICAL LOGGING SYSTEM

1.0 APPLICABILITY

This procedure shall be implemented at least once annually. The calibration results shall be reported in a referenceable document by March 1 of each year. Three days should be allotted to perform the instrument calibration, a dead-time measurement, a primary source calibration, a depth calibration, and a field source correlation. Three months should be allotted for compiling and publishing the report. Therefore it is suggested that the calibration activities for a given year be initiated before December 1 of the previous year.

2.0 DEFINITIONS

- Dead-time measurement - a measurement of the average time the system is inoperative. This is the time required for the system to produce a pulse and to prepare to count the succeeding event.
- Primary source - permanent calibration models used for annual calibration.
- Field source - a 20- μCi ^{226}Ra sealed source used as a calibration check at the well site.

3.0 RESPONSIBLE STAFF

- Cognizant Manager - Appoint authorized technical staff to perform calibration activities, including preparation of the calibration report.
- Authorized Technical Staff - Perform calibration activities and prepare calibration report in accordance with this procedure. Keep the client's borehole geophysicists informed on the progress of the calibration activities and schedule a witness for these activities, if so requested.

4.0 PROCEDURE

4.1 Prerequisites

A controlled laboratory notebook shall be acquired prior to initiating these activities and all pertinent information recorded therein.

4.2 Instrument Calibration

Position Responsible: AUTHORIZED TECHNICAL STAFF

1. Call Hanford Standards Laboratory (376-3276) to schedule a day to perform the instrument calibration. Scheduling should be done

1-2 months in advance. All instrument calibration activities shall take place at the 3717B Building in the 300 Area on the scheduled date.

2. Plug instruments into AC power and allow them to warm up for 15 minutes.
3. Perform pulse generator check.
 - a. Run a shielded cable from output on the pulse generator to a calibrated digital pulse counter supplied by Hanford Standards Laboratory.
 - b. Set scale on the pulse generator to 50 kHz and pulse on positive.
 - c. Adjust the variable amplitude and record the peak voltage.
 - d. Repeat step c with the pulse set on negative.
 - e. Repeat step c for the 10 Hz, 50 Hz, 100 Hz, 500 Hz, 1 kHz, 5 kHz, and 10 kHz scales on the pulse generator, first with the pulse set on positive, then with the pulse set on negative.
 - f. Set the variable amplitude to approximately half scale and the pulse to negative.
 - g. Record two 1-second readings for each frequency setting on the pulse generator (10 Hz through 50 kHz).
 - h. Repeat step g with the pulse set to positive.
 - i. If all readings taken in steps a through h are within tolerable limits (determined by the Hanford Standards Laboratory technician helping perform the work), then the pulse generator shall be considered calibrated. If measurements are not within these limits, the Hanford Standards Laboratory will determine the appropriate corrective action.
 - j. Record the date, time, personnel involved, readings, instrument serial number, prior calibration dates, and steps taken in the laboratory notebook. Sign and date below the last entry on the page and cross out any unused space.
4. Perform rate meter check.
 - a. Set and lock both the suppression and recorder outputs at 10.
 - b. Run a shielded cable from the pulse generator to the input on the rate meter #1.
 - c. Set reverse/normal on the rate meter to normal.

- d. Set positive/negative on the rate meter to negative.
 - e. Set the time constant on the rate meter to 1.
 - f. Set the rate meter to input.
 - g. Disconnect chart recorder and A>D converter from the back of the rate meter. Connect a calibrated volt meter to the recorder output on the back of the rate meter.
 - h. Set the rate meter scale to 100 cps.
 - i. Input 10 Hz, 50 Hz, and 100 Hz from the pulse generator with a shielded cable and record the voltage output in millivolts for each input.
 - j. Repeat step i for scales of 500, 1,000, 5,000, 10,000, and 50,000 cps with input that will produce 10%, 50%, and 100% output.
 - k. Disconnect the shielded cable from the rate meter.
 - l. Set the "line, input, 100 CAL" switch on the rate meter to 100 CAL.
 - m. Set the rate meter scale to 100, 500, and 1,000 cps scales and record each output in millivolts. This will check the internal 100 Hz oscillator in the rate meter itself.
 - n. Repeat steps a through m for rate meter #2.
 - o. If all readings taken in steps a through n are within tolerable limits (determined by the Hanford Standards Laboratory technician helping perform the work), then the rate meter shall be considered calibrated. If measurements are not within these limits, the Hanford Standards Laboratory will determine the appropriate corrective action.
 - p. Record the date, time, personnel involved, readings, instrument serial number, prior calibration dates, and steps taken in the laboratory notebook. Sign and date below the last entry on the page and cross out any unused space.
5. Perform chart recorder calibration check.
- a. Plug the chart recorder channel 2 into the recorder output on the back of the rate meter.
 - b. Switch the rate meter to 100 CAL and the scale to 100 cps.
 - c. Turn on channel 2 of the chart recorder. Using the recorder span, set the pen to full scale. Depress the zero button on

the rate meter and using the recorder zero, adjust the pen to zero. Repeat this step until the proper span has been set. Record and label this span on the chart.

- d. Unplug channel 2 from the recorder output on the back of the rate meter and plug it into a calibrated DC standard voltage generator supplied by the Hanford Standards Laboratory.
- e. Determine the voltage output for the rate meter in step 4m when the rate meter scale was set at 100 cps. This should equal the full-scale input voltage for the chart recorder. Divide the full-scale voltage by ten to obtain 10% input value.
- f. Input the 10% value with the standard voltage generator to the rate meter with a shielded cable and record the pen deflection on the chart. Record the input value and an estimate of the chart deflections in the laboratory notebook.
- g. Add the 10% value to the previous value and input the new value, recording the value and deflection as in step f. Continue this step until you reach full scale.
- h. If all readings taken in the steps above are within tolerable limits (determined by the Hanford Standards Laboratory technician helping perform the work), then the chart recorder shall be considered calibrated. If measurements are not within these limits, the Hanford Standards Laboratory will determine the appropriate corrective action.
- i. Record the date, time, personnel involved, readings, instrument serial number, prior calibration dates, and steps taken in the laboratory notebook. Sign and date below the last entry on the page and cross out any unused space. Label the chart and tape it to a page in the laboratory notebook. Laboratory Record Book page should also be labeled with the attachment identification. Sign and date below the chart and cross out any unused space.

4.3 Depth Calibration Check

Position Responsible: AUTHORIZED TECHNICAL STAFF

NOTE: Depth calibration shall be performed in well 399-5-2.

1. Attach the zero of a 500-ft calibrated steel tape to the zero point (5.1 ft below the top of the cable head) on the gross gamma tool. Verify calibration status of the steel tape prior to use. Note the tape number and calibration date in the notebook.
2. Set the top of the cable head even with the top of the casing. Subtract the stick-up of the casing from 5.1 ft and set the depth odometer on the chart recorder to this depth. Check the reading

on the steel tape; it should be the same as on the chart recorder. Record both of these depths in the laboratory notebook.

3. Run the tool down to 400 ft. Record the odometer and tape readings in the laboratory notebook.
4. Engage the chart drive and set a pen on a major chart division. Label this as 400 ft.
5. Run the tool up 50 ft as indicated by the depth odometer. Record the tape reading and mark the chart by moving the pen sideways manually.
6. Repeat step 5 every 50 ft until the tool is back to the surface.
7. If all odometer and tape readings agree to within 0.5 ft, the odometer will be considered calibrated. If measurements do not meet this criterion, repeat steps 1 through 6. If depth readings are still off by more than 0.5 ft, adjust the sheave wheels inside the horse head slightly and repeat steps 1 through 6 until tape readings are within the 0.5-ft tolerance.
8. Record the date, time, personnel involved, tape serial number, and calibration date in the laboratory notebook. Sign and date the notebook page below the last entry and cross out any unused space. Sign, date, and fold the chart and tape it to a laboratory notebook page.

4.4 Dead-Time Calculation

Position Responsible: AUTHORIZED TECHNICAL STAFF

NOTE: This activity requires the use of two 20- μ Ci ^{226}Ra sources; therefore, the current Radiation Work Permit governing geophysical logging activities applies.

1. Follow steps outlined in section 4.2 of Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company" for setting up and calibrating the gross gamma probe. Fill out a log header with all pertinent information.
2. Place the probe in the vise on the back bumper of the logging truck, with the probe pointing toward the center of the back bumper.
3. Place both ^{226}Ra sources next to each other and equidistant from the center of the probe. Check the count rate produced with this arrangement. A count rate of approximately 10,000 cps is desired. Move sources closer to or farther from the probe to achieve this count rate.
4. Set the rate meter scale to 50,000 cps.

5. Move source 2 at least 30 ft away and record the count rate for 2 minutes.
6. Place source 2 back in its original position and record for another 2 minutes.
7. Move source 1 at least 30 ft away and record for another 2 minutes.
8. Move source 2 at least 30 ft away and record background for 2 minutes.
9. Set the rate meter at 10,000 cps and repeat steps 5 through 8.
10. Move the sources back from the probe until their combined count rates equal approximately 5,000 cps.
11. Repeat steps 5 through 8 with the rate meter set at 10,000 cps.
12. Set the rate meter at 5,000 cps and repeat steps 5 through 8.
13. Move the sources back from the probe until their combined count rate equals approximately 3,000 cps.
14. Repeat steps 5 through 8 twice with the rate meter set at 5,000 cps.
15. Label the chart to show source 1, source 2, sources 1 and 2, and background with the appropriate scales. Write a brief description of the steps taken and list the source serial numbers in the laboratory notebook.
16. Perform a post calibration (outlined in section 4.2.2 of Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company").
17. Include the actual dead-time calculations in the calibration report.

4.5 Field Source Correlation

Position Responsible: AUTHORIZED TECHNICAL STAFF

NOTE: This activity requires the use of two 20- μ Ci ^{226}Ra sources; therefore, the current Radiation Work Permit governing geophysical logging activities applies.

1. Follow the steps outlined in section 4.2 of Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company" to set up and calibrate the gross gamma geophysical logging system.

2. Set the rate meter on line and the scale on 5,000 cps.
3. Attach one of the 20- μ Ci ^{226}Ra sources to the source holder and place the source holder in position 1 on the probe (see Exhibit A).
4. Record 2 minutes at this count rate with the chart recorder.
5. Move the source in its holder to position 2 (see Exhibit A).
6. Change the rate meter scale to 1,000 cps and record 2 minutes at this count rate with the chart recorder.
7. Repeat steps 2 through 6 ten times.
8. Label each recording on the chart as "Pos.1 5,000 cps" or "Pos.2 1,000 cps" and with the serial number of the source used.
9. Reset the rate meter scale to 5,000 cps, replace the first source with the second, again in position 1, and repeat steps 4 through 8.
10. Perform a post calibration (outlined in section 4.2.2 of Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company").
11. Write a brief description of the field source correlation including date, time, location, personnel involved, and source serial number on a page in the laboratory notebook. Sign below the last entry and cross out any unused space. Sign the log and tape it to a page in the laboratory notebook.
12. Calculate average values for both position 1 and 2 for the calibration report. Convert these values to equivalent uranium units and report them as the new base calibration datum points for positions 1 and 2.

4.6 Primary Calibration

Position Responsible: AUTHORIZED TECHNICAL STAFF

NOTE: External contamination (radon) has been detected on the probe after running it through the calibration models. It is suggested that a Health Physics Technician (HPT) be notified prior to performing this task. The HPT will survey the equipment when calibration is finished and provide instruction if contamination is detected.

EXHIBIT A. Field Calibration Source Holder Diagram

POSITION 1

POSITION 2

1. Follow the steps outlined in section 4.2 of Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company" to set up and calibrate the gross gamma geophysical logging system.
2. Before inserting the probe, swab out each of the two calibration models to be used with rags tied to a piece of PVC pipe to remove as much radon as possible.
3. Place the probe in a polyethylene bag and attach the specially cut piece of PVC pipe to the cable head. The pipe will be used to insert the probe into the model. Tape three short pieces of PVC pipe lengthwise to the sides of the probe to keep the probe centralized in the models. All of these pieces of PVC pipe are stored next to the models.
4. Carefully insert the probe into the SBA/SBB model until it strikes the end.
5. Take the slack out of the geophysical logging cable with the hydraulic winch on the logging truck.
6. Set the rate meter scale to 5,000 cps, engage the chart recorder drive, and turn on the chart recorder.
7. Use the hydraulic winch to pull the probe through the model at approximately 5 ft/min. Quit recording when the probe exits the model.
8. Reset the rate meter to scales of 10,000 cps and 50,000 cps, return the probe to the end of the model, take up the slack, and repeat step 7.
9. Label the chart with the appropriate scales, zones, and model (in this case SBA/SBB). Zone SBB will exhibit the highest count rate and should be saturated (excessive noise) on all scales.
10. Replace the SBA/SBB with the SBL/SBH model and repeat steps 4 through 9. The SBH zone will exhibit the highest count rate and should be saturated on all scales.
11. Perform the post calibration (outlined in section 4.2.2 of Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company").
12. Record all pertinent information including date, time, personnel involved, models, scales used, and whether any external contamination was detected on the probe in the laboratory notebook. Sign and date below the last entry on the page and cross out any unused space.

13. Sign and date the log and tape it to a page in the laboratory notebook.

4.7 Preparation of the Calibration Report

Position Responsible: AUTHORIZED TECHNICAL STAFF

1. Incorporate the information gathered in steps 4.2 through 4.6 into a report similar to PNL-7460, "1990 Yearly Calibration of Pacific Northwest Laboratory's Gross Gamma Borehole Geophysical Logging System" (Arthur 1990). This document shall be published by March 1 of each year.

5.0 REFERENCES

- Arthur, R. J. 1990. 1990 Yearly Calibration of Pacific Northwest Laboratory's Gross Gamma Borehole Geophysical Logging System. PNL-7460, Pacific Northwest Laboratory, Richland, Washington.

GL-8 SPONTANEOUS POTENTIAL-RESISTANCE PROBE PROCEDURE

1.0 APPLICABILITY

This procedure describes borehole spontaneous potential-resistivity logging. Spontaneous potential (SP) logs are records of the natural potentials developed between the borehole fluid and the surrounding rock materials and is measured in millivolts. The SP is chiefly used for geologic correlations, determination of bed thickness, and separating porous from nonporous rocks. Resistivity logging devices measure the electrical resistivity of a volume of earth under the direct application of an induced electric current. Resistivity devices are generally used to determine the formation resistivity, formation porosity, mud cake resistivity, invaded zone resistivity and porosity, hydrocarbon and water saturation, fluid resistivity, and formation factor. SP&R logs may be made in uncased, liquid-filled holes only. Maximum logging speed is 100 feet per minute. Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules specifications
- SRP - solid state recorder panel
- ELM - electric log module
- SP&R - spontaneous potential-resistivity.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- NIMS Bin Panel
- chart recorder
- electric log module
- converter module
- resistance SP test box
- ground line
- spontaneous potential-resistivity probe
- well sheave.

4.1.2 Precautions

WARNING: Be sure to turn off all power before handling the probe. If this is not done, the operator may receive an electrical shock. Before

starting to operate this module, make sure that all other systems are off. If this is not observed, the equipment may be damaged.

4.1.3 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field
- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or
- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

4.2.1 Setting Up and Calibrating for Resistance Logging Using the Test Box

1. Remove the 300-volt power supply cable from the NBP and connect to the CONVERTER MODULE.
2. Remove the line connection from the NBP.
3. Connect the TEST BOX to the cable head and the NBP line connection.
4. Switch on the power to the NBP.
5. Switch on power to the SRP.
6. Switch ELM LINES switch to ON.
7. Rotate ELM FUNCTION switch to E-LOG position.
8. Set the X1-X10 switch on the ELM in X1 position.
9. Rotate RES. SCALE switch on ELM to "0" position.
10. Place CAL-LOG switch on ELM in the LOG position.
11. Place 100 CAL-TEST switch on Test Box in 100 CAL position.

12. Place WITHOUT CABLE-WITH CABLE switch on Test Box in the WITH CABLE position.
13. Switch on amplifier 1 and 3 on the SRP. Channel 1 is used for the 64-inch normal and channel 3 is used for the 16-inch normal.
14. Using recorder ZERO controls, base the 16-inch and 64-inch normal pens of the SRP on the left margin of the 20-division chart paper track.
15. Switch the RES. SCALE switch on the ELM to 10G. The pens should deflect 10 divisions on the chart paper. If the pen deflections are not 10 divisions, adjust the recorder SPAN controls.
16. Repeat steps 8, 13, and 14 until the probe is properly calibrated, and record "0" and span on the chart.
17. Place Test Box 100 CAL-TEST switch in the TEST position.
18. Rotate Test Box MAX TEST control and observe pens. The 64-inch normal pen (#1) deflection should be four times greater than the 16-inch normal pen (#3) deflection.

4.2.2 Calibrating the Spontaneous Potential

1. Switch recorder amplifier #2 on the SRP to ON.
2. Rotate the S.P. SELECTOR switch on the ELM to the 100 position.
3. Set the Test Box switch 100 CAL-TEST to the TEST position.
4. Using the recorder ZERO control, base the S.P. pen on the right margin of the 10-division chart paper track.
5. Turn on the Test Box S.P. switch and adjust the MAX TEST control for 10 divisions of pen deflection to the left. If the S.P. pen does not deflect 10 divisions, adjust the recorder span control.
6. With the Test Box S.P. switch actuated, consecutive positions of 50, 150, and 200 on the module S.P. SELECTOR switch should deflect the pen twice, $\frac{2}{3}$, and $\frac{1}{2}$ the distance of the 10 divisions, respectively. Record this on the chart.
7. This completes the calibration procedure. Place all power switches in the OFF position.
8. Disconnect the Test Box and replace cables removed to connect the Test Box.

9. Ensure that the ground circuit is complete to the MUD PIT ground jack on the front of the ELM module. Failure to have a good mud pit ground will result in excessive noise, poor log quality, or no log at all.

4.2.3 Running the Log

1. Connect the probe to the cable head and set to proper measuring point in the well. The 64-inch normal is 5.8 feet from the top of the cable head spring.
2. Lower probe below the surface casing.
3. Switch on main power to the NBP, SRP, and the ELM.
4. Observe the pens while lowering the probe over interval to be logged and select the logging scale. If pens go off scale, switch X1-X10 switch to X10 position.
5. Record the zero setting on resistance pens at the bottom of the hole.
6. Set the S.P. pen two chart divisions to the left of the right hand side of the 10-division chart.
7. Place the SRP transmission lever in the UP position.
8. Run the log. A good logging speed is 25 feet per minute.
9. Record a 30-foot repeat section, or if the well has been logged before, overlap a 30-foot section of the previous log.
10. After log is completed, switch ELM RES. SCALE to "0" to check for drift. Record this on the chart.
11. Make sure power is OFF to the probe before removing it from the well.
12. Review the log for errors and fill in the log heading as discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

4.2.4 Setting Up and Calibrating the Resistance Probe Without the Test Box

1. Make sure mud pit ground is making a good connection.
2. Connect the probe to the cable head, set to proper measuring point, then lower into fluid past the surface casing.
3. Use steps 5 through 8 in Subsection 4.2.1.
4. Place the CAL-LOG switch on the ELM in the CAL position.

5. Use steps 12 through 15 in Subsection 4.2.1.

4.2.5 Setting Up and Calibrating the Spontaneous Potential Probe Without the Test Box

1. Follow steps 1, 2, and 4 in Subsection 4.2.2.
2. Hold the S.P. TEST-LOG switch in the S.P. TEST position. The pen should deflect 10 divisions to the left, and the NORMAL CURRENT meter should read 10 MA of current.
3. If the S.P. pen does not deflect 10 divisions, adjust the recorder span control. The S.P. internal calibration signal is equal to the position of the S.P. selector (if the S.P. selector is on 50, the signal is equal to 50 MV). Therefore, on internal calibration, the recorder pen should deflect 10 divisions on any position of the S.P. selector.
4. This completes the internal calibration procedure. Change the CAL-LOG switch on the ELM to LOG.
5. Follow steps 4 through 12 in Subsection 4.2.3 for running the log.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."
- Procedure GL-11, "Magnetic Probe Procedure."

- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."
- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-9 FLUID RESISTIVITY PROBE PROCEDURE

1.0 APPLICABILITY

This procedure describes borehole fluid-resistivity logging. Fluid-resistivity logs provide a measurement of the resistivity of the in-hole fluid between electrodes in the probe. It is sometimes used to determine the zone of water entry into a well. Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules specifications
- SRP - solid state recorder panel
- ELM - electric log module.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- NIMS Bin Panel
- chart recorder
- electric log module
- converter module
- ground line
- fluid-resistivity probe
- well sheave.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field
- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or

- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

4.2.1 Setting Up the Equipment

1. Connect the probe to the cable head.
2. Put MUD PIT ground line out.
3. Position the probe electrode at a reference point.
4. Lower the probe until it is completely submerged in the borehole fluid.
5. Switch on the main power to the NBP.
6. Rotate the ELM FUNCTION switch to the FLUID RES. position.
7. Place the ELM module X1-X10 switch in the X1 position.
8. Switch on channel three of the SRP recorder. Channel three is selected for standardization and reference purposes.
9. Plug channel three into the output jack on the back of the ELM labeled FLUID RES.

4.2.2 Calibrating the Equipment

1. Place the ELM ON-OFF switch in the ON position.
2. Place the ELM CAL-LOG switch in the CAL position.
3. Switch SRP main power switch to ON.
4. Rotate the RES. SCALES switch on the ELM to the "0" position.
5. Rotate the RES. SCALES switch on the ELM to position 10. The pen should deflect 10 divisions to the right. The Fluid Resistivity internal calibration signal is equal to 10 ohms m^2/m . This signal is constant even if different resistivity scales are used. If the pen does not deflect 10 divisions, it will be necessary to adjust the deflection using the recorder SPAN control.
6. Rotate the RES. SCALES switch on the ELM from position 10 to 20 and observe the pen deflection, then rotate the switch back to position 10. The pen should have deflected 1/2 (5 divisions) of

the 10 divisions. Repeat steps 3 through 6 until the proper span is adjusted. Record this on the chart.

4.2.3 Running the Log

1. Rotate the CAL-LOG switch on the ELM to the LOG position.
2. Begin logging by lowering the probe into the hole at 25 feet per minute. This log is always made going into the borehole.
3. Run a 30-foot repeat section.
4. After the log has been run, rotate the CAL-LOG switch on the ELM to the CAL position and repeat steps 4 through 6 of the Sub-section 4.2.2.
5. Rotate the ELM RES. SCALES switch to the "0" position and record this on the chart.
6. If the calibration check is off by 10%, the log should not be used.
7. Review the log for errors and fill in the heading as discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."

- Procedure GL-11, "Magnetic Probe Procedure."
- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."
- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-10 FLOWMETER PROBE PROCEDURE

1.0 APPLICABILITY

This procedure describes borehole flowmeter logging. Flowmeter logs are used to meter fluid flow rates within either cased or uncased wells. They help determine where fluid is entering or leaving the borehole, and locate lost circulation zones and holes in the casing. This probe is not calibrated and is used for indication only. Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules
- SRP - solid state recorder panel
- RMM - rate meter module
- FMM - flowmeter module.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURES

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- NIMS Bin Panel
- chart recorder
- rate meter module
- flowmeter module
- flowmeter probe
- well sheave
- 200-cc light-weight oil.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field
- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized

technical staff member will decide when a staff member in training is qualified to operate the equipment, or

- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

4.2.1 Setting up the Equipment

1. Remove the top sub from the flowmeter probe. Fill the oil container with thin nonconductive oil.
2. Attach flowmeter probe to the cable head.
3. Place NBP and SRP main power switches in the ON position.
4. Set the RMM MODE switch to LINE.
5. Set the RMM CPS switch to 100 and TC switch to 1.
6. Set the RMM POSITIVE-NEGATIVE polarity switch to POSITIVE.
7. Set the RMM power ON-OFF switch to ON.
8. Select a recorder channel on the SRP and plug the input connector into the output jack in back of the RMM.
9. Using the selected recorder channel zero control, base the pen on the left margin of the chart paper by setting the RMM FUNCTION switch in the CAL 100 position and depressing the ZERO button.
10. Adjust the SRP SPAN control and set the pen on the right margin of the chart paper. Record these settings on the chart paper.
11. Check the flowmeter probe by rotating the rotor blades located on the bottom of the probe. The blades should move freely, and the recorder pen should move to the right.
12. Zero the point of measurement of the tool to the proper reference point. Tool zero is at the impeller blades.

4.2.2 Running the Log

1. The flowmeter may be run into or out of a well at a constant speed to obtain a continuous flow profile versus depth. It may also be stopped at various levels in the well to record the total volume

of flow at any preselected level. When stopped in the well, the recorder time drive may be used to advance the chart paper.

2. If a flow is too great and the pen goes off scale, advance the CPS scale to the next range.
3. Record all scale changes, stops, logging speed, and logging direction on the chart.
4. Review the log for errors and fill in the heading as discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-11, "Magnetic Probe Procedure."
- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."
- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-11 MAGNETIC PROBE PROCEDURE

1.0 APPLICABILITY

This procedure describes borehole magnetic logging. Magnetic surveys are used to locate magnetic reversals in basalt flows and areas of interbedding and to identify different flows. Logs are run in uncased holes only. Normal logging speed is 40 feet per minute. Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure. This probe is not calibrated and is used for indication only.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules specifications
- SRP - solid state recorder panel
- LPM - line power module.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- NIMS Bin Panel
- chart recorder
- line power module
- magnetic probe
- well sheave.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field
- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or

- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

1. Place switch on back of LPM in up position.
2. Plug the number one recorder amplifier input on the SRP into the number one output on the back of the LPM using the 22K ohm resistor.
3. Plug the number two recorder amplifier input on the SRP into the number two output on back of the LPM using the 5.6K ohm resistor and the 100 MFD capacitor.
4. Connect the probe to the cable head.
5. Set number one recorder amplifier ZERO control on the SRP to 487 and SPAN control to 192.
6. Set number two recorder amplifier ZERO control on the SRP to 551 and SPAN control to 052.
7. Set CURRENT on the LPM to 70 milliamperes.
8. Place probe in the well and set to the measuring point.
9. Set the transmission control on the SRP to run 10 inches of chart per 100 feet.

4.2.2 Running the Log

1. Lower the probe to the bottom of the hole. Place the SRP transmission lever in the UP position and log up. A good logging speed is 40 feet per minute.
2. Run a 30-foot repeat section over a portion of good activity.
3. Review the log for errors and fill in the heading as discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

4.2.3 Shutting Down the Equipment

1. Turn all switches to OFF.
2. Disconnect the recorder amplifiers from the back of the LPM.
3. Place switch on back of the LPM in the up position.

4. Change the transmission control on the SRP back to 5 inches of chart per 100 feet.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."
- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."
- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-12 DOWNHOLE TELEVISION SYSTEM OPERATING PROCEDURE

1.0 APPLICABILITY

This procedure describes the operation of the Downhole Television System. Television surveys can help interpret the lithology of a borehole and inspect casing conditions for rust, broken welds, or method of perforation. They are also useful for looking at the position of lost tools before designing a fishing tool to retrieve them. Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

2.0 DEFINITIONS

- VTR - video tape recorder.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- camera and camera housing
- light source
- centralizers
- surface controls and monitor
- video recorder and video tape
- well sheave.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field
- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or
- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on

previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.1.3 Safety Precautions

Television surveys can be hazardous, especially when the work is connected with a drilling rig. Hard hat, gloves, and safety shoes must be worn when working around drilling rigs. Special care should be taken to ensure the electrical power is off before assembling and disassembling the camera and light system. Failure to observe this safeguard may result in electrical shock.

Review Job Safety Analysis on Operation of Government Vehicles.

Review Job Safety Analysis on Operation of the Downhole Television System.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

4.2.1 Connecting Camera and Lighthead to Outer Housing

1. Inspect and lubricate the cable head "O" rings.
2. Slide the centralizer assembly over the cable head.
3. Attach the camera housing to the cable head by rotating the housing, not the cable head.
4. Adjust the f-stop on the camera. A good starting point for the majority of surveys would be a setting of f 5.6. Small diameter holes or bright reflective walls may require a setting that allows less light through the lens, such as f 11. Large holes and cloudy water may require more light at a setting of f 2.8 or smaller. The system is designed to vary the lamp brightness over a wide range to adapt to any f-stop setting, but ideally the setting selected would result in good lighting with the brightness control at midrange to allow adjustments in both directions.
5. Check the lighthead and make sure the viewing port is clean, the banana plugs are undamaged, and the "O" rings are clean and lubricated.
6. Insert the camera part way into the housing and affix the lighthead to the front of the camera by connecting the banana plugs to the respective plugs on the camera front face.
7. Push the camera and lighthead into the housing until the lighthead sits on the shoulder inside the housing. A gentle side-to-side movement may be required to set the lighthead assembly in place.

8. Assemble the four spring steel centralizer bands. Attach them to the front of the camera housing using the four lighthead screws.
9. Adjust the top end of the centralizers to the size hole to be surveyed and tighten the set screw against the cable head.
10. Ensure that all connections are properly made and test the camera and lighthead for operation.

4.2.2 Operating the System

NOTE: Review "Underground Survey Corporation, Water Well and Borehole Survey System Operating Instructions." Review "Operating Instructions, Sony Videocassette Recorder Model VO-2610."

1. Turn on the video tape recorder (VTR) and insert a video tape cassette.
2. Turn on the camera control unit and the monitor.
3. Simultaneously press the VTR REC and PLAY buttons. This starts the VTR to record. Now press the PAUSE button to stop the tape. This saves tape while you adjust the monitor and control unit.
4. Set the camera at the zero measuring point in the well. Camera zero is at the lens. Press the FOOTAGE RESET button and zero the digital readout on the monitor screen. Reset the mechanical counter on the cable reel.
5. Lower the camera out of the surface light and adjust the camera lamp brightness, and the monitor contrast and brightness, until a good picture is obtained.
6. Plug the microphone into a MIC IN jack on the front of the VTR.
7. Press the PAUSE button, starting the tape.
8. Speak into the microphone with information such as the well name, date, diameter, or any other pertinent information about the well.
9. Proceed to lower the camera into the well. The right speed is determined by observing the monitor and adjusting the speed control valve to suit the observers.
10. Verify correct operation of the VTR before proceeding by recording the first 10 to 15 feet or so of the inspection run and playing the tape back.
11. Complete the log.

4.2.3 Shutting Down and Disassembling the Camera

1. Bring the camera to the surface.
2. Shut off all power to the television system.
3. Disassemble the centralizer bows from the lighthouse and the lighthouse from the camera housing.
4. Remove the camera and housing from the cable head. The camera should always be removed from the outer housing when stored. This will prevent the accumulation of moisture by condensation within the camera.
5. Wipe clean all disassembled parts and store in the logging van to avoid damage during transport.

5.0 REFERENCES

- "Operating Instructions, Sony Videocassette Recorder Model VO-2610."
- Underground Survey Corporation, "Water Well and Bore-hole Survey System Operating Instructions."
- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."

- Procedure GL-11, "Magnetic Probe Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."
- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-13 X-Y CALIPER PROBE PROCEDURE

1.0 APPLICABILITY

This procedure describes borehole X-Y caliper logging. X-Y caliper logging is used to determine hole and casing diameter and locate caved zones, wash-outs, casing, and the absence of casing. The X-Y caliper probe with its four arms measures borehole dimensions in two axes simultaneously. One set of arms measures the "X" dimension while the opposing arms measure the "Y" dimension. The tool can measure borehole diameters from 4 to 30 inches. With the optional extension arms installed, the maximum measurement increases to 60 inches. The maximum logging speed is 60 feet per minute. Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules specifications
- SRP - solid state recorder panel
- LPM - line power module
- RMM - rate meter module.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- line power module
- two rate meters
- X-Y caliper calibrator
- chart recorder
- well sheave
- NIMS Bin Panel
- X-Y caliper probe.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field

- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or
- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

4.2.1 Setting Up the Equipment

1. With all power switches in the OFF position, attach the tool to the cable head.
2. Place the LPM meter switch in the VOLTAGE position.
3. Open the caliper arms by placing the LPM NEG-OFF-POS switch to POS and adjusting the CURRENT control clockwise until the meter indicates 100 VDC. After the arms are fully extended, the motor limit switch opens. This shows a voltage kick on the meter.
4. Rotate the CURRENT control on the LPM fully counterclockwise.
5. Rotate the LPM POS-OFF-NEG switch to OFF, then back to POS.
6. Set the LPM meter mode switch to CURRENT and advance the CURRENT control until the meter reads 90 mA DC. Allow the equipment to warm up and stabilize, about 5 minutes.
7. Switch the toggle switches on the SRP amplifiers 1 and 2 to Hi Z.
8. Set the two rate meters as follows:

	<u>X Axis</u> <u>RMM #1</u>	<u>Y Axis</u> <u>RMM #2</u>
POS-NEG Switch	POSITIVE	NEGATIVE
NORMAL-REVERSE Switch	REVERSE	NORMAL
CPS Selector Switch	1000	1000
MODE Switch	LINE	LINE
TIME CONSTANT Switch	1.0	1.0
SUPPRESSION	1000	1000

9. Use SRP pen #1 for the X axis and pen #2 for the Y axis and plug them into their proper position in the back of the rate meters.
10. Place SRP pen #1 in the ON position.
11. Depress the ZERO button on RMM #1 while adjusting SRP pen #1 ZERO control and place the pen one chart division to the left of the center of track 2.
12. Rotate the SPAN control on SRP pen #1 to read 280.
13. Depress the ZERO button on RMM #2 while adjusting SRP pen #2 ZERO control and place the pen one chart division to the right of the center of track 2.
14. Rotate the SPAN control on SRP pen #2 to read 280.

4.2.2 Calibrating the Probe

1. Place calibrator on probe and set for 28-inch diameter.
2. Adjust SRP pen #1 to left edge of track 2 using #1 RMM RECORDER OUTPUT control.
3. Adjust SRP pen #2 to right edge of track 2 using #2 RMM RECORDER OUTPUT control.
4. Set arms in calibrator for 6-inch diameter.
5. Adjust SRP pen #1 to one chart division to the left of the center of track 2 using RMM #1 SUPPRESSION control.
6. Adjust SRP pen #2 to one chart division to the right of the center of track 2 using RMM #2 SUPPRESSION control.
7. Move the arms from the 6-inch to the 28-inch diameter settings in the calibrator while adjusting the RECORDER OUTPUT and SUPPRESSION controls. Repeat these steps until the pens track the calibrated diameter scale correctly. Any combination of spans can be made, such as 4 to 12 inches, or 8 to 20 inches.

4.2.3 Closing the Arms

1. Place the RMM power switches in the OFF position.
2. Turn the LPM CURRENT control fully counterclockwise.
3. Turn the LPM POS-OFF-NEG switch to NEG.
4. Turn the LPM meter switch to VOLTAGE.

5. Advance the LPM CURRENT control until the meter indicates 100V. After the arms are fully closed, the motor limit switch opens and the meter will show an upward kick.
6. Turn the CURRENT control fully counterclockwise and set the NEG-OFF-POS switch to OFF.

4.2.4 Running the Log

CAUTION: Never let the tool slide downward with the arms in the open position. It may bend the arms or damage the tool.

1. Place the probe in the well and set the odometer to the proper measuring point. Tool zero is at the tips of the tool arms.
2. Lower the probe to the bottom of the borehole and motor the arms open.
3. Set the LPM to the proper operating current of 90 mA.
4. Turn on both RMM and both recorder pens. Set SRP direction lever in the up position and log up. Maximum logging speed is 60 feet per minute.
5. Log into known casing size for at least 20 feet to check for instrument drift.
6. After the required survey has been run, stop the tool, close the arms, and lower the tool past a zone of good activity. Open the tool and run a 30-foot repeat section. Close the tool and come out of the hole.
7. Review the log for errors and fill in the heading as discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

4.2.5 Maintaining the Probe

Read the X-Y Caliper Tool Operators Manual for maintenance and care of this probe.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."

- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."
- Procedure GL-11, "Magnetic Probe Procedure."
- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."
- Procedure GL-15, "Fluid Sampler Procedure."

GL-14 X-Y CALIPER PROBE PROCEDURE WITH BOREHOLE VOLUME COMPUTER

1.0 APPLICABILITY

This procedure describes X-Y caliper with borehole volume computer logging. The X-Y caliper is an extremely versatile tool in that it provides two totally independent caliper curves simultaneously. This provides a unique look at an open hole (or casing) capable of showing irregularities in the hole, such as egg-shaped holes, large washouts, and restricted places not possible to find with a conventional two- or three-arm caliper. When the optional Borehole Volume Computer (BVC) is used in conjunction with the standard surface electronics, the X-Y caliper is capable of computing simultaneous borehole volume in units of 1-, 10-, or 100-cubic-foot increments. In addition, the BVC provides an average curve of the borehole diameter derived from the independent X-Y dimensions. The X-Y caliper can measure diameters from 4 to 28 inches. The maximum logging speed is 60-feet per minute. Safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules specifications
- SRP - solid state recorder panel
- LPM - line power module
- RMM - rate meter module
- BVC - borehole volume computer.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- NIMS Bin Panel
- line power module
- two rate meters
- borehole volume computer module
- X-Y caliper calibrator
- chart recorder
- well sheave
- X-Y caliper probe.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field
- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or
- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

4.2.1 Setting Up the Equipment

1. Use RMM #1 for the X axis and RMM #2 for the Y axis.
2. Connect a jumper cable from the Hi Z connector on the back of RMM #1 to the X input on the back of the BVC.
3. Do the same thing for RMM #2 and run it to the Y input on the back of the BVC.
4. Connect the Hi Z recorder output cable from amplifier #1 to the X output on the back of the BVC.
5. Connect the amplifier #2 Hi Z cable to the Y output on back of the BVC.
6. Connect the amplifier #3 cable to the X+Y/2 connector on the BVC.
7. Connect the amplifier #4 cable to the BVC volume marker. The event marker switch on back of the BVC causes the volume mark to be negative in the up position and positive in the down position.
8. Switch all recorder amplifier toggle switches located on the back of each amplifier to the Hi Z position.
9. With the equipment power switches in the off position, connect the probe to the cable head.

10. Place the LPM meter in the VOLTAGE position.
11. Open the arms by placing the LPM NEG-OFF-POS switch to POS and adjust the CURRENT control clockwise until the meter indicates 100 VDC. After the arms are fully extended, the meter limit switch opens, showing a voltage kick on the meter.
12. Rotate the CURRENT control on the LPM fully counterclockwise.
13. Rotate the LPM NEG-OFF-POS switch to OFF, then back to POS.
14. Set the LPM meter mode switch to CURRENT and advance the current control until the meter reads 90 mA DC. Allow the equipment to warm up and stabilize, about 5 minutes.
15. Set the two rate meters as follows:

	<u>X Axis RMM #1</u>	<u>Y Axis RMM #2</u>
POS-NEG Switch	POSITIVE	NEGATIVE
NORMAL-REVERSE Switch	NORMAL	NORMAL
CPS switch	500	500
MODE switch	LINE	LINE
TIME CONSTANT switch	.01	.01
SUPPRESSION	1000	1000

16. Select a span that will bracket the average expected diameter of the borehole. As an example, 4 to 16 inch will be used.
17. Switch the BVC power to ON and set both toggle switches to X. Place the NORM-REV switch to REV.
18. Observe that the count rate decreases when the diameter is decreased and increases when the diameter is increased. This indicates that the tool is working. If the rate meters do not respond as expected, correct the problem before proceeding.

4.2.2 Calibrating the Probe

1. Place calibrator on the probe and set for 4-inch diameter.
2. Turn the SUPPRESSION control on the X axis RMM counterclockwise until the display on the BVC reads 4.0.
3. Set both X-Y toggle switches on the BVC to X.
4. Turn the SUPPRESSION control on the Y axis rate meter counterclockwise until the display on the BVC reads 4.0.

5. Set arms in the 16-inch calibrator holes.
6. With both switches on the BVC in the Y position, turn the RECORDER OUTPUT control on the Y RMM counterclockwise until the display on the BVC reads 16.0 inch.
7. Set both X-Y toggle switches on the BVC to X.
8. Turn the RECORDER OUTPUT on the X axis RMM counterclockwise until the display on the BVC reads 16.0 inches.
9. Repeat steps 1 through 8 until no further adjustment is necessary.
10. On the BVC, turn X, X+Y and Y OUTPUTS fully clockwise.
11. Set the #1 and 2 SPAN controls on the SRP to 500.
12. Place the calibrator on the probe and set to 4.0 inches.
13. Set the X-Y toggle switches on the BVC to X.
14. With the #1 recorder ZERO control, move the X pen one chart division to the left of the center of track 2.
15. Set both X-Y toggle switches in the Y position.
16. With the #2 recorder ZERO control, move the Y pen one chart division to the right of the center of track 2.
17. Set one of the X-Y switches in the X position and the other in the Y position. The digital display should still read 4.0.
18. With the #3 recorder ZERO control, move the X+Y/2 pen one chart division to the right on track 1.
19. Set the arms in the 16-inch holes in the calibrator. The digital display on the BVC should read 16.0.
20. With the X+Y/2 OUTPUT on the BVC, adjust pen #3 to seven chart divisions to the right on track 1.
21. Switch both X-Y switches on the BVC to X.
22. Turn the X OUTPUT on the BVC and adjust pen #1 to seven chart divisions to the left of the center of track 2.
23. Switch both X-Y switches to Y on the BVC.
24. Turn the Y OUTPUT on the BVC and adjust pen #2 to seven chart divisions to the right of the center of track 2.

25. Repeat steps 12 through 24 until no further adjustment is necessary. This calibration makes each chart division equal to 2-inches.
26. The volume mark is run on pen #4 and is set on the right edge of track 1 using the #4 ZERO CONTROL. These marks are either positive or negative, depending on the event marker located on the back of the BVC. A scale selector located on the front of the BVC gives borehole volume in units of 1-, 10-, or 100-cubic-foot increments.

4.2.3 Closing the Arms

1. Shut off power to all modules.
2. Set the LPM CURRENT ADJUST to 0.
3. Switch the POS-OFF-NEG switch to NEG.
4. Change the meter switch to VOLTAGE.
5. Advance the CURRENT control until the meter indicates 100V. After the arms are fully closed, the limit switch on the motor opens and the meter will show an upward kick.
6. Turn the CURRENT control to 0 and set the POS-OFF-NEG switch to OFF.

4.2.4 Running the Log

1. With the probe in the well and the arms closed, set the SRP odometer to the depth reference and lower the tool into the hole.
2. When the bottom of the logging interval is reached, stop the tool and motor the arms open. Never let the tool slide downward in the hole with the arms open. It may bend the arms or damage the tool.
3. Apply the proper current and make sure all modules are ON.
4. Reset the volume marker circuit by placing the VOL-RESET switch on the front of the BVC to RESET and back to VOL.
5. Mark all calibration scales on the chart.
6. Set the SRP chart direction lever in the UP position and log at 60 feet per minute. The BVC was designed for this specific tool speed. Any other speed will give inaccurate results.
7. Note the size of the volume marker pulse and set the amplitude, if required, to one chart division, using the MARKER LEVEL control on the front of the BVC.

8. After the survey, run a repeat section over a zone of good activity. Run an interval of at least 30 feet.
9. Log into known size casing where possible for 100 feet to check the borehole volume. If volume is off by 10%, recalibrate.
10. Close the tool and come out of the hole.
11. Review the log for errors. Fill in the heading as discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

4.2.5 Maintaining the Probe

Read the X-Y Caliper Tool Operators Manual for maintenance and care of this probe.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."
- Procedure GL-11, "Magnetic Probe Procedure."
- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."

- Procedure GL-15, "Fluid Sampler Procedure."

GL-15 FLUID SAMPLER PROCEDURE

1.0 APPLICABILITY

This procedure describes the operation of the Fluid Sampler probe. The Fluid Sampler probe is designed to take samples from various depths below the water surface. It will withstand pressure to 4,000 psi. Additional safety precautions during logging are discussed in Procedure GL-1, Geophysical Well Logging Van Operating Procedure.

2.0 DEFINITIONS

- NBP - NIMS Bin Panel
- NIMS - nuclear instrument modules specifications
- LPM - line power module.

3.0 RESPONSIBLE STAFF

- Authorized Technical Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- logging truck with cable and reel
- AC power source
- NIMS Bin Panel
- line power module
- fluid sampler probe
- sample containers.

4.1.2 Qualification for Authorization

Technical staff will be considered authorized to operate the geophysical well logging equipment in accordance with procedures GL-1 through GL-15 if:

- (a) they have completed a documented Training Assignment requiring the technical staff to read the applicable procedures before going into the field
- (b) they have completed a documented Training Assignment of on-the-job training in the use of the geophysical logging equipment under the supervision of an authorized technical staff member. The authorized technical staff member will decide when a staff member in training is qualified to operate the equipment, or
- (c) the cognizant line manager waives the documented training requirements in (a) and (b) above and authorizes the technical staff based on previous experience. Such a waiver must be documented by memo or similar means and state the basis for the waiver.

4.2 Step-by-Step Instructions

Position Responsible: AUTHORIZED TECHNICAL STAFF

CAUTION: Do not exceed 80 milliamperes or 40 volts to the tool. The motor will burn out if this is exceeded.

4.2.1 Equipment Setup and Sampling Procedure

1. Attach fluid sampler to cable head and hang in the well.
2. Set the depth odometer at the proper depth. The tool zero is 3.4 feet from the top of the cable head spring.
3. Lower the tool to the desired depth that the sample is to be taken.
4. Turn on the NBP.
5. Set the LPM CURRENT-VOLTAGE switch to CURRENT.
6. Set the LPM HIGH-LOW switch to HIGH.
7. Set the LPM NEG-OFF-POS switch to POS.
8. Set the LPM CURRENT ADJUST to 80 milliamps. This step will open the valve for sample collection.
9. Set the LPM CURRENT-VOLTAGE switch to VOLTAGE. The meter should read about 40 volts. When the valve is fully open, the voltage will drop.
10. Switch the LPM NEG-OFF-POS switch to OFF.
11. Allow enough time to fill the sample barrel with fluid. If sampling in mud, allow a little longer time, maybe 5 minutes, to fill.
12. Set the LPM CURRENT-VOLTAGE switch to CURRENT.
13. Set the LPM NEG-OFF-POS switch to NEG.
14. Adjust the LPM CURRENT ADJUST to obtain 80 milliamps; this will close the sample barrel valve.
15. Set the LPM CURRENT-VOLTAGE switch to VOLTAGE. The meter should read about 40 volts. When the valve is fully closed, the voltage will drop.
16. Switch the LPM NEG-OFF-POS switch to OFF.
17. Raise the tool from the well.

18. Slightly open the barrel valve, then close the valve. If a high pressure is present in the sampler, fluid should spray out. This will relieve any excessive pressure.
19. Remove the bottom plug on the sample barrel and collect the sample into the container(s) provided by the PNL well-site geologist/hydrologist. The geologist/hydrologist is responsible for marking the containers and chain-of-custody of the samples.
20. Wash the barrel out two times with distilled water and replace the plug. The tool is ready for the next sample.

5.0 REFERENCES

- Procedure GL-1, "Geophysical Well Logging Van Operating Procedure."
- Procedure GL-2, "Temperature Probe Procedure."
- Procedure GL-3, "Caliper Probe Procedure."
- Procedure GL-4, "Sonic Probe Procedure."
- Procedure GL-5, "Neutron Probe Procedure."
- Procedure GL-6, "Bulk Density Probe Procedure."
- Procedure GL-7, "Gamma Ray Probe Procedure."
- Procedure GL-7A, "Gross Gamma-Ray Logging Procedure - Work Requests from Westinghouse Hanford Company."
- Procedure GL-7B, "Annual Calibration of Pacific Northwest Laboratory's Gross Gamma Geophysical Logging System."
- Procedure GL-8, "Spontaneous Potential-Resistance Probe Procedure."
- Procedure GL-9, "Fluid Resistivity Probe Procedure."
- Procedure GL-10, "Flowmeter Probe Procedure."
- Procedure GL-11, "Magnetic Probe Procedure."
- Procedure GL-12, "Downhole Television System Operating Procedure."
- Procedure GL-13, "X-Y Caliper Probe Procedure."
- Procedure GL-14, "X-Y Caliper Probe Procedure with Borehole Volume Computer."

SA-1 SEDIMENT SAMPLE ANALYSIS/SAMPLE CONTROL PROCEDURE

1.0 APPLICABILITY

This procedure applies to the notification of analytical laboratories of upcoming sediment analysis requirements and the transport, storage, and logging of samples by the laboratory.

The primary purpose of this procedure is to communicate the analyses required early on so that by the end of the project all requested analyses will have been completed. Sample control procedures are established so that the laboratory personnel knows what samples have been delivered for analyses and where these samples are located.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Technical Staff transporting samples to the laboratory
- Laboratory Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- laboratory notebook, PNL numbered (LRB)
- storage facility.

4.2 Step-by-Step Instructions

4.2.1 Sample Transfer and Identification

Position Responsible: TECHNICAL STAFF AND LABORATORY STAFF

1. Before delivery of samples to the laboratory, the Technical Staff shall deliver a completed Request for Analytical Services (RAS) form to the person in charge in the lab detailing the analyses required for the samples.
2. When samples arrive in the lab a Chain of Custody form shall accompany them to acknowledge receipt of the samples. The samples are then properly stored as required by the analyses to be performed, in a refrigerator or other storage facility.
3. As the samples are brought into the lab for analysis the lab staff logs each into a Laboratory Record Book (LRB) or onto sheets provided by requester, by well number and depth or sample number (whichever is provided with the sample).

4. As the samples are subdivided for various analyses, each sample is to be labeled with a well number and depth or sample number or other uniquely identifying label traceable to the original sample.
5. The lab staff performs the analyses in accordance with procedures SA-2 through SA-9 as specified in the Request for Analytical Services.

4.2.2 Records

1. Record in a Laboratory Record Book (LRB) all measurements, calculations, dates and times, all equipment calibration I.D. numbers, and all other information that may be pertinent to the analysis.
2. Records must include equipment used and calibration I.D. numbers if the instrument is M&TE category 1 calibrated. If the instrument is user calibrated that data and equipment I.D. are recorded in the project LRB.
3. All lab data are to be recorded in a PNL numbered Laboratory Record Book (LRB) that has been assigned to the project for which the data are generated. If records are such that they cannot be recorded in an LRB or attached to an LRB the records are placed in a permanent project file. All data must be traceable to the original sample and RAS form.

5.0 REFERENCES

- Procedure SA-2, "Sieve Procedure."
- Procedure SA-3, "Particle-Size Analysis (Hydrometer Method)."
- Procedure SA-4, "Constant Head Hydraulic Conductivity Determination Procedure."
- Procedure SA-5, "Falling Head Hydraulic Conductivity Procedure."
- Procedure SA-6, "Water Retention Procedure."
- Procedure SA-7, "Water Content."
- Procedure SA-8, "Cold Density/Bulk Density."
- Procedure SA-9, "Determining Particle Density."

SA-2 SIEVE PROCEDURE

1.0 APPLICABILITY

This procedure applies to sieve analysis of samples to determine the relative proportions of various grain size fractions found in the sediments underlying Hanford. The samples to be analyzed are collected at various depths during the drilling of monitoring wells.

The dried sample is shaken through a nest of sieves, going from the coarsest at the top to the finest on the bottom, and the fraction retained by each sieve is weighed.

The procedure is divided into two methods. Dry sieving is done on coarse samples, and wet sieving followed by dry sieving is done on fine-textured samples.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Laboratory Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- sieves - brass, 8-inch diameter to meet ASTM-E11 specifications

Wentworth Scale		Fine Soil Sieves	
Sieve No., U.S. Standard	Retained Particle Diameter, mm	Sieve No., U.S. Standard	Retained Particle Diameter, mm
5	> 4.0	10	> 2.00
10	2.0	18	1.00
18	1.0	35	0.50
35	0.5	60	0.25
60	0.25	140	0.106
120	0.125	200	0.075
230	0.063	270	0.053
325	0.045		

- calibrated balance(s) (0.01-g precision)
- pan

- Rotap shaker with circular and tapping motion, equipped with a 20-minute timer
- wire brush for use on #60 sieves and coarser
- paint brushes for use on sieves finer than #60
- Soil Test standard sample splitter
- ultrasonic, 8-inch-diameter by 4-inch-deep sieve cleaner
- drying trays
- mortar and rubber-tipped pestle
- drying oven - adjusted to $105 \pm 2^{\circ}\text{C}$.

4.2 Step-by-Step Instructions

4.2.1 Preparing Samples

Position Responsible: LABORATORY STAFF

All information is to be recorded in a Laboratory Record Book (LRB). This is to include all measurements, calculations, soil moisture condition, sieves used, dates and times, all equipment calibration numbers, and all other information that may be pertinent to the analysis.

1. Log samples in by well number and depth or sample number according to Procedure SA-1, Sediment Sample Analysis/Sediment Control Procedure (if not done previously).
2. Place sample in appropriately labeled pan and place in oven at 105°C for 12 hours or overnight.
3. Remove sample from oven and carefully break up aggregates with mortar and rubber-tipped pestle.
4. Return sample to original sample jar.

4.2.2 Analyzing the Sample by the Dry Sieve Method

Position Responsible: LABORATORY STAFF

1. If the sample weighs more than about 1000 g, pour through sample splitter. If there are large pieces that will not pass through the splitter, place them in the pan into which they would have fallen.
2. Select one of the two pans and weigh the sample and record the weight to the nearest 0.01 g. Return the unused portion of the

sample to the original sample jar. Record calibration number of balance used. Record on data sheet (Figure 1).

3. Inspect a set of sieves (Wentworth scale set) for cleanliness. (See subsection 4.1.1, "Equipment," for mesh sizes.) If the mesh is clogged, clean it with a wire or paint brush. An ultrasonic cleaner can be used if this method fails.
4. Weigh each clean sieve separately and record the weights (Figure 1).
5. Pour the dried sample into the top of the nest of clean sieves.
6. Shake on the Rotap shaker for 20 minutes.
7. Check the sediments in each sieve for aggregates. If present, grind them with the mortar and pestle and return to the same sieve and again shake for 20 minutes. Grind only enough to break up the aggregates. Prolonged grinding will break down the primary particles.
8. Weigh each sieve with the retained soil and record each sieve separately on data sheet. The sum of all the weights should be within 2% of the original sample weight. If the error is greater than 2%, the analysis must be repeated.
9. If the sample is to be analyzed for CaCO_3 , go to step 10. If not, return the sample to the original jar, and stop procedure.
10. Pour all soil fractions that passed through sieve 18 into a plastic jar or bag, label the jar with the sample identification, and save it for CaCO_3 analysis. Return the rest to the original jar.
11. Calculate the amount of soil retained on each sieve and also the percent passing each sieve.

4.2.3 Analyzing the Sample by the Wet Sieve Method

Position Responsible: LABORATORY STAFF

1. Follow the dry sieve method through step 4.
2. Pour the dried sample into a clean #270 sieve. Wash the sample thoroughly by passing a stream of water through the sample on the sieve. Continue to do this until the water passing through the sample is clear.
3. Dry the sample on the sieve in the oven for at least 3 hours or until the sample is dry - longer for large samples.

SAMPLE _____ WT _____ (g) SAMPLE _____ WT _____ (g)

<u>Sieve</u> <u>Size (mm)</u>	<u>Sieve wts (g)</u>	<u>Sieve</u> <u>Size (mm)</u>	<u>Soil +</u> <u>Sieve wt (g)</u>	<u>Soil</u> <u>wt (g)</u>
4.00		4.00		
2.00		2.00		
1.00		1.00		
0.50		0.50		
0.25		0.25		
0.125		0.125		
0.063		0.063		
0.045		0.045		
pan		pan		

SAMPLE _____ WT _____ (g) SAMPLE _____ WT _____ (g)

<u>Sieve</u> <u>Size (mm)</u>	<u>Soil +</u> <u>Sieve wt (g)</u>	<u>Soil</u> <u>wt (g)</u>	<u>Sieve</u> <u>Size (mm)</u>	<u>Soil +</u> <u>Sieve wt (g)</u>	<u>Soil</u> <u>wt (g)</u>
4.00			4.00		
2.00			2.00		
1.00			1.00		
0.50			0.50		
0.25			0.25		
0.125			0.125		
0.063			0.063		
0.045			0.045		
pan			pan		

SAMPLE _____ WT _____ (g) SAMPLE _____ WT _____ (g)

<u>Sieve</u> <u>Size (mm)</u>	<u>Soil +</u> <u>Sieve wt (g)</u>	<u>Soil</u> <u>wt (g)</u>	<u>Sieve</u> <u>Size (mm)</u>	<u>Soil +</u> <u>Sieve wt (g)</u>	<u>Soil</u> <u>wt (g)</u>
4.00			4.00		
2.00			2.00		
1.00			1.00		
0.50			0.50		
0.25			0.25		
0.125			0.125		
0.063			0.063		
0.045			0.045		
pan			pan		

FIGURE 1. Data Sheet

4. When the sample is dry, remove it from the oven and transfer the sample completely to the top sieve of the fine-soil sieve nest.
5. Continue with step 8 of the dry sieve method.

5.0 REFERENCES

- Uebelacker, D. L. 1980. "Granulometric Analysis of Disaggregated Sediment Samples." Analytical Procedure LA-519-131, Rockwell Hanford Operations, Richland, Washington.
- Gee, G. W., and J. W. Bauder. 1986. "Particle-Size Analysis." In Methods of Soil Analysis, Part 1, ed. A. Klute, pp. 383-409. American Society of Agronomy, Madison, Wisconsin.

SA-3 PARTICLE-SIZE ANALYSIS (HYDROMETER METHOD)

1.0 APPLICABILITY

This procedure applies to particle-size analysis of sediment samples by the hydrometer method. The purpose of this procedure is to measure the size distribution of individual particles in a soil sample. This is done by the destruction or dispersion of soil aggregates into discrete units by chemical, mechanical, or ultrasonic means, and the separation of particles according to size limits by sieving and sedimentation.

A sample is first dispersed by mechanical or ultrasonic means, and the resulting suspension is measured with a hydrometer over a given period of time to determine the silt and clay content. The sample is then sieved through a nest of sieves to determine the various sizes of the sand fraction of the sample.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Laboratory Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- standard hydrometer, ASTM 152H, with Bouyoucos scale in g/L (calibrated during procedure)
- electric stirrer (malted-milk-mixer type, with 10,000 rpm motor)
- plunger or rubber stoppers for 1000-mL sedimentation cylinders
- sedimentation cylinders with 1-L mark 36 ± 2 cm from the bottom of the inside
- ROTAP sieve shaker
- metal dispersing cups
- amyl alcohol
- mortar and rubber-tipped pestle
- sodium-hexametaphosphate (HMP) solution (50-g sodium-hexametaphosphate dissolved in water and diluted to 1000 mL)
- balance calibrated to a tolerance of ± 0.01 -g

- set of sieves (3-in. dia), square mesh, woven brass, wire cloth (ASTM E-11) with the following openings: 2000, 1000, 500, 250, 106, 75, and 53 μm
- 8-in. dia 53- μm sieves (ASTM E-11 standard)
- electric oven
- weighing jars
- distilled water at room temperature
- LRB or data sheet.

4.2 Step-by-Step Instructions

4.2.1 Starting the Analysis

Position Responsible: LABORATORY STAFF

All information is to be recorded in a Laboratory Record Book (LRB). This is to include all measurements, calculations, soil moisture condition, method of mixing, dates and times, all equipment calibration numbers, and all other information that may be pertinent to the analysis.

1. Determine the water content of the sample per Procedure SA-7 using a separate portion of the sample.
2. If concretions or aggregates are present, break down in mortar with rubber-tipped pestle.
3. Weigh an appropriate amount of sample into 500-mL plastic wide-mouth jar or a dispersing cup to 0.01 g (40 grams for sand and 10 to 20 grams for silts and clays). Record the serial number of the balance used and the weight of the sample on a data sheet (Figure 1).

4.2.2 Dispersion Method

Position Responsible: LABORATORY STAFF

1. Add 100-mL HMP solution and fill with water to 2/3 full. Screw lid on jar and tape if necessary to prevent leaking.
2. Place jar on horizontal shaker and secure to prevent rolling around. Shake overnight.
3. Pour solution into sedimentation cylinder.

SEDIMENT ANALYSIS DATA SHEET							
SAMPLE _____		Comp. Disk _____		Ntbk No. _____			
		Under DIR _____		Page No. _____			
		Filename _____		Source _____			
Moist Wt. _____ g		ρ_s _____ g/cm ³		Notes _____			
Oven Dry Wt. _____ g		w _____ g/g					
<div style="display: flex; justify-content: space-between;"> Time Began _____ HYDROMETER ANALYSIS </div>							
Minutes	Temp (°C)	R	R _L	θ	C	X	P
0.5							
1							
3							
10							
60							
90							
120							
1440							
<div style="display: flex; justify-content: space-between;"> 53 μm Sieve No. _____ SIEVE ANALYSIS </div>							
Sieve No.	Mesh (μm)	Soil and Sieve Wt. (g)	Sieve Wt. (g)	Soil Wt. (g)	P		
10	2,000						
18	1,000						
35	500						
60	250						
140	106						
200	75						
270	53						
<div style="display: flex; justify-content: space-between;"> Moisture Condition _____ WATER CONTENT </div>							
Sample	Beaker No.	Beaker Wt. (g)	Beak., Wet Soil (g)	Beak., Dry Soil (g)	% H ₂ O	w(g/g)	
<div style="display: flex; justify-content: space-between;"> Balance No. _____ Exp. Date _____ </div>							
<div style="display: flex; justify-content: space-between;"> Date ____/____/____ Method _____ Analyst _____ </div>							

A-1800-190 (07-90)

FIGURE 1. Data Sheet

4.2.3 Optional Dispersion Methods

Position Responsible: LABORATORY STAFF

These optional procedures may be necessary if it is observed that the samples pack in the bottom of the jar during overnight shaking. (This may happen with tight clays or silty soils.)

4.2.3.1 Optional Dispersion Method 1

1. Secure jars to wrist-action shaker and shake at high speed for 4 hr. Remove lid and transfer to an ultrasonic homogenizer. Lower horn into solution 1/2 to 3/4 in. and homogenize at optimal power for 4 min.

4.2.3.2 Optional Dispersion Method 2

1. Add 100 mL of HMP solution to the dispersing cup and fill with water to 2/3 full.
2. Allow solution to stand 10 minutes, then mix for 5 minutes in the electric stirrer (malted-milk-mixer type).
3. Pour solution into sedimentation cylinder.

NOTE: In reporting results in data sheet, clearly indicate which dispersion method was used (e.g., mechanical mixing, overnight shaking, or wrist-action plus ultrasonic dispersion) because preliminary tests suggest that size-fraction yields for some soils may depend on the dispersion technique used.

4.2.4 Finishing the Analysis

Position Responsible: LABORATORY STAFF

1. Transfer sample completely to the sedimentation cylinder and fill the cylinder with distilled water to the 1000-mL mark. Allow the samples to thermally equilibrate with room temperature.
2. Make a "blank" by adding 100 mL HMP solution to the cylinder and filling the cylinder with distilled water to the 1000-mL mark. Temperature (T) and a correction factor (R_L) will be taken from the blank. The R_L reading is used to correct for the HMP in solution.
3. Thoroughly mix the suspension (with a stopper, end over end) for at least 45 seconds. Record the time immediately on stopping the stirring. Add a drop of amyl alcohol if the surface of the suspension is foamy. Restir if necessary.
4. Carefully lower the hydrometer (remove from the blank) into the suspension. Read a hydrometer to the nearest 0.02 scale unit (g/L) without removing the hydrometer. Replace it into the blank

and read temperature and the "blank" reading (R_L). Record all hydrometer readings and times on data sheet.

NOTE: Always read the top of the meniscus.

5. Without remixing the solution between measurements, lower the hydrometer carefully into the suspension 10 seconds before each reading. Take hydrometer readings at 0.5, 1, 3, 10, 30, 60, 90, 120, and 1440 minutes $\pm$ 5 sec. (These data points will usually provide an adequate data set for plotting size-distribution curves.)

NOTE: When the analysis is only for texture (e.g., sand, silt, and clay) and not size distribution, then only the 120 min and 1440 min readings are required (see section 4.2.5 item 5).

NOTE: When transferring the hydrometer from one cylinder to another, wipe once or twice with a paper towel and lower it in exactly the same way each time.

6. After the 1440-minute reading, transfer the suspension completely to an 8-inch, 53- μ m sieve.
7. With a stream of water, wash the sand remaining on the sieve until the water passing the sample is clear.
8. Oven dry the sample at 105°C for at least 1 hour.
9. Transfer the dry sample completely to a 3-inch stack of sieves. The stack of sieves should contain sieves sizes 2000, 1000, 500, 250, 106, 75, and 53 μ m. (Pre-weigh sieves and record weights in LRB or data sheets.)
10. Secure the stack to a ROTAP sieve shaker and shake for 3 minutes.
11. Remove the sieves and weigh each sieve with soil and without soil to a tolerance of 0.1 g. Record weights on data sheet.

4.2.5 Performing Calculations

Position Responsible: LABORATORY STAFF

1. Determine C, the concentration of soil in suspension in g/L, where $C = R - R_L$ with R, the uncorrected hydrometer reading in g/L, and R_L , the hydrometer reading of the blank solution. Determine this for each time interval. Record in data sheet.
2. Determine P, the summation percentage, for the given time interval, where $P = C/C_o \times 100\%$ and C_o = oven dry weight of the soil sample. Record on data sheet.

3. Determine X , the mean particle diameter in suspension (in μm) at time $t(\text{min})$, using the following equation:

$$X = \kappa t^{-1/2} \quad (1)$$

where κ is the sedimentation parameter

$$\kappa = (18\eta h' / [g(\sigma_s - \sigma_1)])^{1/2} \quad (2)$$

where η = fluid viscosity in poise, $\text{g}/(\text{cm}\cdot\text{s})$
 h' = hydrometer settling depth, cm
 g = gravitational acceleration
 σ_s = soil particle density, g/cm^3
 σ_1 = solution density, g/cm^3 .

4. For particle size distribution curve analysis plot the P values (percent finer than) vs the X values (mean particle diameter in μm). If desired, the texture can be obtained by interpolation of $2\mu\text{m}$, values from the graph. The P value at $2\mu\text{m}$ is the clay percentage.
5. Where only texture data are desired, the 120 min and 1440 min data are used. Based on Equation 1, compute $P_{2\mu\text{m}}$ (summation percentage at $2\mu\text{m}$, clay fraction) as follows:

$$P_{2\mu\text{m}} = m \ln (2/X_{24}) + P_{24} \quad (3)$$

where X_{24} = mean particle diameter in suspension at 24 h (from Equation 1)
 P_{24} = summation percentage at 24 h
 $m = (P_{1.5} - P_{24}) / \ln (X_{1.5} / X_{24})$ = slope of the summation percentage curve between X at 1.5 h and X at 24 h
 $X_{1.5}$ = mean particle diameter in suspension at 1.5 h
 $P_{1.5}$ = summation percentage at 1.5 h.

6. Compute the $50\text{-}\mu\text{m}$ (sand) size fraction as the sum of the sieved material from steps 6-11 of section 4.2.4. The sand percentage is the total screened-soil weight (from step 11 of section 4.2.4) divided by the total sample weight.
7. Determine the percent silt as

$$\% \text{ silt} = 100 - (\% \text{ sand} + \% \text{ clay}) \quad (4)$$

8. Record all calculations and results on data sheets and place data sheets in LRBs.

5.0 REFERENCES

- Gee, G. W., and J. W. Bauder. 1986. "Particle-Size Analysis." In Methods of Soil Analysis, Part 1, ed. A. Klute, pp. 383-409. American Society of Agronomy, Madison, Wisconsin.

- ASTM. 1990. Particle-Size Analysis of Soils. Vol. 4.08, D422, American Society for Testing and Materials, Philadelphia, Pennsylvania.
- Procedure SA-7, "Water Content."

SA-4 CONSTANT HEAD HYDRAULIC CONDUCTIVITY DETERMINATION PROCEDURE

1.0 APPLICABILITY

This procedure applies to the determination of hydraulic conductivity of sediment samples by the constant head method.

Conductivity is a measure of the ability of a soil to conduct water. Conductivity is measured in columns of saturated soil by applying a hydraulic head and measuring the volume of water that passes through the sample in a known time.

Two methods of measurement are used. A constant head method is used if the hydraulic conductivity of a sample is fairly high. A falling head method is used if the hydraulic conductivity is low (see Procedure SA-5). A rule of thumb is if the hydraulic conductivity is less than 10^{-5} cm/sec, falling head is used. If the hydraulic conductivity is greater than 10^{-5} cm/sec, constant head is used. If the results of one method are questionable, retest using the other method, in the conductivity range from 10^{-4} to 10^{-6} cm/s.

An exception to this is the use of the RUSKA permeameter for low permeable samples of small dimension which can be subjected to relatively high pore water pressures without significant changes in porosity. Samples of rock like materials (welded tuffs, grouts, cements, etc.) may be run using a constant head device which confines the samples under relatively high pressures.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Laboratory Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- rigid-walled sample container of known volume enclosed with lids having an inflow valve connected to a constant head device and an outflow valve at the opposite end
- balance calibrated to ± 0.01 g
- timer
- Ruska permeameter (for tight core and rock samples of small dimension)
- calipers calibrated to a tolerance of ± 0.01 cm

- constant head device (diagram 1).
- Laboratory Record Book.

4.2 Step-by-Step Instructions

4.2.1 Performing the Analysis

Position Responsible: LABORATORY STAFF

All information is to be recorded in a Laboratory Record Book (LRB). This is to include all measurements, calculations, head levels, water contents, beginning and ending dates and times, all equipment calibration numbers, and all other information that may be pertinent to the analysis.

1. Measure the diameter (± 0.01 cm) and length (± 0.01 cm) of the sample container using a calibrated caliper (± 0.01 cm). Calculate the volume. Record measurements and calculations in Laboratory Record Book (LRB), referencing the calibration number of the caliper used.
2. Determine the weight of soil (± 0.01 g) required to pack the sample to the density required by the requester of the analysis. Record weight of the soil density required and the balance calibration number in the LRB.
3. Pack the sample in the rigid-walled sample container to the density required by the requester of the analysis.
4. Enclose the sample with the end caps and ensure that there are no leaks around the caps.
5. Connect the inflow valve to the constant head device (see Figure 1).
6. Connect the outflow valve to a graduated cylinder (to be able to measure the amount of percolate from the sample).
7. Imbibe the sample with water before any tests are run by allowing water to flow through the sample until the outflow is constant.
8. Record the initial time in the LRB and allow the water to flow through the sample for a predesignated time period.
9. Record the amount of percolate collected over the predesignated time period in the Laboratory Record Book.

FIGURE 1. Diagram of the Constant Head Device

10. Using Procedure SA-7, determine the water content of the samples after the hydraulic conductivity measurements are finished. Record results in LRB.
 11. Repeat steps 8 to 10 three to five times. Make three to five runs. Calculate the hydraulic conductivity for each run. Determine the average hydraulic conductivity and standard deviation.
 12. If required by the analysis requester, calculate the porosity and saturation ratio. (See section 4.2.3.) Record calculations in the LRB.
- 4.2.2 Determining the Hydraulic Conductivity of Low Permeable Materials Using the RUSKA Permeameter (Model 1013-801-00)
- 4.2.2.1 Preparation of Core Sample:
1. Select appropriate rubber core holder and fill with sample.
 2. Each sample must be saturated prior to making liquid permeability measurements. The core should be vacuum saturated for 0.5 to 1 hr before measurements are taken.
- 4.2.2.2 Start Up Procedure:
1. Install sample holder (S) in apparatus, as shown in Figure 2.
 2. Fill head bulb with water; pinch valve closed.
 3. Turn valve C full counter clockwise.

FIGURE 2. Ruska Permeameter

4. Turn three way valve A one revolution clockwise from full counter clockwise. Full counter clockwise is open air vent unless overflow tygon tube from C is closed (air locked or end of tube underwater). One revolution clockwise is closed vent and will not fill buret in this position. Two or more revolutions clockwise from full counter clockwise is gas pressure.
5. Turn Valve B full clockwise. Closed.
6. Open pinch valve.
7. Open B counter clockwise.
8. Open pressure source - slightly.
9. Turn A counter clockwise to open vent and fill buret to upper bulb.
10. Turn A clockwise one revolution to close vent.
11. Turn B clockwise to close water supply.
12. Turn C clockwise to set test pressure.
13. Ready stopwatch.

14. Turn A one revolution clockwise to open gas.
15. Start watch when meniscus hits the bite tip line on buret; stop when it hits bottom line.
16. Turn C counter clockwise to shut off pressure source.
17. Remove sample.

4.2.2.3 Performing Calculations Using the Ruska Apparatus

Use the equation for K listed in section 4.2.3. The hydraulic head difference is the gage pressure (i.e., 2 bars or atms). Convert gage pressure to head units using standard conversion tables (e.g., 1020 cm H₂O = 1 bar pressure). Measure the length of the sample in cm. Measure the flow in the graduate buret in cm³/s. Report conductivity in cm/s. Record values in LRB.

4.2.3 Performing Calculations

Position Responsible: LABORATORY STAFF

1. Determine the constant head hydraulic conductivity by using the following equation:

$$K = (Q/At) (L/\Delta H) \quad [1]$$

where Q = volume of water that passes through the sample in known time, "t"

A = cross-sectional area of the sample

L = length of the sample in container

ΔH = hydraulic head difference (inflow elevation minus outflow elevation).

2. Determine the porosity by using the following equation:

$$p = 1 - \frac{\rho_b}{\rho_s} \quad [2]$$

where ρ_b = bulk density of the sample (Procedure SA-8)

ρ_s = particle density of the sample (Procedure SA-9).

3. Determine the saturation ratio by using the following equation:

$$S = \text{sat. ratio} = \frac{\theta}{p} \quad [3]$$

where θ = gravimetric water content • bulk density

p = porosity (e.g., Equation 2).

NOTE: Gravimetric water content is obtained using Procedure SA-7.

4. Record all calculations in LRB.

5.0 REFERENCES

- Procedure SA-5, "Falling Head Hydraulic Conductivity Procedure."
- Procedure SA-7, "Water Content."
- Procedure SA-8, "Clod Density/Bulk Density."
- Procedure SA-9, "Determining Particle Density."

SA-5 FALLING HEAD HYDRAULIC CONDUCTIVITY PROCEDURE

1.0 APPLICABILITY

This procedure applies to the determination of hydraulic conductivity of sediment samples by the falling head method. It also describes the calculations for determining the porosity and saturation ratio (when used in conjunction with Procedure SA-7, Water Content, and Procedure SA-9, Determining Particle Density).

Conductivity is a measure of the ability of a soil to conduct water. Conductivity is measured in columns of saturated soil by applying a hydraulic head and measuring the volume of water that passes through the sample in a known time.

Two methods of measurement are used. A constant head method is used if the hydraulic conductivity of a sample is fairly high. A falling head method is used if the hydraulic conductivity is low (see Procedure SA-5). A rule of thumb is if the hydraulic conductivity is less than 10^{-5} cm/sec, falling head is used. If the hydraulic conductivity is greater than 10^{-5} cm/sec, constant head is used. If the results of one method are questionable, retest using the other method, in the conductivity range from 10^{-4} to 10^{-6} cm/s.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Laboratory Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- a large buret acting as a standpipe that will easily be read for change in head in a few hours or less (if the conductivity is very low, a small-volume buret can be used so as to detect small amounts of water passing through the sample)
- rigid-round-walled container designed for packing sample tightly
- thermometer
- balance calibrated to a tolerance of ± 0.01 g
- calipers calibrated to a tolerance of ± 0.01 cm
- end caps to fit tightly over ends of container with inlet/outlet valves in each cap

- clear tubing to connect burets to conductivity unit
- LRB
- timer.

4.2 Step-by-Step Instruction

4.2.1 Performing the Analysis

Position Responsible: LABORATORY STAFF

All information is to be recorded in a Laboratory Record Book (LRB). This is to include all measurements, calculations, head levels, water contents, beginning and ending dates and times, all equipment calibration numbers, and all other information that may be pertinent to the analysis.

1. Measure the diameter and length of the sample container to within ± 0.01 cm using a calibrated caliper. Calculate the volume [volume = $(\pi/4 \cdot \text{length} \cdot \text{diameter}^2)$]. Record measurements and calculations in Laboratory Record Book (LRB).
2. Determine the weight of soil required to pack the sample to the density required by the requester of the analysis [weight = required density $\cdot$ volume]. Record weights in LRB. Weigh out soil to within ± 0.01 g. Record weights and balance calibration number in LRB.
3. Pack sample in rigid-walled container to bulk density specified by Technical Staff. If the sample is to be run on an undisturbed core sample, cut casing around sample to a predetermined length.
4. Enclose the sample with the end caps and seal against leaking.
5. Measure the cross-sectional area of the standpipe, the temperature of the water, the sample length and diameter.
6. Connect the inlet valve to the tubing connected to the standpipe. (Diagram?)
7. Allow water to flow from the standpipe through the sample to allow the sample to wet up.
8. Fill the buret with water to a height greater than arbitrary height, H1.
9. In a predetermined time, measure the time for the hydraulic head difference to fall from H1 to H2. Record H1, H2, and time in LRB (H1 and H2 are water level elevations in the buret relative to the flow outlet). As shown in the figure (i.e., Diagram of falling head permeameter).

FIGURE 1. Apparatus for Measuring Hydraulic Conductivity by the Falling-Head Method

10. Calculate hydraulic conductivity using equation (1). Record calculations in LRB.
11. Repeat steps 7-10 three to five times. [In the calculations (see 4.2.2), average the hydraulic conductivity of each run.]
12. Using Procedure SA-7, determine the water content of the sample after the hydraulic conductivity measurements are finished. Record results in LRB.
13. If required by the analysis requester, calculate the porosity and the saturation ratio. Record calculations in LRB.

4.2.2 Performing Calculations

Position Responsible: LABORATORY STAFF

1. Calculate the conductivity from the equation

$$K = (a l / A t) \ln(H_1 / H_2) \quad [1]$$

where a = the area of cross section of the standpipe

l = the length of the sample

A = cross-sectional area of the sample

t = the time for the hydraulic head to decrease from H₁ to H₂

H₁, H₂ = height of water above outflow port at time 1 and time 2, respectively.

2. Determine the porosity by using the following equation:

$$p = 1 - \frac{\rho_b}{\rho_s} \quad [2]$$

where ρ_b = bulk density of the sample
 ρ_s = particle density of the sample (Procedure SA-9).

3. Determine the saturation ratio by using the following equation:

$$S = \text{sat. ratio} = \frac{\theta}{p} \quad [3]$$

where θ = gravimetric water content (Procedure SA-7) • bulk density
 p = porosity (e.g., Equation 2).

5.0 REFERENCES

- Klute, A., and C. Dirksen. 1986. "Hydraulic Conductivity and Diffusivity: Laboratory Methods." In Methods of Soil Analysis, Part 1, ed. A. Klute, pp. 687-732. American Society of Agronomy, Madison, Wisconsin.
- Procedure SA-7, "Water Content."
- Procedure SA-9, "Determining Particle Density."

SA-6 WATER RETENTION PROCEDURE

1.0 APPLICABILITY

This procedure applies to the determination of water retention for sediment samples.

The relation between the soil water content and the soil water suction is a fundamental part of the characterization of the soil's hydraulic properties. The water retention function is primarily dependent on the pore-size distribution of the soil as determined by the arrangement and size of the particles.

The traditional method of determining the water retention function involves establishing a series of equilibria between water in the soil sample and a body of water at a known potential. The soil-water system is in hydraulic contact with the body of water via a porous plate or membrane. At each equilibrium, the volumetric water content of the soil is determined and paired with a value of the matric pressure head, determined from the pressure in the body of water.

For measured soil tensions less than 100 cm H₂O, a hanging water column method of analysis is used, and for tensions between 100 and 4080 cm H₂O, a pressure plate extractor (Soil Moisture Equipment Corporation, Santa Barbara, California) is employed. For measuring samples drier than 15300 cm H₂O a CX-1 humidity sensor (Decagon Devices, Pullman, WA) is used. Very coarse samples (materials having 90% or more sand and gravel content) can be run using drainage column tests.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Laboratory Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- buchner funnels, 150-mL and 350-mL capacity, 300-cm H₂O bubbling pressure
- rubber stoppers to fit in the neck of the funnels
- connectors fitted into a hole in the stopper and connected to 1/4-inch clear tubing at least 150 cm long. For the hanging water columns, the tubes should be at least 150 cm long. In either case a continuous water column from the bottom of the porous plate to the open end of the tube is required.

- rings of a known volume (not more than 3 cm tall) and fitting on porous plate in buchner funnel
- rack to hold several funnels and allow for at least 100-cm head on the samples
- pressure plate extractor apparatus
- pressure plate cells of various retention pressures
- air source, pressure gauge, and regulator
- 10-mL graduated cylinders
- distilled water
- weighing boats
- balance calibrated to a tolerance of ± 0.01 g
- drying oven
- CX-1 relative humidity sensor and plastic sample cups
- cylinders 1-cm to 5-cm height & 5-cm (or larger) diameter for pressure-drainage
- coarse-mesh screen and gauze
- Laboratory Record Book.

4.2 Step-by Step Instructions

4.2.1 Hanging Water Column Method

Position Responsible: LABORATORY STAFF

All information is to be recorded in a Laboratory Record Book (LRB). This is to include all measurements, calculations, head levels, water contents, beginning and ending dates and times, all equipment calibration numbers, and all other information that may be pertinent to the analysis.

1. Soak the buchner funnels in water overnight to wet the plates.
2. Fill the underside of the funnel completely with water and put the stopper in the neck, making sure no air bubbles are trapped.
3. Turn the funnel over quickly and fill top of funnel with about 1/4 inch of water. Allow the tube to fill with water and clamp off.
4. Clamp funnel to rack with space to allow for 100-cm head.

5. Clamp a 10-mL graduated cylinder to the rack below the funnel.
6. To the bottom of the ring into which the sample will be packed attach a filter paper disk the same diameter as the outside ring. This is done by covering the filter paper with a large piece of nylon net or gauze, stretching it tight, and taping it to the ring. Cut away the excess material.
7. Do a water content analysis on the same material on which the test will be run in accordance with Procedure SA-7. Record the water content in an LRB.
8. Pack the ring to a predesignated density (as determined by the person requesting the analysis) with a known amount of air-dried soil.
9. Place the packed cell on the porous plate in the buchner funnel. Allow the sample to imbibe water overnight. If necessary, add more water to the plate as the sample absorbs it (see Figure 1).
10. On the outside of the funnel, mark the mid-length point of the sample. This is the 0-cm head value.
11. Place the open end of the tubing in a graduated cylinder, move the cylinder to where the head value is 0 (that is, the open end of the tube is level with the midpoint of the sample), and unclamp the tube.
12. Cover the buchner funnel first with a damp paper towel and then with a plastic bag to prevent evaporation.
13. Allow drainage from the tube for several days until it stops (<0.01 mL per 24 hr). Clamp the tube.
14. Remove the packed cell and weigh to ± 0.01 g. Record the weight and the calibration number of the balance used in an LRB.
15. While the cell is out of the funnel, rewet the porous plate by using a squeeze bottle.
16. Move the graduated cylinder with the tube to the next head level and reclamp.
17. Replace the packed cell onto the plate, making sure there is good contact. Open the clamp on the tube.
18. After the sample has equilibrated at the final head level, remove the sample, weigh it, and analyze its water content using the equation in Procedure SA-7.

FIGURE 1. Hanging Water Column

19. Repeat steps 13 to 18 for all head levels specified by the requester of the analysis.
20. Weigh the empty cell, filter paper, and nylon netting.
21. Calculate the volumetric water content for each head level using the equation in Procedure SA-7.

4.2.2 Drainage Column Tests for Coarse Samples

For samples that are coarse textured and drain readily (i.e., materials that have 90% or more sand and gravel content), it is often convenient to run a drainage test to determine the water retention characteristics. For these materials, the following procedure can be used.

Position Responsible: LABORATORY STAFF

NOTE: Run drainage-pressure head measurements in duplicate.

1. Pack columns of soil to a desired density, representative of observed field values. Columns can be taped sections that are at least 1 cm (up to 10 cm) high and at least 5 cm in diameter. Total column height can range from 10 to 50 cm. Before packing sample into the bottom section, tape a fine screen to the bottom using a gauze covering to tape to outside of column to prevent loss of sample. As each section is packed, place the next empty cylinder on top and tape it to the outside of the finished column to provide support during testing.
2. After filling, cover top with coarse mesh screen and lay column on its side (horizontally) and allow sample to saturate in water for at least 16 hr.
3. After saturating the column thoroughly, place column vertically on a rack and anchor securely with clamps. Allow to drain freely. Place bottom of column into an outflow beaker (>1-cm height) and allow the water to flow out of both the column and the beaker. Allow drainage to cease (may take up to several days) and then remove column in sections, top to bottom.
4. Measure the water content of each section using the method described in Procedure SA-7.
5. Relate the water content with the pressure head, where the pressure head is equivalent to the height above the free water surface (water in the beaker). That is, calculate the odumetric water content for each section paired with the placement of the section in the column (i.e., 0-10 cm above the free water surface to 40-50 cm above the free water surface).

4.2.3 Pressure Plate Extractor Method

Position Responsible: LABORATORY STAFF

NOTE: This test is done in triplicate - three cells per sample.

1. Label small cells (1 by 3 cm) with sample identification with permanent ink pen.
2. Do a water content analysis on a separate sample of the air-dry soil in accordance with Procedure SA-7 if it was not done for the hanging water column analysis.
3. Pack cells to a predesignated density (as determined by the person requesting the analysis) with a known amount of air-dried soil.
4. Place the cells on the pressure plate with a bubbling pressure appropriate to the pressure at which the test run will be conducted.

NOTE: If the small rings are to be packed with sand or are of a low density, put the ring on the porous plate before packing. If the sample is a silt or clay to be packed to a high density, pack it first and carefully move it to the plate.

5. Place the pressure plate in the extractor and flood the plate with distilled water. Let it stand overnight to allow the plate and samples to saturate (see Figure 2).
6. Connect the tube from the plate to the outlet valve on the extractor vessel and seal the lid.
7. Raise the internal air pressure to the predetermined (as determined by the person requesting the analysis) test level.
8. After the excess water has drained into a beaker, replace beaker with a 10-mL graduated cylinder.
9. Allow the system to reach equilibrium (several days to several weeks). When there is no measurable (<0.1 mL per 24 hr) drainage from the outlet tube, the system has reached equilibrium.
10. Remove the samples from the plates and determine the water content for each sample (see Procedure SA-7). Average the 3 results. The data are recorded in an LRB as volumetric water content paired with the pressure head at which the sample was tested.

4.2.4 Relative Humidity Sensor Method

Position Responsible: LABORATORY STAFF

1. Calibrate the CX-1 prior to use in accordance with manufacturers instructions using a distilled water sample and several standard salt solutions (saturated salt solutions of known relative humidity). Document the calibration in the LRB.
2. After completing the calibration procedure, pack the plastic cup approximately 3/4 full and tamp down soil. Place in CX-1 and

FIGURE 2. Pressure Plate Extractor

record the A_w (water activity units) and temperature ($^{\circ}\text{C}$). The water activity is related to the equilibrium relative humidity of the sample so that $A_w = \text{RH}/100$ where RH is the relative humidity.

NOTE: Expose the sample to air as little as possible to prevent evaporation of any water from the sample.

3. Measure the water content (Procedure SA-7) of the sample. Use a balance calibrated to a tolerance of ± 0.001 g.
4. Calculate tension (pressure) using the following equation:

$$\tau = \frac{RT}{M} \ln \frac{\text{RH}}{100}$$

where T = temperature, $^{\circ}\text{K}$ (degrees Kelvin = $273.15 + ^{\circ}\text{C}$)
 M = molecular wt of water (0.018 Kg/mol)

$$\frac{\text{RH}}{100} = A_w = \text{sample water activity}$$

$$\tau = -0.461 \frac{\text{MPa}}{^{\circ}\text{K}} (T \cdot \ln a_w)$$

5.0 REFERENCES

- Klute, A. 1986. "Water Retention: Laboratory Methods." In Methods of Soil Analysis, Part 1, ed. A. Klute, pp. 635-660. American Society of Agronomy, Madison, Wisconsin.
- Rawlins, S. L., and G. S. Campbell. 1986. "Water Potential: Thermocouple Psychrometry." In Methods of Soil Analysis, Part 1, ed. A. Klute, pp. 597-618. American Society of Agronomy, Madison, Wisconsin.
- Procedure SA-7, "Water Content."

SA-7 WATER CONTENT

1.0 APPLICABILITY

This method applies to the laboratory determination of the water (moisture) content of soil and soil-aggregate mixtures by weight. The water content of a material is defined as the ratio, expressed as a percentage, of the mass of pore water in a given amount of material to the mass of the solid material particles.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Laboratory Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- electric drying oven controlled at $110 \pm 5^{\circ}\text{C}$, or microwave oven at least 650 W set at full power
- calibrated balance accurate to 0.01 g
- oven-proof weighing jars or, for microwave oven, Pyrex beakers.

4.2 Step-by-Step Instructions

4.2.1 Convective-Oven Drying

Position Responsible: LABORATORY STAFF

All information is to be recorded in a Laboratory Record Book (LRB). This is to include all measurements, calculations, water contents, dates and times, all equipment calibration numbers, and all other information that may be pertinent to the analysis.

1. Determine and record the weight of wet soil plus container in an LRB. Record the serial number and calibration expiration date of the balance(s) used in an LRB.

NOTE: Subsample in such a way as to obtain a representative sample.

2. Place sample(s) plus container in electric oven at $110 \pm 5^{\circ}\text{C}$ for overnight or 12 hours.
3. Determine the weight of dry soil plus container.

4. Determine the weight of container only.
5. Record all weights and calculations in LRB.

4.2.2 Microwave Drying

NOTE: This procedure only for samples less than 20 g.

Position Responsible: LABORATORY STAFF

1. Determine the weight (wt) of wet soil plus glass container.
2. Place sample(s) in oven on high power for 20 minutes.
3. Determine the weight of dry soil plus container.
4. Determine the weight of container only.
5. Record all weights and calculations in LRB.

4.2.3 Performing Calculations

Position Responsible: LABORATORY STAFF

1. Calculate water content according to the formula:

$$M = w \times 100 = \frac{(W_{ww} + W_T) - (W_{od} + W_T)}{(W_{od} + W_T) - W_T}$$

where M_w = dry wt. water content
 w = mass fraction of soil water (g H₂O/g soil)
 W_{ww} = wet soil weight
 W_{od} = oven dry soil weight
 W_T = Container (tare) weight.

5.0 REFERENCES

- ASTM. 1986. "Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures." Annual Book of ASTM Standards, Vol. 4.08. ASTM D2216, American Society for Testing and Materials, Philadelphia, Pennsylvania.
- Gee, G. W., and M. E. Dodson. 1981. "Soil Water Content by Microwave Drying: A Routine Procedure." Soil Science Society of America Journal 45(6).

SA-8 CLOD DENSITY/BULK DENSITY

1.0 APPLICABILITY

This procedure applies to the determination of the bulk density of clods or coarse peds.

The bulk density of clods or coarse peds can be calculated from their mass and volume. The volume may be determined by coating the clod with a water-repellant substance and by weighing first in air, then again while immersed in a liquid of known density, making use of Archimedes' principle. The clod or ped must be sufficiently stable to cohere during coating, weighing, and handling.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Laboratory Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- balance to weigh to at least 1500 g calibrated to a tolerance of ± 0.01 g
- light-weight string or nylon thread
- large ring stand with clamp attached
- paraffin in a container kept at 60°C into which the soil sample suspended by a piece of string can be dipped
- thermometer to 40°C calibrated to a tolerance of $\pm .1^\circ\text{C}$
- Laboratory Record Book.

4.2 Step-by-Step Instructions

4.2.1 Performing Analysis

Position Responsible: LABORATORY STAFF

All information is to be recorded in a Laboratory Record Book (LRB). This is to include all measurements, calculations, water contents, dates and times, all equipment calibration numbers, and all other information that may be pertinent to the analysis.

1. Weigh air-dried clod or ped and record the weight. Record the serial number of the balance and calibration expiration date.
2. Carefully tie a length of string around the clod, making sure that there is at least a 50-cm (20 in.) tail. Make sure the clod can be lifted and moved using the string. Weigh clod and string to determine tare weight of string and record tare weight in the LRB.
3. Dip the clod momentarily in paraffin and allow excess wax to drain; make sure the entire sample is covered with the paraffin. Allow the paraffin to dry completely before continuing the test.
4. Weigh the clod with its coating and string. Determine the tare weight of the string plus paraffin.
5. Fill a large beaker (200 mL or larger) 3/4 full of water. Place it on the balance, weigh, and record in the LRB the weight (W_{BW}). Leave it on the balance.
6. Measure the temperature of the water and record.
7. Place the ring stand next to the balance and make sure the clamp is placed on the ring stand over the beaker of water by approximately 25 to 30 cm (10 to 12 in.).
8. Slowly lower the clod by the attached string into the beaker of water, making sure the clod doesn't touch the bottom or sides of the beaker. Attach the string to the clamp and allow the clod to stop swinging and the balance to give a steady weight reading (W_{BWSP}). Record the weight in the LRB.
9. Obtain a correction for water content of the sample by breaking open clod or ped and determine water content per Procedure SA-7.

4.2.2 Performing Calculations

Position Responsible: LABORATORY STAFF

1. Calculate bulk density (D_b) as follows:

$$D = dw \cdot W_{ods} / \{W_{bf} - [(W_{sa}) \cdot dw/dp]\}$$

where dw = density of water at temperature of determination

W_{ods} = oven-dry weight of sample

W_{sa} = weight of sample in air

W_{sap} = weight of sample plus paraffin coating in air

dp = density of paraffin (approximately 0.9 g/cm³)

W_{bf} = weight of water displaced; i.e., the total weight (W_{BWSP}) less the weight of the beaker and water (W_{BW}) (see items 5 and 8 above).

$$W_{ods} = W_{sa} / (1 + w) \text{ (Procedure SA-7)}$$

where W_{ods} = oven dry sample weight

W_{sa} = sample weight at moisture content w .

5.0 REFERENCES

- ASTM. 1988. Annual Book of Standards. Vol. 4.08, D1188, American Society for Testing and Materials, Philadelphia, Pennsylvania.
- Blake, G. R., and K. H. Hartge. 1986. "Bulk Density." In Methods of Soil Analysis, Part 1, ed. A. Klute, pp. 363-384. American Society of Agronomy, Madison, Wisconsin.
- Procedure SA-7, "Water Content."

SA-9 DETERMINING PARTICLE DENSITY

1.0 APPLICABILITY

This procedure applies to particle density analysis of sediment samples. The particle density value is the ratio of total mass of the solid particles to their total volume.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Laboratory Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- 100-mL volumetric flask with stopper
- distilled water
- hot plate or desiccator and vacuum pump
- thermometer
- balance calibrated to a tolerance of $\pm .01$ g
- evaporating dish
- LRB or data sheet.

4.2 Step-by-Step Instructions

4.2.1 Determining Particle Density

Position Responsible: LABORATORY STAFF

All information is to be recorded in a Laboratory Record Book (LRB). This is to include all measurements, calculations, soil moisture condition, water contents, dates and times, all equipment calibration numbers, and all other information that may be pertinent to the analysis.

1. Weigh a clean, dry 50-mL volumetric flask with stopper, to a tolerance of .01 g. Record weight in an LRB or on a data sheet along with the balance calibration number (Figure 1).
2. De-air 200 mL of distilled water and allow to return to room temperature.
3. Add approximately 10 g of air-dry soil to the flask.
4. Clean the outside of the flask of any soil that may have spilled during transfer.

SAMPLE	PYC #	PYC WT (g)	PYC + SOIL (g)	PYC, SOIL, H ₂ O	PYC + H ₂ O	P _S	$\bar{P}_S$ (g/cm ³)
	A						
	B						
	C						
	A						
	B						
	C						
	A						
	B						
	C						
	A						
	B						
	C						
	A						
	B						
	C						
	A						
	B						
	C						
	A						
	B						
	C						
	A						
	B						
	C						
	A						
	B						
	C						

PARTICLE DENSITY

scales calibration # _____
 expiration date _____

analyst _____ Date _____

FIGURE 1. Data Sheet

5. Weigh the flask with the contents and stopper to a tolerance of .01, and enter weight on the data sheet (or in LRB).

6. Fill the flask about one-half full with distilled water.

NOTE: Be sure to wash into flask any soil adhering to the inside of the flask's neck.

7. Remove entrapped air by gently boiling the contents of the flask for several minutes or by placing in a desiccator and using a vacuum pump to remove entrapped air.

8. Equilibrate the flask and its contents to room temperature.

9. Add enough de-aired distilled water, at room temperature, to fill the flask to the mark.

10. Carefully insert the stopper into the flask, leaving no bubbles.

11. Thoroughly dry and clean the outside of the flask.

12. Weigh the flask and contents to a tolerance of .01 g. Record the weight on the data sheet (or in LRB).

13. Insert a thermometer into the flask and determine the temperature of the contents.

14. Adjust the temperature of the contents to room temperature if necessary.

15. Remove soil and water from flask.

16. Fill flask with de-aired distilled water at room temperature.

17. Insert stopper, dry the flask, and weigh the flask to a tolerance of .01 g.

4.2.2 Performing the Calculations

Position Responsible: LABORATORY STAFF

1. Calculate the particle density (D_p) as follows:

$$D_p = \frac{dw \cdot (W_s - W_a)}{(W_s - W_a) - (W_{sw} - W_w)}$$

where d_w = density of water in g/cm^3 at temperature measured
 W_s = weight of flask and soil sample corrected to oven dry water content (W_{od})
 W_a = weight of flask and air
 W_{sw} = weight of flask filled with soil and water
 W_w = weight of flask with water

$$W_{od} = W_{sa} / (1 + w) \text{ (Procedure SA-7)}$$

where W_{od} = oven dry sample weight

W_{sa} = sample weight at moisture content w .

5.0 REFERENCES

- ASTM. 1988. "Specific Gravity of Soils." D854 in Annual Book of Standards. Vol. 408, American Society for Testing and Materials, Philadelphia, Pennsylvania.
- Blake, G. R., and K. H. Hartge. 1986. "Particle Density." In Methods of Soil Analysis, Part 1, ed. A. Klute, pp. 377-382. American Society of Agronomy, Madison, Wisconsin.
- Procedure SA-7, "Water Content."

SA-10 FILTER PAPER SOIL SUCTION MEASUREMENT PROCEDURE

1.0 APPLICABILITY

This procedure applies to the determination of soil suction using laboratory filter papers as sensors. The soil suction is a measure of the energy state of pore water in unsaturated soil. It is also referred to as the moisture (soil water) tension and defined formally as the equivalent negative pressure of water in an unsaturated porous medium equal to the pressure that must be applied to the medium to bring water to hydraulic equilibrium through a porous permeable material with a pool of water of the same chemical composition (SSSA 1975).

A sandwich of 3 Whatman 42 filter papers is buried in a soil sample. The container is sealed and the filter paper is allowed to equilibrate for a minimum of 2 days. Water content is measured on the filter paper, and the soil suction is calculated using an equation, obtained from the filter paper water characteristic curve, that relates filter paper suction to filter paper water content (Campbell 1987). The soil suction is assumed to be equal to the filter paper suction. Because the filter paper is very thin and little mass (water) is exchanged, this assumption appears to be valid, particularly for samples equilibrated for several days.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Laboratory Staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- calibrated balance (0.01-g precision)
- calibrated balance (0.001-g precision)
- Whatman 42 filter paper (4.2- or 5.5-cm diameter)
- moisture-tight tins or glass jars (such as 1-pint wide-mouth canning jars with lids)
- small moisture-tight weighing jars or small plastic bags
- 2.5-cm-wide plastic tape
- insulated chest (ice chest type).

4.2 Step-by-Step Instructions

4.2.1 Performing Analysis

Position Responsible: LABORATORY STAFF

All information is to be recorded in a Laboratory Record Book (LRB). This information is to include all measurements, calculations, water contents, dates and times, equipment calibration numbers, and all other information that may be pertinent to the analysis.

1. Prior to use, dry the Whatman 42 filter papers overnight in a drying oven (105°C) and place over desiccant in a desiccator for storage until used.
2. Samples must be delivered in a moisture-tight container and stored in a manner such that no field moisture is lost before analysis.
3. Prior to opening sample container:
 - a. Weigh 2 small beakers to a tolerance of 0.01 g. Record beaker number and weight in an LRB or on a data sheet along with the balance calibration number. These numbers will be used to do a water content analysis in accordance with Procedure SA-7.
 - b. Have ready a sandwich of 3 Whatman 42 filter papers (4.2- or 5.5-cm diameter). It may be helpful to label the center filter paper with the sample number. Make the label as small as possible and in pencil so the absorption capacity of the filter paper will not be disturbed.

NOTE: After opening the moisture can that contains the soil sample, work as quickly as possible to prevent moisture loss from evaporation.

4. Before opening the moisture can, shake it thoroughly to remix any water clinging to the sides of the container from condensation.
5. Weigh the 2 beakers with the soil samples to a tolerance of 0.01 g and record with the beaker number and weight. Be sure to include the sample number with the beaker number and weights so data are traceable to the original samples. Dry, reweigh, and calculate water contents (in accordance with Procedure SA-7).
6. Place the resealed moisture cans with the filter paper in an insulated chest and allow to equilibrate for a minimum of 2 days.
7. At the end of the equilibration period, place the center filter paper of the 3-layer stack in a separate small container of predetermined weight. (The tare weight of the container is determined to the nearest 0.001 g and recorded in an LRB.)

8. Weigh the container plus filter paper to the nearest 0.001 g, dry, and reweigh (Procedure SA-7). Determine the water content of the filter paper.

9. Calculate the soil suction, S , using the following equation:

$$S = 0.011w^{-3.68} \text{ MPa} \quad (\text{Eq. 1})$$

where w is the gravimetric water content, expressed as g H_2O /g filter paper.

5.0 OPTIONAL PROCEDURES

5.1 Measurement of Soil Humidity

Measure soil humidity using a CX-1 water activity meter (Decagon Devices, Pullman, Washington) on soil samples before placing of filter papers in the container.

Label a CX-1 sample cup with the sample number. This sample cup will be used to analyze the relative humidity of the sample in accordance with Procedure SA-6, Water Retention Procedure, Section 4.2.4.

Open the can. Take 2 random samples of about 20 g each and place in pre-weighed beakers. Fill the labeled CX-1 cups half full of soil, tamp down, and cover with lids. Tamp down the soil remaining in the moisture can. Place the prepared filter paper sandwich on the sample, refill the can with the remaining soil, and tamp it down. Replace lid and tape around lid.

Also repeat the humidity measurement on the soil sample immediately after removal of the filter papers. (See Procedure SA-6, Water Retention Procedure, Section 4.2.4, for details on humidity measurement method.) Calculate soil water suction using the relationship $S \approx \psi_T$ (for relatively salt-dry soil), where ψ_T is the total water potential.

5.2 Comparison of Suction Estimates

Compare suction estimates using humidity measurement water with those using the filter paper method.

6.0 COMMENTS

If Whatman 42 filter paper is not used, Eq. 1 may be inappropriate. In addition, for wet soils (e.g., suctions less than about 0.05 MPa) the data generally fit an exponential relationship better than they fit Eq. 1 (see Campbell and Gee 1986; Graecen, Walker, and Cook 1989). Thus, for filter paper water content (g/g) values greater than 0.45, use the following equation:

$$S = 10^{-3} \exp (5.55 - 3.11 w) \text{ MPa} \quad (\text{Eq. 2})$$

This relationship was developed for Whatman 42 paper and should not be used for other brands. Methods to develop this relationship for other brands of paper can be obtained from Graecen, Walker, and Cook (1989).

7.0 REFERENCES

- Campbell, G. S. 1987. International Conference on Measurements of Soil and Plant Water Status, Volume 1, p. 116. Utah State University, Logan, Utah.
- Campbell, G. S., and G. W. Gee. 1986. "Water Potential: Miscellaneous Methods." In Methods of Soil Analysis, ed. A. Klute, Part 1, p. 619-632. American Society of Agronomy, Madison, Wisconsin.
- Graecen, E. L., G. R. Walker, and P. G. Cook. 1989. Procedure for the Filter Paper Method of Measuring Soil Water Suction. Rept. 108, Division of Soils, CSIRO, Canberra, Australia.
- SSSA. 1975. Glossary of Soil Science Terms. Soil Science Society of America, Madison, Wisconsin.
- Procedure SA-6, "Water Retention Procedure."
- Procedure SA-7, "Water Content."

AT-1 SETTING AND INSTRUMENTING THE TEST PUMP

1.0 APPLICABILITY

This procedure applies to the setting of test pumps in wells for the purpose of hydrologic testing.

2.0 DEFINITIONS

- Data Logger - a field computer that operates a transducer and records the measurements
- Discharge pipe - the pipe that carries water away from the well to the point of disposal
- Pump - the mechanism used to lift water from the well
- Pump inlet - the location on the pump that water enters. May be at bottom or along the side of the pump.
- Pump motor - the unit used to drive the pump. May be combined with pump as an electric submersible unit or an internal combustion engine mounted above the well with a drive shaft to the pump.
- Stilling pipe or stilling well - a length of steel or poly pipe either attached to the riser pipe or inserted into the well. Water level measurements are made inside the stilling pipe to reduce the effects of water turbulence.
- Transducer - an electro-mechanical device for measuring water pressure
- Riser pipe - the pipe connected to the pump that conducts water to the top of the well
- Well head - the top of the well casing where the riser pipe and the discharge pipe are connected. May also include an adjacent flow control valve and water sample outlet.

3.0 RESPONSIBLE STAFF

- Project Manager
- Project Hydrologist
- Well-Site Geologist.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

Pumping equipment is placed in monitoring wells to complete well development and perform aquifer (hydrologic) testing. Installation of water level measurement devices at the time of pump setting can, in many instances, result in considerable cost savings for the project. Therefore, this procedure addresses the steps needed to set a pump in a monitoring well and install temporary water level measurement devices necessary for determining the effects of pumping.

The equipment needed includes:

- pump and drive motor (an electric generator or other power source must be provided if pump uses an electric motor)
- riser pipe from pump to well head
- stilling pipe
- Aquifer Test Well Information sheet.

The selection and sizing of pumping equipment is normally made following discussions among the well driller, the project hydrologist, the well-site geologist, and consulting the Aquifer Test Plan (if one exists). Because the hydraulic properties at a newly drilled well have not yet been determined, estimation of the well yield is subject to uncertainty.

The following monitoring equipment is needed to perform pump setting:

- water level measuring devices (e.g., steel or electric tapes with a pressure transducer and data logger).

Graduated steel tapes, electric tapes, and pressure transducers are commonly used to measure water levels. A measurement device should be dedicated to each well for the test period. The measurement equipment must be in good condition, and instrument function (i.e., electric tapes and transducers) should be confirmed before use in the field. Electric and steel tapes should be full length. Instrument precision should be sufficient to resolve drawdown to better than ± 0.04 ft.

Steel tapes that are used shall have been standardized according to Procedure WL-2. Electrical tapes that are used shall have a precision of ± 0.04 ft. Pressure transducers that are intended to be used for aquifer tests shall have been calibrated. Documentation of standardization and calibration shall be available.

When steel and electric tapes are used in a pumping well, a stilling pipe is needed to reduce the effects of pump turbulence and/or water cascading down the well from the upper portions of the screened interval. A stilling pipe commonly consists of a small diameter (3/4-in.) pipe attached to the pump column and open at both ends. The tubing extends below the water surface to a point below estimated maximum drawdown (i.e., 3 feet above pump inlet). Water level measurements are taken inside the stilling pipe.

The following equipment is required for personal protection when working in the vicinity of a drilling or pump setting rig:

- safety shoes
- hard hat
- safety glasses.

The following additional equipment is required for working adjacent to noisy internal combustion engines:

- ear plugs or sound suppression ear muffs.

The following equipment is required when working with contaminated water:

- chemical-resistant coveralls
- chemical-resistant boots or boot coverings
- chemical-resistant gloves
- face shield
- sealing tape (duct tape)
- face masks with appropriate air filters or a supplied air source as determined by the safety officer and results of periodic monitoring.

Consult the Site Safety Plan, RCRA/CERCLA regulations, and OSHA regulations for additional information.

4.1.2 Safety Precautions

A drilling rig or a pump setting rig is used for hoisting pipe and other components during installation and removal of the pumping system. This activity poses potential hazards from falling or swinging objects and from pinch points. Additional hazards may exist during pumping. If the pump or drive motor is located above the ground surface, a rotating drive shaft may be present adjacent to the well measuring point. Contact with this shaft during operation by loose clothing, hair, or skin may cause severe or fatal injury. If an electric motor is used to drive the pump, temporary power cords and fuse boxes may be installed, and these represent a potential shock hazard.

Drive motors for pump setting machines may be noisy. This is especially true of large horsepower internal combustion engines used without benefit of mufflers.

If the ground water contains hazardous concentrations of contaminants (i.e., radioactive, organic, or inorganic chemicals), special precautions must be taken to protect workers and the environment. Before contact with this water or vapors in the borehole, personnel should refer to the required onsite documents referring to radiation protection, expected chemical contaminants, and worker safety. Water sample or borehole gas analysis taken during drilling should be examined for indications of hazardous materials before pumping water from the well.

At sites where contamination is known or suspected, field staff must have completed radiation safety training and hazardous material handling courses. Where organic compounds are suspected, staff must have completed hazardous material training. Periodic borehole gas monitoring while drilling and pump setting is also required. Disregard for these precautions may result in unnecessary exposure to hazardous chemicals and severe injury.

4.2 Step-by-Step Instructions

4.2.1 Setting the Pump

Position Responsible: PROJECT HYDROLOGIST AND WELL SITE GEOLOGIST

1. Determine the chemical and radiological hazard of the well water in association with the site safety officer and select level of worker protection.
2. Have the driller bail the well to remove bore slurry until relatively clean water with about 1 tablespoon of silt and sand per 5-gallon bucket is obtained in the bailer.
3. Ensure that the driller did collect, size, and steam clean all the equipment that will be used inside the well column (i.e., the pump, motor, riser pipe, submersible pump wire, stilling pipe, and associated fittings). In many cases, the well driller will provide these materials.
4. Collect and clean electric or engineers tapes and weighted steel tape to be used in measuring water levels.

NOTE: Record information on the Aquifer Test Well Information sheet (Figure 1).

AQUIFER TEST WELL INFORMATION

Location _____ Date(s) of Test _____

Well Number _____ Procedure Number _____

BOREHOLE INFORMATION

Type of Test(s) _____ Well Depth _____

Open Interval(s) _____

Well Diameter _____ Screen Type/Size _____

Observation Well(s) _____ Depth of Pump Intake _____

Comments _____

MEASUREMENT EQUIPMENT AND DATUM INFORMATION

Water-Level Measurements: _____ Discharge Measurements: _____

Electric Tape(s) _____ Flow Meter(s) _____

Steel Tape(s) _____ Bucket and Stop Watch _____

Transducer/Datalogger(s) _____ Orifice Plate _____

Measuring Point _____ Other _____

Datum/Distance _____

Comments _____

WELL CONFIGURATION DIAGRAM
(well as-built, pump setting)

WELL HEAD DIAGRAM
(setup of pipes, valves, meters, etc)

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FIGURE 1. Aquifer Test Well Information Sheet

5. Lower a weighted tape (electric water level indicator or steel) and determine well depth and condition of bottom. Record findings on the Aquifer Test Well Information sheet (Figure 1). A sudden change in weight when lowering indicates a clean bottom. A gradual change in weight may indicate a mud and silt slurry on the well bottom.
6. Consult the geologist's drilling log to determine the total well depth and the thickness of any slurry on the bottom of the well. If the depth to the solid bottom of the well differs more than 1 foot from depth noted on the well log, inform the well-site geologist or project manager. Remember that drillers and geologists' measurements are normally relative to land surface. If there is a dense slurry at the bottom of the well greater than 2 feet thick have the driller continue bailing.
7. Measure the water level in the well according to Procedure WL-1.
8. Consult with well driller and review the Aquifer Test Plan (if one exists) to estimate well yield.
9. Determine the depth of the pump setting. Well development and hydrologic testing require a pump setting very near the bottom of the well. The pump should be set 0.5 to 2.5 feet above the bottom of the well. The driller or pump installer should have a selection of riser pipe lengths to produce this setting.
10. Ensure that the driller installs pumping devices and stilling pipe. Measure and record to the nearest 1/2 foot the distance of the pump inlet below the pump connection to the riser pipe (done before pump is set) and the total length of the riser pipe. The stilling pipe and transducers can be taped directly to the riser pipe during pump installation to avoid difficulties with tangled electric wires and tight spots along the well casing.
11. Measure the water level in the well.
12. Subtract the depth of the water level from the depth of the pump inlet. The maximum available pump drawdown is about 3 feet less than this distance.

5.0 REFERENCES

- Procedure WL-1, "Water-Level Measurement Procedure."
- Procedure WL-2, "Procedure for Standardizing Steel Tapes."

AT-2 CONFIGURATION OF SURFACE FITTINGS AND MONITORING DEVICES FOR WELL DEVELOPMENT OR HYDROLOGIC TESTING

1.0 APPLICABILITY

This procedure applies to the setup and configuration of surface-based pumping and measurement devices used to develop and test wells.

2.0 DEFINITIONS

- Discharge pipe - the pipe that carries water away from the well to the point of disposal
- Riser pipe - the pipe connected to the pump that conducts water to the top of the well
- Well head - the top of the well where the riser pipe and the discharge pipe are connected. The term may also include an adjacent flow control valve and water sample outlet.
- Flow control valve - a valve that places a physical restriction in the flow valve stream to reduce the rate at which water moves through the piping system
- Flow meter - a mechanical device that measures the flow rate and/or the cumulative flow of water in a pipe.

3.0 RESPONSIBLE STAFF

- Project Hydrologist
- Well-Site Geologist.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following monitoring equipment is needed to prepare the well for testing and development:

- flow rate measuring devices (e.g., flow meter, bucket, and time piece)
- flow rate control valve (e.g., gate valve or ball valve)
- discharge pipe from well head to point of land disposal or water collection system
- Aquifer Test Well Information Sheet.

Measurement of well discharge or flow rate can be made by any of the following methods:

- in-line impeller flow meter
- proportional impeller flow meter
- orifice plate and pressure measurement
- ultrasonic flow meter
- bucket and stop watch.

Discharge rate is difficult to measure accurately. The devices described above have various advantages for the given pumping situation. Absolute instrument accuracy for the flow meter should be within 10%.

Flow meters that are to be used for constant-discharge tests shall have been calibrated by a standards laboratory. Documentation of this calibration shall be available.

Whichever techniques are used to measure flow in the discharge line, two criteria must be met. First, the discharge pipe has to be full of water at the measurement point, and second, a straight section of pipe free of valves or diameter changes must be both upstream and downstream of the measurement device according to manufacturer's instructions. When flow rates are less than 40 gpm, a calibrated bucket of at least 5-gallon capacity and a time piece can provide a very accurate and reliable method for measuring flow.

Convey the discharge water into a collection system or as far away from the pumping and observation wells as is practical. Document the location of the discharge on the Aquifer Test Well Information sheet (Figure 1). Area-wide infiltration can reenter the aquifer and invalidate hydrologic tests. Temporary irrigation piping can be used to carry the water away from the site. Disposal must consider the rate and volume of water that is to be discharged.

The following equipment is required for personal protection when working in the vicinity of a drilling or pump setting rig:

- safety shoes
- hard hat
- safety glasses.

Consult the Site Safety Plan, RCRA/CERCLA regulations and OSHA regulations for additional information.

4.1.2 Safety Precautions

A drilling rig or a pump setting rig is used for hoisting pipe and other components during installation and removal of the pumping system. This activity poses potential hazards from falling or swinging objects and from pinch points.

AQUIFER TEST WELL INFORMATION

Location _____ Date(s) of Test _____

Well Number _____ Procedure Number _____

BOREHOLE INFORMATION

Type of Test(s) _____ Well Depth _____

Open Interval(s) _____

Well Diameter _____ Screen Type/Size _____

Observation Well(s) _____ Depth of Pump Intake _____

Comments _____

MEASUREMENT EQUIPMENT AND DATUM INFORMATION

Water-Level Measurements:

Discharge Measurements:

Electric Tape(s) _____ Flow Meter(s) _____

Steel Tape(s) _____ Bucket and Stop Watch _____

Transducer/Datalogger(s) _____ Orifice Plate _____

Measuring Point _____ Other _____

Datum/Distance _____

Comments _____

WELL CONFIGURATION DIAGRAM
(well as-built, pump setting)

WELL HEAD DIAGRAM
(setup of pipes, valves, meters, etc)

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FIGURE 1. Aquifer Test Well Information Sheet

At sites where contamination is known or suspected, field staff must have completed radiation safety training and hazardous material handling courses. Where organic compounds are suspected, staff must have completed hazardous material training. Periodic borehole gas monitoring while drilling and pumping is also required. Disregard for these precautions may result in unnecessary exposure to hazardous chemicals and severe injury.

4.1.3 Other Prerequisites

This procedure requires the previous installation of the well pumping and measuring equipment in the well described in Procedure AT-1, Setting and Instrumenting the Test Pump.

4.2 Step-by-Step Instructions

Position Responsible: PROJECT HYDROLOGIST OR WELL SITE GEOLOGIST

1. Determine disposal location for discharge water based on the existing Effluent Monitoring Plan, if one exists. Contaminated water may have to be contained at the site and then transported to an appropriate disposal facility.

NOTE: The steps below are usually performed by a well drilling contractor. The project hydrologist or well site geologist will advise the contractor and ensure the steps are carried out correctly.

NOTE: Record information on the Aquifer Test Well Information sheet (Figure 1).

2. Connect 90° angle tee or elbow fitting to riser pipe. Orient direction of piping such that access can be gained to well casing and pipe fittings without close contact to any possible rotating drive shafts or other machinery.
3. A short section of discharge pipe fitted with a hose faucet connection shall be mounted just before the flow control valve. This faucet should be at the bottom of the pipe and can be used to take water samples and flush sand from the discharge pipe before the sand reaches the flow meter. If available, connect this short section of pipe with faucet fitting to the elbow or tee fitting.
4. Place a straight section of pipe without couplings or fittings at least 10 pipe diameters or more downstream from the connection to the riser pipe or any other fitting. Then, if available, install impeller-type flow meter device and a straight pipe section at least 5 pipe diameters in length.

Support pipe weight with portable stands or braces to prevent sagging of pipe. Pipe sections upstream and downstream of the flow meter should be nearly level.

5. Connect flow control valve to discharge pipe at a convenient distance to permit easy access for adjustment of the pumping rate. Gate valves can be used for this purpose, mounted with the valves sideways or upside down to ensure a full pipe upstream for proper flow meter operation and prevent air becoming trapped behind the valve and water discharging in surges.
6. Connect discharge pipe to flow control valve and continue to disposal location. Continue placing supports under pipe to allow a gradual bending toward ground.
7. Place a straight and level section of pipe without couplings or fittings at least 10 pipe diameters upstream of pipe end if an orifice plate is to be used to measure the flow rate.

CAUTION: Discharge line consisting of portable aluminum irrigation pipe normally leaks appreciable quantities of water at joint couplings. Measurement of flow at the end of the pipe line can be substantially less than the flow at the well head. Do not combine measurement methods such as orifice plate or bucket and time piece methods with portable irrigation pipe.

CAUTION: If portable aluminum pipe line is used to convey ground water to the disposal location, appreciable quantities of water may leak at joint couplings. These leaks may represent surface contamination depending on the quality of the ground water being pumped. Ground water must meet the Westinghouse Hanford Company interim standard of 1/25 of the DOE derived concentration guide for radioactive constituents and drinking water standards for all other (i.e., metals and organic) constituents to be disposed of at the land surface.

5.0 REFERENCE

- Procedure AT-1, "Setting and Instrumenting the Test Pump."

AT-3 STARTING THE PUMP AND CLEARING THE BOREHOLE OF CONSTRUCTION FLUIDS

1.0 APPLICABILITY

This procedure applies to the initial pumping of wells before well development or hydrologic testing.

NOTE: This procedure can be waived if the project hydrologist or well site geologist determines that the well has been adequately cleared of construction fluids by bailing.

2.0 DEFINITIONS

- Discharge pipe - the pipe that carries water away from the well to the point of disposal
- Pump - the mechanism used to lift water from the well
- Pump inlet - the location on the pump that water enters. It may be at bottom or along the side of the pump.
- Pump motor - the unit used to drive the pump. It may be combined with pump as an electric submersible unit or an internal combustion engine mounted above the well with a drive shaft to the pump.
- Riser pipe - the pipe connected to the pump that conducts water to the top of the well
- Well head - the top of the well where the riser pipe and the discharge pipe are connected. The term may also include an adjacent flow control valve and water sample outlet.
- Flow control valve - a valve that places a physical restriction in the flow stream to reduce the rate at which water moves through the piping system
- Flow meter - a mechanical device that measures the flow rate and/or the cumulative flow of water in a pipe.

3.0 RESPONSIBLE STAFF

- Project Hydrologist
- Well Site Geologist.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following equipment is needed for the initial pumping of a monitoring well:

- an electric generator, internal combustion engine, or other power source
- water level measuring devices (e.g., steel or electric tapes)
- flow rate measuring devices (e.g., flow meter, bucket, and time piece)
- flow rate control valve (e.g., gate valve or ball valve)
- discharge pipe from well head to point of land disposal or water collection system
- Aquifer Test Well Information sheet
- Aquifer Test Data sheet.

Graduated steel tapes, electric tapes, and pressure transducers are commonly used to measure water levels. The measurement equipment must be in good condition, and instrument function should be confirmed before use in the field. Instrument precision should be sufficient to resolve drawdown to ± 0.04 ft.

Steel tapes that are used shall have been standardized according to Procedure WL-2. Electrical tapes that are used shall have a precision of ± 0.04 ft. Pressure transducers that are used shall have been calibrated by a standards laboratory. Documentation of standardization and calibration shall be available.

The following equipment is required for personal protection when working in the vicinity of a drilling or pump setting rig:

- safety shoes
- hard hat
- safety glasses.

The following additional equipment is required for working adjacent to noisy internal combustion engines:

- ear plugs or sound suppression ear muffs.

The following equipment is required when working with water containing unknown types or unknown levels of contaminants:

- chemical-resistant coveralls
- chemical-resistant boots or boot coverings
- chemical-resistant gloves
- face shield
- sealing tape (duct tape)
- face masks with appropriate air filters or a supplied air source as determined by the safety officer and results of periodic monitoring.

4.1.2 Safety Precautions

Precautions must be taken when starting the pump in the well. The intent of the following instructions is to avoid personal injury and/or damage to pumping equipment. If the pump or drive motor is located above the ground surface, a rotating drive shaft may be present adjacent to the well measuring point. Contact with this shaft during operation by loose clothing, hair, or skin may cause severe or fatal injury. If an electric motor is used to drive the pump, temporary power cords and fuse boxes may be installed and represent a potential shock hazard.

Drive motors for pump motor or electric generators may be noisy. This is especially true of large horsepower internal combustion engines used without benefit of mufflers.

If the ground water contains hazardous concentrations of contaminants (i.e., radioactive, organic, or inorganic chemicals), special precautions must be taken to protect workers and the environment. Before the start of well pumping, personnel should consult the required onsite documents (e.g., Effluent Monitoring Plans and Health and Safety Plans) referring to radiation protection, expected chemical contaminants, and worker safety. Water sample or borehole gas analysis taken during drilling should be examined for indications of hazardous materials before pumping large quantities of water from the well.

At sites where contamination is known or suspected, field staff must have completed radiation safety training and hazardous material handling courses. Where organic compounds are suspected, staff must have completed hazardous material training. Periodic borehole gas monitoring while drilling and pumping is also required. Disregard for these precautions may result in unnecessary exposure to hazardous chemicals and severe injury.

4.1.3 Other Prerequisites

This procedure requires the previous installation of well test pump (see Procedure AT-1), water level monitoring devices, and a discharge line to the ground-water disposal area (see Procedure AT-2).

4.2 Step-by-Step Instructions

4.2.1 Starting the Pump

Position Responsible: PROJECT HYDROLOGIST OR WELL SITE GEOLOGIST

1. Determine the chemical and radiological hazard of well water in association with the site safety officer, and select level of worker protection.

NOTE: Record pertinent information on the Aquifer Test Well Information sheet (Figure 1) and Aquifer Test Data sheet (Figure 2).

2. Partially close the flow control valve. This will prevent rapid dewatering of the well if the initial yield of the well is less than the capacity of the pump.

CAUTION: Reducing the discharge to a small portion of the pump capacity may cause rapid over-pressurization of surface fittings and/or over-heat a submersible pump motor. If in doubt, leave the valve fully open and be prepared to rapidly operate valve to reduce flow rate or to terminate pumping.

3. Start the internal combustion engine for the pump or electric generator and allow it to warm up for about 10 minutes.
4. Take a water level measurement in the well. Make all water level measurements from a consistent measuring point, which should be marked, and in accordance with Procedure WL-1, when possible. Record the totalizer meter reading on the Aquifer Test Data sheet if a flowmeter with a totalizer is used.

NOTE: Record all data on water level, flow rate, changes in water color, and time of observations on the Aquifer Test Data sheets (Figure 2). Record time of measurements based on a 24-hour clock (e.g., record 1:00 PM as 13:00 hours).

5. Start pump and determine if mechanical operation has begun. Electric submersible pumps can be very quiet at the surface. Feel the riser pipe at the well head, and check for minor vibration or humming noise.
6. Observe the end of the discharge pipe, an open faucet installed in the discharge pipe, or the flow meter. Ensure that water is flowing through the piping system. Water may require several seconds to fill the portion of riser pipe above the water table and reach

AQUIFER TEST WELL INFORMATION

Location _____ Date(s) of Test _____

Well Number _____ Procedure Number _____

BOREHOLE INFORMATION

Type of Test(s) _____ Well Depth _____

Open Interval(s) _____

Well Diameter _____ Screen Type/Size _____

Observation Well(s) _____ Depth of Pump Intake _____

Comments _____

MEASUREMENT EQUIPMENT AND DATUM INFORMATION

Water-Level Measurements:

Discharge Measurements:

Electric Tape(s) _____ Flow Meter(s) _____

Steel Tape(s) _____ Bucket and Stop Watch _____

Transducer/Datalogger(s) _____ Orifice Plate _____

Measuring Point _____ Other _____

Datum/Distance _____

Comments _____

WELL CONFIGURATION DIAGRAM
(well as-built, pump setting)

WELL HEAD DIAGRAM
(setup of pipes, valves, meters, etc)

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FIGURE 1. Aquifer Test Well Information Sheet

page _____ of _____

Data for Well _____

Pumping Well _____

Observation Wells _____

Location _____

Type of Aquifer Test _____

How Q Measured _____

How W.L.'s Measured

Rad./Dist. of/From Pumping Well _____

Meas. Point for W.L.'s _____

Elevation of Meas. Point _____

Depth of Pump/Airpipe _____

Pump On: date _____ time _____

Pump Off: date _____ time _____

Duration of Aquifer Test _____

FIGURE 2. Aquifer Test Data Sheet

the well head. Feel riser pipe at well head for temperature change (becoming colder in summer months and warmer in the winter), if no observable discharge points are available. The discharge pipe may take several tens of seconds or more to fill if the water disposal location is greater than 100 feet distant.

7. If no water is being discharged, stop the pump motor. The pump may not be receiving power, be mechanically sand locked, or is of insufficient power to lift water to the land surface.
8. Determine if the well has undergone rapid dewatering by listening for sucking sounds inside the casing, surging sounds inside piping, continuity of demand load on drive unit, and operation of flow meter.
9. Confirm that the well has not been dewatered by evaluating water level measurements. Based on measurements of pump inlet elevation and the maximum available drawdown, determine the present height of the water column above the pump inlet. A water column height of at least 3 feet above the pump inlet should be maintained at all times.
10. Record flow rate and color of discharge water. Inform site safety officer of any unusual odors at the well head. If organic contaminants are suspected of being present in the ground water, have an organic vapor detector reading taken at the point of discharge and at the well head.
11. Continue pumping at this initial rate for several minutes while observing rate of water level decline. If sufficient available drawdown exists, increase discharge rate with flow control valve. If possible, increase the flow rate as a step function, where the flow rate changes quickly and then maintains that rate for a period of 5 to 10 minutes.
12. Repeat steps 9, 10 and 11 until the pump is at full capacity or the maximum drawdown has been achieved. Observe the discharge water, and maintain pumping until water clears. Describe the size and amount of any sand grains or surface films in the discharge water. Sand- and silt-sized particles in the water are common in newly constructed wells.
13. Maintain a constant pumping rate for 20 to 30 minutes, and describe the final clarity and sand content of the discharge water.
14. Stop the pump unless Procedure AT-4, "Well Development Before Hydrologic Testing," is to be performed immediately following clearing of construction fluids.

15. Measure and record the water level as the well recovers from pumping. Record the totalizer meter reading on the Aquifer Test Data sheet if a flowmeter with a totalizer is used.

5.0 REFERENCES

- Procedure AT-1, "Setting and Instrumenting the Test Pump."
- Procedure AT-2, "Configuration of Surface Fittings and Monitoring Devices for Well Development or Hydrologic Testing."
- Procedure WL-1, "Water-Level Measurement Procedure."
- Procedure WL-2, "Procedure for Standardizing Steel Tapes."

AT-4 WELL DEVELOPMENT BEFORE HYDROLOGIC TESTING

1.0 APPLICABILITY

This procedure applies to developing wells for aquifer testing.

NOTE: Steps in this procedure may directly follow steps in Procedure AT-3, Starting the Pump and Clearing the Borehole of Construction Fluids.

2.0 DEFINITIONS

- Discharge pipe - the pipe that carries water away from the well to the point of disposal
- Pump - the mechanism used to lift water from the well
- Pump inlet - the location on the pump that water enters. It may be at bottom or along the side of the pump.
- Pump motor - the unit used to drive the pump. It may be combined with pump as an electric submersible unit or an internal combustion engine mounted above the well with a drive shaft to the pump.
- Well head - the top of the well where the riser pipe and the discharge pipe are connected. The term may also include an adjacent flow control valve and water sample outlet.
- Flow control valve - a valve that places a physical restriction in the flow stream to reduce the rate at which water moves through the piping system
- Flow meter - a mechanical device that measures the flow rate and/or the cumulative flow of water in a pipe
- Turbidity - a lack of clarity in the water as a result of suspended clay, silt, organic material, or inorganic constituents.

3.0 RESPONSIBLE STAFF

- Project Hydrologist
- Well-Site Geologist.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following equipment is needed for well development:

- an electric generator, internal combustion engine, or other power source

- water level measuring devices (e.g., steel or electric tapes)
- flow rate measuring devices (e.g., flow meter, bucket, and time piece)
- flow rate control valve (e.g., gate valve or ball valve)
- discharge pipe from well head to point of land disposal or water collection system
- Aquifer Test Well Information sheet
- Aquifer Test Data sheet.

Graduated steel tapes, electric tapes, and pressure transducers are commonly used to measure water levels. A measurement device should be dedicated to each well for the test period. The measurement equipment must be in good condition, and instrument function should be confirmed before use in the field. Electric and steel tapes should be full length. Instrument precision should be sufficient to resolve drawdown to ± 0.04 ft.

Steel tapes that are used shall have been standardized according to Procedure WL-2. Electrical tapes that are used shall have a precision of ± 0.04 ft. Pressure transducers that are used shall have been calibrated by a standards laboratory. Flow meters that are used for constant-discharge tests shall have been calibrated by a standards laboratory. Documentation of calibration and standardization of this equipment shall be available.

The following equipment is required for personal protection when working in the vicinity of a drilling or pump setting rig:

- safety shoes
- hard hat
- safety glasses.

The following additional equipment is required for working adjacent to noisy internal combustion engines:

- ear plugs or sound suppression ear muffs.

The following equipment is required when working with water containing contaminants of unknown type or concentration:

- chemical-resistant coveralls
- chemical-resistant boots or boot coverings
- chemical-resistant gloves
- face shield
- sealing tape (duct tape)

- face masks with appropriate air filters or a supplied air source as determined by the safety officer and results of periodic monitoring.

4.1.2 Safety Precautions

Precautions must be taken when starting the pump in the well. The intent of the following instructions is to avoid personal injury and/or damage to pumping equipment. If the pump or drive motor is located above the ground surface, a rotating drive shaft may be present adjacent to the well measuring point. Contact with this shaft during operation by loose clothing, hair, or skin may cause severe or fatal injury. If an electric motor is used to drive the pump, temporary power cords and fuse boxes may be installed and represent a potential shock hazard.

Drive motors for pump motor or electric generators may be noisy. This is especially true of large horsepower internal combustion engines used without benefit of mufflers.

If the ground water contains hazardous concentrations of contaminants (i.e., radioactive, organic, or inorganic chemicals), special precautions must be taken to protect workers and the environment. Before the start of well development, personnel should consult the required onsite documents (e.g., Effluent Monitoring Plans and Health and Safety Plans) referring to radiation protection, expected chemical contaminants, and worker safety. Water samples or borehole gas analysis taken during drilling should be examined for indications of hazardous materials before pumping large quantities of water from the well.

At sites where contamination is known or suspected, field staff must have completed radiation safety training and hazardous material handling courses. Where organic compounds are suspected, staff must have completed hazardous material training. Periodic borehole gas monitoring while drilling and pumping is also required. Disregard for these precautions may result in unnecessary exposure to hazardous chemicals or severe injury.

4.1.3 Other Prerequisites

This procedure requires the previous installation of well pump (see Procedure AT-1), water level monitoring devices, and a discharge line to the ground-water disposal area (see Procedure AT-2). The initial pumping and clearing of borehole fluids is also required before using this procedure (see Procedure AT-3).

4.2 Step-by-Step Instructions

4.2.1 Developing the Well

Position Responsible: PROJECT HYDROLOGIST OR WELL-SITE GEOLOGIST

1. Determine the chemical and radiological hazard of the well water in association with the site safety officer, and select level of worker protection.

NOTE: Record pertinent information on the Aquifer Test Well Information sheet (Figure 1) and the Aquifer Test Data sheet (Figure 2).

2. Start pump following precautions outlined in Procedure AT-3, or continue from step 10 of Procedure AT-3, "Starting the Pump and Clearing the Borehole of Construction Fluids." Record the water level, flow rate, changes in water color, and time of observations on the standard Aquifer Test Data sheets (Figure 2). Measure water levels from a consistent measuring point, which should be marked. Record time of measurements based on a 24-hour clock (e.g., record 1:00 PM as 13:00 hours). Record totalizer reading on the Aquifer Test Data sheet if a flow meter with a totalizer is used.

NOTE: If the pump does not have a check valve and has been installed specifically for well development, go to step 3. If the pump has a check valve, go to step 5.

3. Increase pumping rate by opening flow control valve while closely measuring water level decline in well. Observe flowstream and note any change in color or clarity. Allow water level to reach maximum drawdown or a level about 3 feet above pump inlet.
4. Stop pumping by idling direct-drive engine or shutting off pump power on an electrical motor. Measure and record water level recovery. When water level recovers to about 80% of the difference between the initial static level and the maximum level during pumping, repeat steps 2 to 4 for at least 5 pump and recovery cycles. Record the pumping rate, maximum water level recovery between pumping cycles, the number of pumping and recovery cycles, and minimum water level during pumping.

CAUTION: Be alert for dewatering of the well. This condition is not serious if the pump is shut off as soon as air enters the pump. Determine if the well has undergone dewatering by listening for sucking sounds inside it, surging sounds inside piping, continuity of demand load on drive unit, operation of flow meter, or water levels reaching a point about 1 to 2 feet above pump inlet and then stabilizing.

5. Continue pumping at the initial rate for several minutes while observing the rate of water level decline. Maintain this pumping rate until water levels stabilize, or for a maximum of about 30 minutes. If sufficient available drawdown exists, increase discharge rate by opening flow control valve. If possible, increase the flow rate as a step function, where the flow rate changes quickly. Measure and record the water level.

AQUIFER TEST WELL INFORMATION

Location _____ Date(s) of Test _____

Well Number _____ Procedure Number _____

BOREHOLE INFORMATION

Type of Test(s) _____ Well Depth _____

Open Interval(s) _____

Well Diameter _____ Screen Type/Size _____

Observation Well(s) _____ Depth of Pump Intake _____

Comments _____

MEASUREMENT EQUIPMENT AND DATUM INFORMATION

Water-Level Measurements:

Discharge Measurements:

Electric Tape(s) _____ Flow Meter(s) _____

Steel Tape(s) _____ Bucket and Stop Watch _____

Transducer/Datalogger(s) _____ Orifice Plate _____

Measuring Point _____ Other _____

Datum/Distance _____

Comments _____

WELL CONFIGURATION DIAGRAM
(well as-built, pump setting)

WELL HEAD DIAGRAM
(setup of pipes, valves, meters, etc)

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FIGURE 1. Aquifer Test Well Information Sheet

page _____ of _____

Data for Well: _____

Pumping Well _____

Observation Wells _____

Location _____

Type of Aquifer Test _____

How Q Measured _____

How W.L.'s Measured _____

Rad./Dist. of/From Pumping Well _____

Meas. Point for W.L.'s _____

Elevation of Meas. Point _____

Depth of Pump/Airpipe _____

Pump On: date _____ time _____

Pump Off: date _____ time _____

Duration of Aquifer Test _____

FIGURE 2. Aquifer Test Data Sheet

6. Repeat step 5 until the pump is at full capacity or the maximum drawdown has been achieved. Observe and record the appearance of the discharge water, discharge rate, and water levels.
7. Well development at the maximum discharge rate or maximum drawdown should continue at a minimum until the water is clear (i.e., the bottom of a white plastic 5-gallon bucket is visible when filled with discharge water) and sediment removed from the aquifer is less than about 1 tablespoon of sediment for 5 gallons of water.
8. If a constant-discharge test is to be conducted using the existing pump and discharge configuration, set the flow control valve to allow the desired discharge rate. Record this discharge rate.
9. Take a final water level measurement and stop the pump. Make water level measurements following a water level measurement schedule of one measurement every minute for the first 5 minutes after pump shut off and then a measurement every 5 minutes. Continue taking water level measurements until the well recovers to the initial static level or 30 minutes of measurements have been taken. Record the totalizer reading on the Aquifer Test Data sheet if a flow meter with a totalizer meter is used.

5.0 REFERENCES

- Procedure AT-1, "Setting and Instrumenting the Test Pump."
- Procedure AT-2, "Configuration of Surface Fittings and Monitoring Devices for Well Development or Hydrologic Testing."
- Procedure AT-3, "Starting the Pump and Clearing the Borehole of Construction Fluids."
- Procedure WL-2, "Procedure for Standardizing Steel Tapes."

AT-5 CONSTANT DISCHARGE TEST

1.0 APPLICABILITY

This procedure applies to hydrologic testing in wells.

The overall purpose of this procedure is to provide guidance in aquifer test decision making for hydrologic characterization studies. Aquifer testing involves many variables and requires that important decisions be made while the test is in progress. Therefore, primary decisions concerning an aquifer test cannot be predetermined. This procedure assumes that Procedures AT-1, AT-2, AT-3, and AT-4 have been conducted at the well.

2.0 DEFINITIONS

- Data logger - a field computer that operates a transducer and records the measurements
- Discharge pipe - the pipe that carries water away from the well to the point of disposal
- Pump - the mechanism used to lift water from the well
- Pump inlet - the location on the pump that water enters. It may be at the bottom or along the side of the pump.
- Pump motor - the unit used to drive the pump. It may be combined with the pump as an electric submersible unit or an internal combustion engine mounted above the well with a drive shaft to the pump.
- Stilling pipe - a length of poly or steel pipe either attached to the riser pipe or inserted into the well. Water level measurements are made inside the stilling pipe to reduce the effects of water turbulence.
- Transducer - an electro-mechanical device for measuring water pressure
- Riser pipe - the pipe connected to the pump that conducts water to the top of the well
- Well head - the top of the well where the riser pipe and the discharge pipe are connected. The term may also include an adjacent flow control valve and water sample outlet.
- Aquifer test - a test to characterize the hydrologic properties of the geologic materials surrounding the well bore
- Flow control valve - a valve that places a physical restriction in the flow stream to reduce the rate at which water moves through the piping system

- Flow meter - a mechanical device that measures the flow rate and/or the cumulative flow of water in a pipe.

3.0 RESPONSIBLE STAFF

- Project Hydrologist
- Well-Site Geologist.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

Equipment needed to perform an aquifer test is nearly the same as that needed for well development. In many instances, considerable savings in cost and effort can be made by planning a combined program of development and testing at each well using the same equipment. The pumping equipment needed to test the well include

- well pump with check valve
- an electric generator, internal combustion engine, or other power source
- water level measuring devices (e.g., steel or electric tapes, transducer, and data logger)
- stop watch(es) (if more than one are used, they shall be synchronized to within 1 second)
- flow rate measuring devices (e.g., flow meter, bucket, and time piece)
- flow rate control valve (e.g., gate valve or ball valve)
- discharge pipe from well head to point of land disposal or water collection system
- Aquifer Test Well Information sheet
- Aquifer Test Data sheets
- semilogarithmic graph paper
- flood lights (if testing will be conducted during non-daylight hours).

The selection and sizing of pumping equipment is normally made following discussions among the well driller, the project hydrologist, and the well-site geologist and consulting the Aquifer Test Plan, if one has been written.

Because the hydraulic properties at a newly drilled well have not yet been determined, estimation of the well yield is subject to uncertainty.

Graduated steel tapes, electric tapes, and pressure transducers are commonly used to measure water levels. A measurement device should be dedicated to each well for the test period. Back-up measurement equipment should also be available. The measurement equipment must be in good condition and instrument function (i.e., electric tapes and transducers) should be confirmed before use in the field. Instrument precision should be sufficient to resolve drawdown to ± 0.04 ft.

Pressure transducers read water pressure directly and do not need to be installed inside of a stilling pipe. Refer to Procedure WL-3 or WL-4 for installation and use of pressure transducers and data loggers.

Steel tapes that are used shall have been standardized according to Procedure WL-2. Electrical tapes that are used shall have a precision of ± 0.04 ft. Pressure transducers that are used shall have been calibrated by a standards laboratory. Flow meters that are used shall have also been calibrated by a standards laboratory. Documentation of calibration and standardization of this equipment shall be available.

The following equipment is required for personal protection when working in the vicinity of a drilling or pump setting rig:

- safety shoes
- hard hat
- safety glasses.

The following additional equipment is required for working adjacent to noisy internal combustion engines:

- ear plugs or sound suppression ear muffs.

The following equipment is required when working with water containing unknown contaminants or unknown concentration of contaminants:

- chemical-resistant coveralls
- chemical-resistant boots or boot coverings
- chemical-resistant gloves
- face shield
- sealing tape (duct tape)
- face masks with appropriate air filters or a supplied air source as determined by the safety officer and results of periodic monitoring.

Consult Site Health and Safety Plan, and RCRA, CERCLA, and OSHA requirements for additional information.

4.1.2 Safety Precautions

Pump or drive motor may be located above the ground surface and a rotating drive shaft may be present adjacent to the well measuring point. Contact with this shaft during operation by loose clothing, hair, or skin may cause severe or fatal injury. If an electric motor is used to drive the pump, temporary power cords and fuse boxes may be installed and represent a potential shock hazard. Drive motors for pump setting machines may be noisy. This is especially true of large horsepower internal combustion engines used without benefit of mufflers.

If the ground water contains hazardous concentrations of contaminants (i.e., radioactive, organic, or inorganic chemicals), special precautions must be taken to protect workers and the environment. Before the start of well development, personnel should examine the required onsite documents (e.g., Effluent Monitoring Plan and Health and Safety Plan) referring to radiation protection, expected chemical contaminants, and worker safety. Water sample or borehole gas analysis taken during drilling should be examined for indications of hazardous materials before pumping large quantities of water from the well.

At sites where contamination is known or suspected, field staff must have completed radiation safety training and hazardous material handling courses. Where organic compounds are suspected, staff must have completed hazardous material training. Periodic borehole gas monitoring while drilling and pumping is also required. Disregard for these precautions may result in unnecessary exposure to hazardous chemicals and severe injury.

4.1.3 Other Prerequisites

Procedures AT-1, "Setting and Instrumenting the Test Pump"; AT-2, "Configuration of Surface Fittings and Monitoring Devices for Well Development or Hydrologic Testing"; AT-3, "Starting the Pump and Clearing the Borehole of Construction Fluids"; and AT-4, "Well Development Before Hydrologic Testing" should have been followed at this well previously. Pumping rate should be determined through analysis of the results of Procedure AT-4.

4.2 Step-by-Step Instructions

Position Responsible: PROJECT HYDROLOGIST OR WELL-SITE GEOLOGIST

4.2.1 Conducting the Constant Discharge Test

1. Determine the chemical and radiological hazard of the well water in association with the site safety officer, and select level of worker protection.

NOTE: Record all pertinent information on the Aquifer Test Well Information sheet (Figure 1) or the Aquifer Test Data sheets (Figure 2).

AQUIFER TEST WELL INFORMATION

Location _____ Date(s) of Test _____

Well Number _____ Procedure Number _____

BOREHOLE INFORMATION

Type of Test(s) _____ Well Depth _____

Open Interval(s) _____

Well Diameter _____ Screen Type/Size _____

Observation Well(s) _____ Depth of Pump Intake _____

Comments _____

MEASUREMENT EQUIPMENT AND DATUM INFORMATION

Water-Level Measurements:

Discharge Measurements:

Electric Tape(s) _____ Flow Meter(s) _____

Steel Tape(s) _____ Bucket and Stop Watch _____

Transducer/Datalogger(s) _____ Orifice Plate _____

Measuring Point _____ Other _____

Datum/Distance _____

Comments _____

WELL CONFIGURATION DIAGRAM
(well as-built, pump setting)

WELL HEAD DIAGRAM
(setup of pipes, valves, meters, etc)

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FIGURE 1. Aquifer Test Well Information Sheet

Aquifer Test Data

SAMPLE DATA SET

page 1 of 3

Data for Well 211-H2-14

Pumping Well SAME

Observation Wells

Location 200 E

Type of Aquifer Test DEV & CONSTANT Q

How Q Measured FLOW METER # 179-84-32, BUCKET 6 GAL

How W.L.'s Measured ETAPPE # 3374

Rad./Dist. of/From Pumping Well -

Meas. Point for W.L.'s TOC TOP OF CASING

Elevation of Meas. Point 1.7 ABOVE L.S.

Depth of Pump/Airpipe 312'

Pump On: date 6-12-87 time

Pump Off: date 6-12-87 time

Duration of Aquifer Test

Time		Water Level Data				Discharge		Recorded By	Comments
t =	at t' = 0	Static Water Level				Reading	Q		
87 Day	Clock Time	1	2	3	4	Reading	Q		
6-12	13:10					285.75		PLO	PRETEST
	13:22					285.76		PLO	"
	13:28					285.75	FT 100	PLO	"
	13:30	0				285.75	21743	PLO	START TEST ONE
	13:31	1				-	50	PLO	WATER VERY DIRTY
	13:32	2				287.71	~ 45	PLO	
	13:33	3				297.0	40	PLO	
	13:34	4				298.52	-	PLO	WATER CLEARING
	13:35	5				-	31745	38	PLO
	13:36	6				299.51	-	PLO	
	13:37	7				302.44	-	PLO	SOME SAND IN PIPE
	13:38	8				-	325	PLO	
	13:39	9				305.02	-	PLO	
	13:40	10				305.06	31748	370	PLO STOP
	13:45					298.9		PLO	RECOVERY
	13:50					296.23		PLO	NEW Q = 1 gpm
	13:55					295.70		PLO	
	13:56	0				295.87	31749	PLO	START TEST TWO
	13:57	1				290.-	20	PLO	ADJ Q
	13:58	2				291.03	15	PLO	" " CLEAR
	13:59	3				293.12	8	PLO	" "
	14:00	4				294.30	10	PLO	" "
	14:01	5				295.11	-	PLO	
	14:02	6				295.25	7	PLO	" "
	14:03	7				295.64	10	PLO	" "
	14:05	9				296.97	10	PLO	WATER CLEAR YELLOW
	14:06	10				297.30	9.5	PLO	33 SEC / 6 GAL
	14:08	12				297.92	10	PLO	" NO SAND
	14:11	15				298.40	10	PLO	
	14:13	17				298.67	-	PLO	
✓	14:16	20				299.21	21750	10	PLO 36 SEC / 6 GAL
	14:17	21	0	-		299.33		PLO	OFF
	14:18	22	1	22		292.-		PLO	
	14:19	23	2	11.5		290.11		PLO	
	14:20	24	3	8		289.53		PLO	
	14:21	25	4	6.25		288.22		PLO	
	14:22	26	5	5.2		289.51		PLO	
	14:24	28	7	4		289.25		PLO	
✓	14:26	30	9	3.3		287.57		PLO	

FIGURE 2. Aquifer Test Data Sheet

2. Install water-level measuring equipment in the pumping and observation wells and measure the water level in the wells. This equipment may be installed, and data collected, some time before aquifer testing to establish pre-test trends. When making these and other measurements, record the data on water level, flow rate, and time of observations on the standard Aquifer Test Data sheets. Record time of measurements based on a 24-hour clock (e.g., record 1:00 PM as 13:00 hours). Take water level measurements in each well from a consistent measuring point, which should be marked. Also record the well casing inside diameter, screen inside diameter, pump diameter, pump column (riser pipe) outside diameter, the depth to the bottom of the pump, and location of the pump intake on the Aquifer Test Well Information sheet. In addition, record the measurement point (or reference point) location, and vertical distance to a reference point (usually land surface) (± 0.1 foot or better), locations of the observation wells in relation to the pumping well, and distance between the pumping well and all observation wells (± 1.0 foot or better). These data can be collected before or after the aquifer test. Record the totalizer reading on the Aquifer Test Data sheet if a flowmeter with a totalizer meter is used.

NOTE: Entries onto the Aquifer Test Data sheets shall be initialed when so indicated under "Recorded by" column.

3. Start internal combustion engine for pump or electric generator and allow it to warm up for about 10 minutes. The desired discharge rate should have been determined during well development (Procedure AT-4), and the flow control valve previously set. The riser pipe should be full before starting the test. If the flow control valve has not been previously set, partially close the valve. If the riser pipe is not full, turn on the pump for a short time (less than 10 minutes should suffice) until water is being pumped through the discharge line. If the discharge rate has not previously been set by adjusting the flow control valve, it can be adjusted at this time. The transducer/data logger system can also be checked for proper operation at this time. Turn the pump off.

CAUTION: Reducing the discharge to a small portion of the pump capacity may cause rapid over-pressurization of surface fittings and/or over-heat a submersible pump motor. If in doubt, leave the valve fully open and be prepared to rapidly operate the flow control valve to reduce flow rate or to terminate pumping.

4. Prepare the data logger to collect pressure data at the desired frequencies. Refer to Procedure WL-3 or WL-4. Set the data logger to start at the planned time that the pump will be started (this ensures that very early time data are not missed).
5. Take a water level measurement in the pumping and observation wells. Compare this measurement with the measurement taken in

step 2. Water level changes greater than 0.05 foot indicate well recovery from development or other pre-test pumping. Wait 10 minutes and confirm water level stability. Record the totalizer reading on the Aquifer Test Data sheet if a flow meter with a totalizer is used.

6. Record the well number, date, and time of day. Start the pump and determine if mechanical operation has begun. Electric submersible pumps can be very quiet at the surface. Feel the riser pipe at the well head and check for minor vibration or humming noise.
7. Begin making water level measurements (see steps 13 and 14) in the pumping and observation wells. Water level measurements should be taken frequently at the beginning of the test, with the frequency decreasing as the length of the test increases. An example schedule is given in Table 1. A frequency of one minute may not be sufficient in some cases.

TABLE 1. Common Frequency of Data Collection in Aquifer Testing

<u>Time Since the Start of Pumping (minutes)</u>	<u>Measurement Frequency</u>
0 - 10	every 1 minute
10 - 20	every 2 minutes
20 - 40	every 5 minutes
40 - 80	every 10 minutes
80 - 120	every 20 minutes
120 - 360	every 30 minutes
360 - 600	every 40 minutes
600 - 1440	every 60 minutes
1440 - on	every 120 minutes

8. Observe the end of the discharge pipe, an open faucet installed in the discharge pipe, or the flow meter. Ensure that water is flowing through the piping system. Feel riser pipe at well head for temperature change (becoming colder in summer months and warmer in winter time), if no observable discharge points are available. The discharge pipe may take several tens of seconds or longer to fill if the water disposal location is greater than 100 feet distant.

NOTE: If no water is being discharged, stop pumping. The pump may not be receiving power, may be mechanically sand locked, or may be of insufficient power to lift water to the land surface.

NOTE: Determine if the well has undergone rapid dewatering by listening for sucking sounds inside it, surging sounds inside piping, continuity of demand load on drive unit, and operation of flow meter.

9. Confirm that the well has not been dewatered by evaluating the water level measurements. Based on measurements of pump inlet elevation and the maximum available drawdown, determine the present height of the water column above the pump inlet. A water column height of at least 3 feet above the pump inlet should be maintained throughout the test. If this level of drawdown occurs in the early portion of a test, the test may have to be prematurely terminated.
10. Check and record flow rate at one-quarter to one-half the frequency at which water level measurements are made. Previous experience or scoping calculations will allow an approximation of the proper pump discharge based on transmissivity and height of the water column in the bore.
11. Based on the desired pumping rate and the results of steps 6 through 10, adjust the pumping rate with the flow control valve. Discharge adjustment to the planned rate should be made as early in the test as possible. If the well is being pumped at a rate too low, the rate can be increased without stopping the pump because the system is understressed.

If the rate is far too high (i.e., the well ran dry), stop the pump and record water level recovery data to aid in determining a long-term sustainable pumping rate. The test can be restarted at the lower pumping rate following water level recovery. The well should be allowed to recover to at least 95% of the static level before resuming the test. The period of recovery is approximately equal to the pumping period.

NOTE: Adjusting the discharge rate by changing engine speed of the drive unit is not usually precise enough to maintain the discharge rate within prescribed limits. Pumping rates, especially at early times, require regular monitoring and adjustment to maintain a steady rate. As water levels drop, the total hydraulic head is increased, and discharge rates commonly decrease. Small scale adjustment to discharge rate may not be discernable with instantaneous indicators. Time-averaged discharge rates over 10-minute intervals from a totalizing meter are generally sufficient to accurately determine discharge rate. Discharge rates should be measured and adjusted as required throughout the test. Variation of discharge rate should be limited and maintained within 10% of the nominal rate.

NOTE: Once a pumping rate has been established reasonably close to the desired rate, it is best to conduct the test at that operational pumping rate. Flow rate adjustment is not a linear function of valve operation. Small valve adjustments can cause large changes in flow rate causing oscillations between values higher than and lower than the planned pumping rate.

12. Record flow rate and color of discharge water. Inform site safety officer of any unusual odors at the well head. If organic

contaminants are suspected of being present in the ground water, have an organic vapor detector reading taken at the point of discharge and at the well head.

13. Continuously evaluate drawdown at the pumping well and observation well(s) during the test to ensure that the changes in water level are recorded at the appropriate frequency. The early portion of the test requires a more rapid data collection rate than at later times. The objective is not to collect data according to a strict predetermined standard, but to collect an appropriate amount of data to describe what is happening to the water levels. A minimum rate of data collection is 10 measurements for each cycle of logarithmic time (e.g., the period from 0 to 10 minutes or 10 to 100 minutes). A common schedule is provided in Table 1.

Data loggers can be programmed to measure the water level every 1 to 2 minutes throughout the test and will record the water level response in great detail. Although this frequency of measurement is not needed to track events during the test, it ensures that any unusual events or responses are recorded in their entirety and requires no additional effort by the field staff.

14. Observation wells exhibit a time delay between the start of pumping and water level response. Measure response of observation wells at regular intervals of 2 to 10 minutes (depending on responses observed in pumping well) to ascertain the initiation of drawdown. When the observation well begins to draw down in response to pumping, reset the measurement frequency to the measurement schedule used at the beginning of the test at the pumping well. The frequency of measurements in observation wells should be sufficient to describe the changes in water level(s) that are occurring.
15. Plot the water level and flow rate measurements taken in the early portion of the test and all subsequent water level measurements on semi-log graph paper to track well response during pumping. Evaluate the drawdown response in the first 10 to 20 minutes of pumping. A data trend, under most circumstances, will be established by this point in the test. Plot time since the start of pumping in minutes along the logarithmic X axis. Plot water level decline from static level (drawdown) and flow rate along the Y axis as illustrated in Figure 3. The semi-log data plot should indicate a linear trend.

Analysis of drawdown response and pumping rate are needed to confirm that test conditions are producing interpretable data. A change in the rate of drawdown may be the result of a hydrologic effect or a change in the pumping rate. Assuming the well yield is reasonably close to the expected value, an estimate of drawdown per logarithmic time cycle can be determined. The slope of the semi-log drawdown plot is directly proportional to pumping rate. Therefore, if the slope indicates that over a specified pumping

FIGURE 3. Example of Semi-Log Graph Paper Used to Track Well Response During Pumping

period the well will have twice as much drawdown as planned, the pumping rate can simply be cut in half. Carefully monitor well response and maintain a constant pumping rate to provide quality data for interpretation. If the drawdown rate is acceptable, the initial rate can be maintained and the test continued. If the drawdown rate is excessive, stop the pump and follow the instructions in step 11.

16. Examine the field data plots for the pumping and observation wells to determine if the measurement frequency is appropriate. The overriding objective is to define the water level changes occurring in the well(s). If conditions are regular and slowly changing, then a standard frequency is adequate. Sudden water level changes or any other change that results in a nonlinear response as noted on the semi-log data plot requires an increase in sampling frequency. The frequency of measurements should be sufficient to describe any variance that occurs.
17. Data analysis during the test aids in determining when enough information has been collected. Events such as mechanical failure may terminate the pumping portion of the test. In that case, begin recovery data collection immediately. Other events such as intercepting a recharge boundary or the well reaching equilibrium may suggest termination of pumping before the scheduled end of the test. If data are erratic or static over a significant portion of the test period, shut down the pump and record the recovery data.

Analyze drawdown data in the field by the Cooper-Jacob method (Cooper and Jacob 1946) to determine when sufficient data have been collected for analysis. If an observation well is used, ensure that the condition that "u" is less than 0.01 is met for a sufficient amount of data from which to make an analysis.

NOTE: It must be recognized that it is improper to terminate a test solely on the basis of a predetermined test interval. If the field data plots indicate that interesting or unusual data trends are developing, consider extending the pumping period. Examples of unusual data trends include sudden changes in the slope of the drawdown plot, water level increases, and water levels following a step-like pattern. Illustrative cases are found in Chapter 16 of Groundwater and Wells (Driscoll 1986). In many cases, additional pumping time is necessary to properly define the hydraulic effect that is being noted. Identification and interpretation of such events is fundamental to aquifer characterization.

18. Prepare the data logger to collect recovery data at a frequency similar to that for drawdown data. Set the data logger to start recording at the planned time that the pump will be shut off.
19. Turn off the pump and observe water-level recovery in all wells. Repeat a data collection frequency similar to Table 1 or that

which was used in observing drawdown. Record the totalizer reading on the Aquifer Test Data sheet if a flow meter with a totalizer meter is used.

20. Analyze recovery data in the field by the Cooper-Jacob method (Cooper and Jacob 1946) to demonstrate when useful data are no longer being collected. Data loggers can be allowed to continue operation for 12 to 24 hours after the pump is shut off.

NOTE: Example data sheets and data plots are presented in Figures 1 and 2. These figures demonstrate some of the analyses that are useful in guiding the early stages of an aquifer test. The example data plot compresses several types of information (i.e., two short episodes of drawdown, discharge rate for the second test, and water level recovery) onto a single sheet. For convenience and clarity, multiple sheets can be used. Figures 1 and 2 demonstrate the data that must be recorded to document test activities. Figure 2 illustrates that the initial discharge rate was adjusted to a lower value and the test restarted. The length of the tests is not representative.

NOTE: Interpretation of aquifer tests beyond the level described above is outside the scope of test procedures.

5.0 REFERENCES

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- Procedure AT-2, "Configuration of Surface Fittings and Monitoring Devices for Well Development or Hydrologic Testing."
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- Procedure AT-4, "Well Development Before Hydrologic Testing."
- Procedure WL-2, "Procedure for Standardizing Steel Tapes."
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- Procedure WL-4, "Installation, Operation, and Removal of a Data Logger and Pressure Transducer."

AT-6 AQUIFER SLUG INJECTION AND WITHDRAWAL TEST

1.0 APPLICABILITY

This procedure applies to conducting slug tests in single wells or piezometers with various configurations before or after the wells or piezometers have been developed or completed. Slug tests are initiated by causing an instantaneous change in hydraulic head through a sudden introduction or removal of a known volume (a cylinder) and then observing the water-level recovery response with time (Lohman 1979).

Slug testing yields an estimate of in situ hydraulic conductivity near a well. The representativeness of the estimate depends on the hydrogeologic conditions and the quality of the well (Hvorslev 1951). It also depends on how the test is performed.

Other procedures that are applicable in conducting slug tests are Procedures WL-1, WL-3, and WL-4.

2.0 DEFINITIONS

- Data Logger - a field computer that operates a transducer and records the measurements
- Transducer - an electro-mechanical device for measuring water pressure
- Aquifer Test - a test to determine the hydrologic properties of the geologic materials surrounding the well bore
- Slug Test - a test to determine the hydrologic properties of the geologic materials surrounding the well bore, conducted by suddenly introducing or withdrawing a cylinder of known volume and then observing the change in water level with time.

The word "well" shall refer to well or piezometer throughout this procedure.

3.0 RESPONSIBLE STAFF

- Project Hydrologist
- Well-Site Geologist.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

- cylinder of known volume
- supporting line (e.g., cable or monofilament fishing line)

- water-level measuring devices (e.g., standard steel tape, electric water-level indicator, or calibrated transducer and data logger)
- engineering measuring tape
- stop watch(es)
- Slug Test Record Forms (Figure 1)
- Aquifer Test Data Sheets (Figure 2).

A drilling or pump setting rig may be required to lower or lift the known volume (cylinder) in the well if the cylinder is too heavy to hold manually.

If more than one stop watch is used, synchronize all stop watches to within 1 sec.

4.1.2 Safety Precautions

The following equipment is required for personal protection when working in the vicinity of a drilling or pump setting rig:

- safety shoes
- hard hat
- safety glasses.

The following equipment may be required as specified by the site safety officer:

- chemical-resistant coveralls
- chemical-resistant boots or boot coverings
- chemical-resistant gloves
- face shield
- sealing tape (duct tape)
- face masks with appropriate air filters or a supplied air source as determined by the safety officer and results of periodic monitoring.

A drilling or pump setting rig may be used to lower or lift the cylindrical volume. These activities pose potential hazards from falling or swinging objects.

Well Number _____ Date of Test _____

Location _____ Type of Test _____

Personnel Conducting Test _____

Depth to Water _____

SLUG INFORMATION

Slug Construction Materials _____

Length of Slug _____ Diameter of Slug _____

Volume of Attachments (if applicable) _____

WELL CONFIGURATION AT TIME OF TEST

Borehole Diameter
of Tested Interval _____

Open Interval:

Depth to Bottom _____	Length _____	Borehole Diameter of Tested Interval _____
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Cased Interval:

Depth to Bottom _____	Length _____	Inside Diameter _____
--------------------------	--------------	--------------------------

Screened Interval:

Depth to Bottom _____	Length _____	Inside Diameter _____
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COMMENTS: _____

Signature _____ Date _____

FIGURE 1. Slug Test Record Form

page _____ of _____

Data for Well _____

Pumping Well _____

Observation Wells _____

Location _____

Type of Aquifer Test _____

How Q Measured _____

How W.L.'s Measured _____

Rad./Dist. of/From Pumping Well _____

Meas. Point for W.L.'s _____

Elevation of Meas. Point _____

Depth of Pump/Airpipe _____

Pump On: date _____ time _____

Pump Off: date _____ time _____

Duration of Aquifer Test _____

FIGURE 2. Aquifer Test Data Sheet

At sites where contamination is known or suspected, field staff must have completed radiation safety training and hazardous material handling courses. Where organic compounds are suspected, staff must have completed hazardous material training. Disregard for these precautions may result in unnecessary exposure to hazardous chemicals and severe injury.

4.1.3 Other Prerequisites

The cylindrical slug shall be constructed of materials that will not introduce contaminants or other debris into the well.

4.2 Step-by-Step Instructions

4.2.1 Conducting the Slug Injection Test

Responsible Staff: PROJECT HYDROLOGIST AND/OR WELL-SITE GEOLOGIST

1. In association with the site safety officer, determine the chemical and radiological hazard of the well water, and select level of worker protection.
2. Select a slug whose outside diameter is less than the inside diameter of the well casing or screen below the water level. The diameter of the slug must be such that it allows clearance for an electric water-level indicator probe to fit in the space between the slug and the screen or casing. The transducer, cable, cable connections, or other possible obstructions in the well; height of the water column; supporting line tension limitations; and expected water-level response during testing must also be considered when selecting the slug size.

NOTE: It is recommended that the chosen cylindrical slug be constructed of heavy materials, such as carbon steel casing filled with sand and sealed at both ends. This will allow the slug to drop quickly in the water when it is released.

3. Record information pertaining to the test on a Slug Test Record Form (Figure 1). Record the well number, date of test, location, type of test (injection or withdrawal), persons conducting test, and the depth to water under the correct Slug Test Record Form heading. Record the construction materials of the slug, length of slug, diameter of slug, volume of other attachments (e.g., cable or eye hook) that may cause significant displacement of water under "Slug Information." Record borehole diameter, open interval information (if applicable), cased interval, and screened interval (if applicable) under "Well Configuration at Time of Test." Record make, model, and serial number of measurement equipment on the Aquifer Test Data Sheet (Figure 2). Information can be entered on the forms before or after the slug test.

4. Synchronize all timing pieces (watches or clocks) that will be used during the slug test. Also synchronize watches with the clock in the data logger. This should be done before activating the data logger in step 7.
5. Measure the static water level in the well being tested using a standard steel tape or an electric water-level indicator according to Procedure WL-1. Measure from an established measurement reference point or from the north side of the top of casing if the reference point has not yet been established.
6. If you plan to monitor the water level with a recorder during the slug injection test, install a transducer in the well according to Procedure WL-3 or WL-4. Make sure that the transducer, cable, or any attached couplings will not interfere with the introduction of the slug. If, by displacement, submergence of the probe causes the water level to rise above the static water level, allow the water level to recover before proceeding.
7. Activate the data logger to begin collecting baseline data at a constant time interval of 5 min or less, if baseline data are desired. Preset the data logger to collect data according to a logarithmic or approximate time scale for the actual slug test. The data logger should be set to measure and record water-level data at a sufficient rate to describe the response of the water levels during the test. A recommended schedule is provided in Table 1.

TABLE 1. Frequency of Data Collection for Slug Testing

<u>Time Since the Start of Injection or Withdrawal (sec)</u>	<u>Measurement Frequency Interval (sec)</u>
0 - 10	1
10 - 30	2
30 - 100	5
100 - 300	20
300 - 600	50
600 - 1200	100
1200 - 3600	300
> 3600	600

8. Attach the slug to the supporting line on the rig or other support. Make sure the slug is attached securely. If you plan to introduce the slug into the water manually, secure the end of the supporting line.

Steps 9, 10, and 12 should be used only as a guide in positioning and releasing the slug and do not have to be strictly adhered to. It is important to ensure that the bottom of the slug is above the static water level before it is released and that the top of the slug is below the static water level after it is released.

9. Measure from the end of the slug with an engineering measuring tape and mark off the supporting line. Suspend the slug in the well so that the bottom of the slug is 0.1 foot above the static water level. Use the steel tape measurement performed in Step 5 to determine the correct position of the slug. Be careful not to immerse any part of the slug into the water while positioning the slug. If the slug is inadvertently immersed in the water, reposition the slug and allow the water level to return to static before proceeding.

NOTE: Ideally, the slug should be placed as close to the water as possible before it is released. This will reduce the pressure wave caused by splashing upon impact.

10. Mark the supporting line at a fixed point (e.g., top of well casing). This mark will be referred to as the unsubmerged reference point. Mark the supporting line beyond the unsubmerged reference point at a distance equal to at least 0.1 foot greater than the length of the slug. This mark will be referred to as the submerged reference point.
11. If, for some reason (e.g., delays in setting up equipment), the predetermined time of the beginning of the slug test has changed, reset the data logger to the new time.
12. At the predetermined time quickly release the slug into the well and allow the slug to drop until the submerged reference point reaches at least the level of the fixed point. This will ensure that the slug is completely submerged in the water below the static water level.
13. Measure the water level with an electric water-level indicator at the instant the slug is completely submerged, if possible, and record the water level on the Aquifer Test Data Sheet. Continue to measure and record water-level data at a sufficient rate possible to describe the response of the water levels. A schedule is provided in Table 1. It may not be possible to measure the water level during the first 100 sec as frequently as scheduled. Measurements every 10 sec for the first 100 sec of the test will suffice when using an electric water-level indicator.

NOTE: It is recommended that the times of measurements for at least the first 30 min be prerecorded on the Aquifer Test Data Sheet before conducting the test. This will alleviate confusion as to when each measurement should be taken.

14. Continue to measure and record the water-level recovery until H/H_0 is less than 0.1 (Cooper et al. 1967) where

H = head inside the well at time t after injection of the slug, above the initial head

H_0 = head inside the well above the initial head at the instant the slug is injected.

NOTE: Step 14 should be used only as a guide because it may not be possible to attain $H/H_0 < 0.1$ within a reasonable time. The length of the test should be left to the discretion of the Project Hydrologist.

15. When all testing is completed, remove the slug from the well.

4.2.2 Conducting the Slug Withdrawal Test

1. Perform Steps 1 through 5 in Section 4.2.1. Ignore the note following Step 2 in Section 4.2.1.
2. If you plan to monitor the water level with a recorder during the slug withdrawal test, install a transducer in the well according to Procedure WL-3 or WL-4. Make sure that the transducer, cable, or any attached couplings will not interfere with the removal of the slug. Also make sure the transducer is below the lowest expected water level upon removal of the slug. The change in water level upon removal of the slug theoretically can be calculated by dividing the volume of the slug by the cross-sectional area of the casing or screen. If, by displacement, submergence of the probe causes the water level to rise above the static water level, allow the water level to recover before proceeding.
3. Perform Step 7 in Section 4.2.1.
4. Attach the slug to the supporting line on the rig or other support. Make sure the slug is attached securely. If you plan to remove the slug from the water manually, secure the end of the supporting line.

Steps 5, 6, and 9 should be used only as a guide in positioning and removing the slug and do not have to be strictly adhered to. The important steps are to ensure that the top of the slug is below the static water level before the test is conducted and that the bottom of the slug is above the static water level after it is withdrawn.

5. Measure from end of the slug with an engineering measuring tape and mark off the supporting line. Suspend the slug in the well so that the bottom of the slug is above the static water level. Use the steel tape measurement performed in Step 5 of Section 4.2.1 to determine the correct position of the slug. Mark the supporting line at a fixed point (e.g., top of well casing). This mark will be referred to as the unsubmerged reference point.

6. Lower the slug slowly so that it is completely submerged. The top of the slug should be below the static water level. Use the water-level measurement performed in Step 5 of Section 4.2.1 to determine the correct position of the slug. Make sure that the electric water-level indicator or pressure probe will not interfere with or be damaged by the slug.
7. Allow the water level to recover to its static level or establish a pretest trend, before proceeding.
8. Measure the water level in the well being tested using a standard steel tape or an electric water-level indicator according to Procedure WL-1 and record the measurement on the Aquifer Test Data Sheet. Measure the water level from the measurement reference point.
9. At the predetermined time, quickly withdraw the slug from the water until the unsubmerged reference point reaches the fixed point. This will ensure that the slug is completely withdrawn from the water.
10. Measure the water level with an electric water-level indicator at the instant the slug is withdrawn, if possible, and record water level on the Aquifer Test Data Sheet. Continue to measure and record water-level data at a sufficient rate to describe the response of the water levels. A recommended schedule is provided in Table 1. It may not be possible to measure the water level during the first 100 sec as frequently as scheduled. Measurements every 10 sec for the first 100 sec of the test will suffice when using an electric water-level indicator.

NOTE: It is recommended that the times of measurements for at least the first 30 min be prerecorded on the Aquifer Test Data Sheets before conducting the test. This will alleviate confusion as to when each measurement should be taken.

11. Continue to measure and record the water-level recovery until H/H_0 is less than 0.1 where

H = head inside the well at time t after removal of the slug, above the initial head

H_0 = head inside the well above the initial head at the instant the slug is removed.

NOTE: Step 11 should be used only as a guide because it may not be possible to attain $H/H_0 < 0.1$ within a reasonable amount of time. The length of the test should be left to the discretion of the Project Hydrologist.

12. When all testing is completed, remove the slug from the well.

NOTE: If you plan to conduct the slug withdrawal test after the slug injection test, follow Steps 1 through 14 of Section 4.2.1 followed by Steps 3, 7, 8, 9, 10, 11, and 12 of Section 4.2.2. Also, the transducer may have to be repositioned to a greater depth if it is expected that the water level will drop below it when the slug is withdrawn.

5.0 REFERENCES

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SG-1 USING GROUND-PENETRATING RADAR FOR GEOPHYSICAL SITE SURVEYS

1.0 APPLICABILITY

This geophysical sensing method measures variations in electromagnetic fields to detect and characterize natural or manmade features, objects, or materials in the ground. To provide this characterization, electromagnetic waves are backscattered from objects or interfaces in the ground.

2.0 DEFINITIONS

- ATV--all-terrain vehicle.

3.0 RESPONSIBLE STAFF

- Task leader
- Technical staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following equipment is required to conduct surveys using ground-penetrating radar:

- Geophysical Survey Systems, Inc. (GSSI) ground-penetrating radar system, operator's manual, and circuit diagrams
- digital data acquisition unit and operator's manual
- all-terrain vehicle (ATV) with on-board batteries or generator for equipment power
- GSSI P731 calibrator
- spare cables and batteries.

Written descriptions of the geophysical field work will be recorded in field notebooks. The contents of these notebooks will include site descriptions, explanations of the work being performed, a list of the instruments used in the work, records of instrument settings, notations of anomalous occurrences, and descriptive details relating to data collection (e.g., line numbers, traverse directions, obstructions, deviations, data record numbers, and data file names). A separate notebook will be used by each individual or group that is performing independent field work.

4.1.2 Safety Precautions

The ATV used for ground-penetrating radar surveys will not be operated on steep slopes or embankments that, in the judgement of the operator, cannot be safely negotiated.

The SITE SAFETY OFFICER shall evaluate safety issues related to potential chemical or radioactive contamination of the site and to the possibility of ground subsidence over collapsing waste materials or containers before initiation of geophysical field work.

4.2 Step-by-Step Instructions

4.2.1 Calibrating and Preparing the Equipment

1. Before operation of the survey system, inspect and, if needed, clean the cables, connectors, and tape recorder heads. Inspect and, if needed, charge the battery. (During operation, battery status is indicated by a voltmeter and indicator lights on the radar control unit.)
2. Inspect the ATV for adequate gas and oil levels and tire pressure.
3. Record performance of steps 1 and 2 in the field notebook.
4. Record a travel-time calibration record, utilizing the P731 calibrator, at least once per day during field operations and whenever a change is made in the timing parameters of the radar system. This will be a special data record on the recording medium used for the rest of the radar field data (digital magnetic tape or disk).
5. Record the performance of the calibration procedure and the location of the calibration data in the recorded data set in the operator's field notebook.

4.2.2 Defining and Mapping Boundaries

1. The emplacement of a survey grid will normally be done by KEH surveyors before the initiation of geophysical measurements, but may be done by PNL geophysical survey personnel where appropriate (e.g., at small sites). In the latter case, the locations of the grid lines will be determined by use of a measuring tape and will normally be later surveyed by KEH to obtain relocatable coordinates in the Hanford coordinate system. Surveying may be unnecessary at certain sites where the survey grids or individual survey lines can be clearly and accurately defined by reference to known control points or other permanent features (e.g., buildings).
2. The nodes of a survey grid located in a large open area will normally be marked by wooden stakes. Alternative markers such as

paint or metal spikes may be employed in areas where wooden stakes are inappropriate due to presence of asphalt, concrete, vehicle traffic, or other factors.

3. The spacing of the stakes or alternative markers which define a survey grid will be determined in part by the requirements of other site characterization tasks. If the grid is defined by wooden stakes, the spacing of the stakes should not be less than 25 ft (8 m) to ensure that there will be sufficient room to maneuver the GPR equipment. Unless all of the survey lines are coincident with a line of stakes (see note below), the spacing of the stakes should be 100 ft (30 m) or less. This will help to ensure accuracy in the location of survey lines that are more closely spaced than the marked grid lines.

NOTE: Geophysical survey lines are not always coincident with the grid lines for at least two reasons: 1) because of spatial resolution requirements, it may be appropriate to collect geophysical data along lines that are more closely spaced than the grid lines, and 2) the stakes are obstructions that make it impossible to maneuver survey vehicles and certain geophysical instruments directly along the grid lines. Instead, data may be collected along lines that are offset by measured distances from the grid lines. The amount of offset and direction relative to the grid will be recorded in the field notebook and accounted for in the subsequent data analysis. Other major obstructions on the ground surface (bushes, rocks, surface debris, pipes, fences, posts, buildings, fixed machinery, etc.) will also be recorded in the field notebook. Only those obstructions greater than the lateral spatial resolution of the survey instrument or the subsurface feature to be detected will be recorded.

4.2.3 Collecting the Data

NOTE: The survey system may be towed by the ATV or pulled by the operator. If towed, a footage counter mounted on the ATV provides position data that are inserted into the data records. If pulled, no footage counter is provided. The method of transport will be recorded in the field notebook.

1. Activate the equipment and allow it to warm up for 1 min.
2. Adjust the system parameters such as time scale, gain, filter, sampling rate, and signal frequency rate (antenna selection) to optimize the radar signals. Record all instrument settings in the operator's field notebook.
3. Position the survey system along the survey line and transport the instrument along the line at a constant speed of 2 to 5 ft/sec. This will allow an along-track data spacing of 1 ft or less. It is generally not cost effective to attempt to obtain a fixed data

spacing. Record pertinent data (e.g., direction, location, track number, obstructions) relating to each traverse in the operator's field notebook.

4. Record radar data in digital form on magnetic tape cartridges or disks.
5. Repeat steps 3 and 4 until all survey lines have been traversed.
6. Write the file name and date on the paper label on each data cartridge or disk.
7. Transfer the data to the laboratory computer for processing. Record the unprocessed data on 9-track magnetic tape for long-term storage and transmittal to Westinghouse Hanford Company.

4.2.4 Data Processing

1. Process the radar data using a PC or DEC VAX computer. Processing steps may include clutter removal, filtering, synthetic aperture focusing, and image enhancement. Intermediate output products will be amplitude-modulated radar profiles in the form of photographic prints or laser printer images. Selected profiles can be provided at any reasonable scale as requested by Westinghouse Hanford Company. The final product will be a 22 in. x 18 in. site map showing the interpreted locations, depths, and characteristics of waste materials and other waste-related features. This map may include the results of the other types of geophysical surveys performed at the site.
2. In accordance with an established software control system, a magnetic copy of all raw and processed data collected shall be placed into the permanent project record file. The data shall be traceable to the date and location of collection, and to the LRB in which the data collection is recorded.

The program used to process data shall be referenced in the project LRB. A listing and description of the program will be placed into the permanent project record files and shall be controlled in accordance with an established software control system.

SG-2 USING MAGNETOMETERS TO CONDUCT GEOPHYSICAL SITE SURVEYS

1.0 APPLICABILITY

This geophysical sensing method measures variations in magnetic field to detect and characterize natural or manmade features, objects, or materials in the ground. To provide this characterization, magnetic materials produce measurable anomalies in the ambient (earth's) magnetic field.

2.0 DEFINITIONS

The term "gradiometer" refers to a particular type of magnetometer that uses two sensors separated by a fixed distance to estimate the gradient of a magnetic field.

3.0 RESPONSIBLE STAFF

- Task leader
- Technical staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following equipment is required to perform magnetometer surveys:

- cesium vapor magnetometer, operator's manual, and circuit diagrams OR proton precession magnetometer and operator's manual OR flux-gate gradiometer and operator's manual
- digital recorder and operator's manual
- personal computer (PC) with floppy disk drive
- floppy disks
- 6-V gel-cell battery pack (if using cesium vapor magnetometer)
- size C, non-magnetic internal batteries (if using proton precession magnetometer)
- spare batteries.

Written descriptions of the geophysical field work will be recorded in field notebooks. The contents of these notebooks will include site descriptions, explanations of the work being performed, general field procedures, a list of the instruments used in the work, records of instrument settings, notations of anomalous occurrences, and descriptive details relating to data collection (e.g., line numbers, traverse directions, obstructions, deviations, data

record numbers, and data file names). A separate notebook will be used by each individual or group that is performing independent field work.

4.1.2 Safety Precautions

The SITE SAFETY OFFICER shall evaluate safety issues related to potential chemical or radioactive contamination of the site and to the possibility of ground subsidence over collapsing waste materials or containers before initiation of geophysical field work.

4.2 Step-by-Step Instructions

4.2.1 Calibrating and Preparing the Equipment

1. Before operation of the magnetometer, inspect and, if needed, clean the cables, connectors, and tape recorder heads. Inspect and, if needed, charge the battery. (During operation, low battery voltage is indicated on the front panel display of the magnetometer.)

NOTE: The calibration of cesium vapor and proton precession magnetometers is determined by fundamental physical constants and is not adjustable by the user. A correct reading of the known ambient magnetic field indicates that the instrument is functioning correctly. The ambient field at Hanford is approximately 56,000 gammas.

2. Check short-term stability of the magnetometer daily by a 1-min sequence of measurements at a fixed field location. Variations of ± 1 gamma and ± 5 gammas will be considered acceptable for the proton precession and cesium vapor magnetometers, respectively.
3. Check long-term stability of the magnetometer by repeating at least one survey line at each site. This test is for reasonable and expected behavior. Variations of a few gammas are normal; much larger local variations will occur in areas of high magnetic gradient.
4. Monitor diurnal variations in the earth's magnetic field by making periodic measurements at a fixed location at an interval of 1 hr or less (these measurements are not necessary if the fluxgate gradiometer is used).
5. Record the performance of steps 1, 2, 3, and 4 in the operator's field notebook.

4.2.2 Collecting the Data

NOTE: The magnetometer is carried by the operator.

1. Before beginning the survey, ensure that the operator is not carrying or wearing any magnetic object (e.g., knife, belt buckle, or steel-reinforced boots) that can affect the magnetic measurement.
2. Activate the instrument and allow it to warm up for 1 min. (5 min for the cesium vapor magnetometer.)
3. Carry the magnetometer along predetermined survey lines at a constant speed of 3 to 5 ft/sec. Data will be automatically recorded in digital form at a rate of several samples per second. The survey lines are referenced to a grid defined and marked in accordance with Procedure SG-1, Using Ground-Penetrating Radar for Geophysical Site Surveys, Section 4.2.2.
4. Transfer the data stored in the digital data recorder to floppy disk using the onsite PC. Label (site, data set name), date, and back up each floppy disk.
5. Record any pertinent data (e.g., direction, location, track number, obstructions) relating to each traverse in the operator's field notebook.

4.2.3 Data Processing

1. Process the magnetic data using a PC or DEC VAX computer. Processing steps may include interpolation, filtering, correction for diurnal variations, and subtraction of the ambient field. Output products may include magnetic profiles, contour maps, and color-coded maps of magnetic amplitudes. The primary output product will be a site map showing the interpreted locations of magnetic waste materials. These results may be included on a more general site map that contains the results of other geophysical surveys.
2. In accordance with an established software control system, a magnetic copy of all raw and processed data collected shall be placed into the permanent project record file. The data shall be traceable to the date and location of collection, and to the LRB in which the data collection is recorded.

The program used to process data shall be referenced in the project LRB. A listing and description of the program will be placed into the permanent project record files and shall be controlled in accordance with an established software control system.

SG-3 USING ELECTROMAGNETIC INDUCTION FOR GEOPHYSICAL SITE SURVEYS

1.0 APPLICABILITY

This geophysical sensing method measures variations in electromagnetic fields to detect and characterize natural or manmade features, objects, or materials in the ground. To provide this characterization, measurable secondary magnetic fields are induced in conductive objects by an alternating magnetic field source at or above the ground surface.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Task leader
- Technical staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following equipment is required to perform electromagnetic induction:

- Geonics EM34-3 or EM-31 ground conductivity meter, operator's manual, and circuit diagrams
- digital data acquisition unit (for EM-31)
- size C internal batteries
- spare cables and batteries
- personal computer (PC) with floppy disk drive
- floppy disks.

Written descriptions of the geophysical field work will be recorded in field notebooks. The contents of these notebooks will include site descriptions, explanations of the work being performed, a list of the instruments used in the work, records of instrument settings, notations of anomalous occurrences, and descriptive details relating to data collection (e.g., line numbers, traverse directions, obstructions, deviations, data record numbers, and data file names). A separate notebook will be used by each individual or group that is performing independent field work.

4.1.2 Safety Precautions

The SITE SAFETY OFFICER shall evaluate safety issues related to potential chemical or radioactive contamination of the site and to the possibility of ground subsidence over collapsing waste materials or containers before initiation of geophysical field work.

4.2 Step-by-Step Instructions

4.2.1 Calibrating and Preparing the Equipment

NOTE: The ground conductivity meter is factory calibrated.

1. Before operation of the ground conductivity meter, inspect and, if needed, clean the cables, connectors, and tape recorder heads. Inspect and, if needed, charge the battery.
2. Conduct equipment functional tests as specified in the operator's manual.
3. Check the long-term repeatability of the instrument before use by measuring the ground conductivity at PNL's test site near the 2400 Stevens Building. Make any needed adjustments according to the procedures listed in the operator's manual.
4. Record the performance of steps 1, 2, and 3 in the operator's field notebook.

4.2.2 Collecting the Data

NOTE: The instrument is carried by the operator.

1. Activate the instrument and allow it to warm up for 1 min.
2. Carry the instrument along predetermined survey lines at a constant speed of 3 to 5 ft/sec. Data will be automatically recorded in digital form at a rate of several samples per second. The survey lines are referenced to a grid defined and marked in accordance with Procedure SG-1, Using Ground-Penetrating Radar for Geophysical Site Surveys, Section 4.2.2.
3. Record pertinent data related to each survey line in the operator's field notebook.
4. Transfer the recorded data to floppy disks and label (site, data set name), date, and back up the disks.

4.2.3 Data Processing

1. Process the data using a PC or DEC VAX computer. Processing steps may include interpolation and filtering. Output products may include conductivity (apparent) profiles, contour maps, and

color-coded maps. The primary output product will be a site map showing the interpreted locations of detected waste materials or subsurface structures. These results may be included on a more general site map that contains the results of other geophysical surveys.

2. In accordance with an established software control system, a magnetic copy of all raw and processed data collected shall be placed into the permanent project record file. The data shall be traceable to the date and location of collection, and to the LRB in which the data collection is recorded.

The program used to process data shall be referenced in the project LRB. A listing and description of the program will be placed into the permanent project record files and shall be controlled in accordance with an established software control system.

SG-4 USING A METAL DETECTOR FOR GEOPHYSICAL SITE SURVEYS

1.0 APPLICABILITY

This geophysical sensing method measures variations in electromagnetic fields to detect and characterize natural or manmade features, objects, or materials in the ground. To provide this characterization, measurable secondary magnetic fields are induced in conductive objects with a sensor specialized to detect metallic objects.

2.0 DEFINITIONS

N/A

3.0 RESPONSIBLE STAFF

- Task leader
- Technical staff.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment

The following equipment is required to conduct surveys using a metal detector:

- Fisher M-scope pipe and cable locator and operator's manual
- spare batteries.

Written descriptions of the geophysical field work will be recorded in field notebooks. The contents of these notebooks will include site descriptions, explanations of the work being performed, a list of the instruments used in the work, records of instrument settings, notations of anomalous occurrences, and descriptive details relating to data collection (e.g., line numbers, traverse directions, obstructions, deviations, data record numbers, and data file names). A separate notebook will be used by each individual or group that is performing independent field work.

4.1.2 Safety Precautions

The SITE SAFETY OFFICER shall evaluate safety issues related to potential chemical or radioactive contamination of the site and to the possibility of ground subsidence over collapsing waste materials or containers before initiation of geophysical field work.

4.2 Step-by-Step Instructions

4.2.1 Calibrating and Preparing the Equipment

NOTE: The locator is an uncalibrated instrument used for indication only. Frequent adjustments are required onsite to ensure good sensitivity.

These are normally made by maximizing the response to a known target such as a buried pipeline or a metal plate placed on the ground surface. Record the performance of this procedure in the operator's field notebook.

1. Before operating the instrument, check the battery using the instrument's front-panel, battery-check function switch. Replace the battery if low voltage is indicated.

4.2.2 Collecting the Data

NOTE: The instrument will be carried by the operator.

1. Activate the instrument and allow it to warm up for 1 min.
2. Carry the instrument along a survey line at a constant speed of 1 to 5 ft/sec until a response is obtained.
3. Move the instrument in an areal pattern to define the boundaries of the detected object or material.
4. Mark the boundaries on the ground (e.g., spray paint, marks in the dirt, rocks).
5. Record the location in the operator's field notebook.

4.2.3 Data Processing

1. Replot the field records and present them either as a separate map or as a component of a more general site map containing the results of other geophysical surveys.

CR-1 IDENTIFICATION, EVALUATION, AND TREATMENT OF CULTURAL RESOURCES

1.0 APPLICABILITY

This procedure describes techniques to be used and information to be recorded during the identification of cultural resources by Pacific Northwest Laboratory (PNL) staff or subcontractors. It is to be followed before any earth disturbance pursuant to hazardous or nuclear waste management.

2.0 DEFINITIONS

- Artifact - Anything with form or position that cannot be attributed to natural processes.
- Feature - A nonportable, nondiscrete artifact or close association of artifacts.
- Isolate - A group of two or fewer artifacts found within less than 10 m (33 ft) of each other, and/or greater than 20 m (66 ft) from a site.
- Site - The locus of concentrated human activity, indicated by the presence of artifacts in specified densities, tactically defined as artifacts found in groups of three or more with less than 10 m (33 ft) between objects, or groups of one or more features.
- Traditional Use Area - Locations traditionally used by ethnic groups and important for religious observance, resource gathering, or community cohesion.
- Temporally Diagnostic - Having characteristics unique to a single period of prehistory.
- Identification - The process of locating cultural resource properties, including sites, objects, structures, and places with a long history of human use.
- Literature and Records Review - An inspection of extant records on history, prehistory, ethnography, and cultural resources to obtain information about any known cultural resources and registered historic properties that may exist in a project area and provide background data on the kinds and distributions of cultural resources that might exist on previously unsurveyed lands (often referred to as Class 1 survey).
- Field Survey - The systematic inspection of the land surface and, when necessary, subsurface probing, to locate previously undiscovered cultural resource sites and objects.
- HCRC - Hanford Cultural Resources Classification.

3.0 RESPONSIBLE STAFF

- Task Leader
- Cognizant Staff Members.

4.0 PROCEDURE

4.1 Prerequisites

4.1.1 Equipment/Supplies

- Laboratory Record Book (LRB)
- Hanford Cultural Resources Survey Form
- HCRC Comments/Continuation Form
- HCRC Isolate Forms
- HCRC Site Forms
- HCRC Photo Log
- compass.

4.2 Step-by-Step Instructions - Identifying Sites, Buildings, and Objects

Literature and records review and field survey are the means used to identify cultural resources of this kind. A literature and records review is required in all cases of planned disturbance. A field survey is required only when undisturbed ground is to be impacted and/or a literature review indicates that cultural resources may be present, and no cultural resources survey has been conducted or when field surveys that were conducted failed to use techniques equivalent to, or more intensive than, those described below, as determined by the task leader.

4.2.1 Conducting a Literature and Records Review

Position Responsible: TASK LEADER AND/OR COGNIZANT STAFF MEMBER

Review all available documentation to determine

- whether the area(s) in question has ever been surveyed for cultural resources
- whether the survey met the minimum requirements described in Section 4.2.2 below
- whether cultural resources have been found and their locations recorded, and
- whether or not those resources have been evaluated for and/or listed on the National Register of Historic Places.

Records and literature that are to be reviewed include, but are not limited to, the archaeological site records file for the subject state, reports on previous cultural resource surveys and excavations in the vicinity of the project site, local histories, and county land ownership records. In

addition, regional experts in history and prehistory may also be consulted. The results of a literature and records review shall be documented in the project LRB. The entry shall be signed and dated by the author.

4.2.2 Conducting a Field Survey

Position Responsible: COGNIZANT STAFF MEMBER

Procedures used to conduct cultural resource surveys follow guidelines established by the Washington State Office of Archaeology and Historic Preservation. An intensive survey entails pedestrian search of the entire area to be impacted either directly or indirectly by a project.

1. Conduct the survey in parallel transects, maintained by compass bearing and spaced no more than 20 m apart, visually scanning the area 5 m to either side of the transect center line.
2. Where ground surface exposure is less than 20%, such as in old fields colonized by non-native plant species, scrape the plant cover from an area approximately 30 cm in diameter and expose mineral soil at intervals of approximately 5 m along the transect lines.
3. In areas where geomorphology indicates high potential for buried artifact deposits, as determined by the Task Leader and following standard archaeological techniques (e.g., Hester, Heizer, and Graham 1975), conduct subsurface tests a maximum of 25 m apart, excavating up to 2 m deep using a 10-cm-dia bucket auger. Screen the excavated soil through 1/4-in. wire cloth and save all shells, bones, and stone artifacts and count and weigh all fire-modified rocks. Discard any fire-modified rocks after recording the count and weights.
4. In areas covered by modern fill, excavate backhoe trenches if Holocene sediment deposits are suspected beneath the ground surface and the setting indicates a high potential for archaeological deposits, as determined by the Task Leader.
5. During the survey, seek features and artifacts of prehistoric or historic (>50 years old) manufacture.
6. Record the following information, and anything else deemed pertinent, for each parcel of land surveyed on Hanford Cultural Resources Survey Forms (Figure 1) and place in the project LRB:
 - time of day work commenced and ceased
 - names of the survey participants
 - weather conditions
 - light intensity

HANFORD CULTURAL RESOURCES SURVEY FORM

Page 1 of 3
Form __ of __

Project name: Project #: Survey site #: _____

Date: Start time: Survey participants:
End time:

Weather: Light: Wind:

Map reference:

Description of project area and survey strategy:

Previous disturbance:

Topography:

Surface sediments (including depth indications):

FIGURE 1. Hanford Cultural Resources Survey Form

HANFORD CULTURAL RESOURCES SURVEY FORM (Cont'd.)

Page 2 of 3
Form ___ of ___

Date:

Project #:

Survey site #: _____

Plant types/communities and relative abundance. List in decreasing order of dominance:

Ground cover (%):

Animals observed and inferred:

Cultural material observed:

Cultural material collected:

Evaluation of the potential for recovery of paleoenvironmental data:

FIGURE 1. (contd)

HANFORD CULTURAL RESOURCES SURVEY FORM (contd)

Page 3 of 3
Form ___ of ___

Date: _____

Project #: _____

Survey site #: _____

Comments: _____

Sketch map:

		match sheet _____							
match sheet								match sheet	
		match sheet _____							

Scale

Recorder: _____

Date: _____

FIGURE 1. (contd)

- description of the area to be surveyed and the survey strategy to be used (if it deviates from standard procedures)
- kind and extent of any previous anthropogenic disturbance to the survey area
- topographic setting, geomorphology, and edaphic conditions
- approximate percentage of mineral soil exposed
- vegetation and fauna
- locations of any auger tests excavated
- presence, location, and content of any cultural properties, ranging from isolated artifacts to dense artifact concentrations and historic farm complexes. Plot locations on USGS 1:24,000 scale maps and on a sketch map of a larger scale appropriate to the size of the cultural property observed, as in Section 4.3.1, step 1, below.
- artifacts collected, if any (see discussion of artifact collection policies, below).

The person entering the information must sign and date the form(s).

7. Use an HCRC Comments/Continuation Form (Figure 2) to record additional or continued information from the survey forms and other field data forms used with this procedure. Place this information into the LRB as well.

4.3 Step-by-Step Instructions - Recovery of Surficial Cultural Resource Data

4.3.1 Recovering Isolates

Position Responsible: COGNIZANT STAFF MEMBER

NOTE: COGNIZANT STAFF MEMBERS collect isolates only when they are found in areas scheduled for surface modification or if they are in an area considered to be susceptible to unauthorized collection. Sufficient documentation, including photographs of the area surrounding the find, should be made at the time of the discovery to permit analysis (see Section 4.2.2, step 6, above).

1. Mark isolates with a project sequence number on project topographic maps at a scale of 1:24,000. Sequence numbers take the format HI-YEAR-SEQUENCE NUMBER (Chatters 1989).
2. Describe the isolate on an HCRC Isolate Form (Figure 3) and place in the project LRB and in the Isolate Record Log (Figure 4) with respect to:

HCRC COMMENTS/CONTINUATION FORM

Project #:

1) HCRC survey: Survey site #: _____

Page ____ of ____

2) HCRC isolate: Isolate #: _____

3) HCRC site: Site #: _____

Continuation of form _____

Recorder: _____ Date: _____ LRB #: _____ Page #: _____

FIGURE 2. HCRC Comments/Continuation Form

HCRC ISOLATE FORM

Page 1 of

Prehistoric Historic Isolate # (HI-year-sequence #):

Project: Service assessment Other

Project #: Microenvironment(s):

Plot #:

Elevation:

Location: 1/4 of 1/4 of 1/4 of Section T , R .

Map reference(s): Aerial photo reference:

UTM: Zone , m. Easting m. Northing

General location and access:

Description and functional type:

Topographic setting:

slope:
aspect:

Direction/distance to permanent water:

Name of permanent water source:

Surface sediments (including depth indications):

Recorder: Date: LRB #: Page #:

FIGURE 3. HCRC Isolate Form

HCRC ISOLATE FORM (contd)

Page 2 of ____.

Isolate # _____ Site #: _____ Project #: _____

Plant types and relative abundance (a = abundant, c = common, r = rate).
List in order of dominance:

Ground cover (%):

Animals observed and inferred:

Photograph #s:

Draw to scale if temporally diagnostic:

Comments:

Recorder: _____ Date: _____ LRB #: _____ Page #: _____

FIGURE 3. (contd)

[illegible]

461

- functional type
- topographic setting, including slope and aspect
- habitat setting.

The person entering the information must sign and date the form(s) or LRB entry.

3. If isolates are temporally diagnostic, photograph and draw to scale. Photographs are numbered, as taken, by roll and frame on HCRC Photo Log forms (Figure 5). Roll numbers are sequential beginning in 1987. Photo Log forms are placed in LRBs and entered in a continuously maintained photographic log notebook.

4.3.2 Recovery of Sites

Position Responsible: COGNIZANT STAFF MEMBER

As with isolates, no artifacts will be collected unless they are considered to be susceptible to unauthorized collection. Sites will be duly recorded in the official archaeological/historic site files of the appropriate state.

1. Give the site a temporary site number of the form HT-YEAR-SEQUENCE NUMBER.
2. Mark site location on topographic maps at a scale of 1:24,000 with inferred site boundaries distinctly labeled.
3. Fully describe the site on an HCRC Site Form (Figure 6) and transfer or copy the description into the LRB. Descriptions will include, when applicable
 - a map of the extent of the site at an appropriate scale, showing locations of features, the area of artifact distribution, and any modern anthropogenic disturbance. Maps will also show the location of the site with respect to surveyed grid markers, landforms, roads, and any other features that will aid in relocating the site.
 - kinds and quantities of artifacts observed with special attention to the presence of materials that may be used to determine site age or function
 - any unusual or diagnostic characteristics that will aid in analysis of site age or function
 - characteristics of surface sediments and any indications of accumulation of Holocene sediments
 - topographic setting
 - habitat setting

HCRC PHOTO LOG

ROLL # _____ COLOR SLIDE _____ COLOR PRINT _____ B&W _____ ASA _____.

EXPOSURE #	PROJECT #	SITE #	SUBJECT	DIRECTION OF VIEW	DATE	PHOTOGRAPHER
------------	-----------	--------	---------	----------------------	------	--------------

1

2

3

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FIGURE 5. HCRC Photo Log

HCRC SITE FORM

Page 1 of ____.

Prehistoric____ Historic____ Site # (HT-year-sequence #):

Project:____ Service assessment____ Other____

Project #:____ Microenvironment(s):

Plot #:____

Site type:

Elevation:

Location:____1/4 of____1/4 of____1/4 of Section____ T____. R____.

Map reference(s): Aerial photo reference:

UTM:Zone____, ____ m.Easting ____ m.Northing

General location and access:

Description of site:

Site dimensions:

Site area:

Site condition: Excellent____, Good____, Fair____, Poor____

Agent of impact:

Estimated depth of cultural material:

National Register potential:

____Significant

____Non-significant

Justify:

Topographic setting:

Degree of slope:

Aspect of slope:

Direction/distance to permanent water:

Name of permanent water source:

Surface sediments (including depth indications) and depositional environment:

Recorder: _____ Date: _____ LRB #: _____ Page #: _____

FIGURE 6. HCRC Site Form

HCRC SITE FORM (contd)

Page 2 of ____.

Site #:

Plant types and relative abundance (a = abundant, c = common, r = rare). List species in order of dominance:

Ground cover (%):

Animals observed and inferred:

Total number of objects:

Maximum density of objects:

Debitage: numbers present:

Greatest concentration:

lithologies:

Type:

Formed tools:

Quantity

Type

Description

Features:

Site date:

How dated:

Photograph #s:

Comments:

Recorder: _____ Date: _____ LRB #: _____ Page #: _____

FIGURE 6. (contd)

CULTURAL RESOURCES SITE MAP

SITE #: _____

match sheet _____

match sheet _____

Scale _____

Comments: _____

Recorder: _____ Date: _____ Page ___ of ___
 Recorder: _____ Date: _____ LRB #: _____ Page #: _____

FIGURE 6. (contd)

- any modern anthropogenic disturbance to the site and an estimate of how long ago it occurred.

The person entering the information must sign and date the form or LRB.

4. Enter site information on the HCRC Site Log (Figure 7).
5. Photograph the site, including setting overviews, features, and temporally diagnostic artifacts.
6. Objects that indicate site age and/or function and features contained within site boundaries will be
 - marked with a number on project maps
 - described on HCRC Site Forms (Figure 6) and in LRBs with respect to their position within the site, keyed to map location numbers
 - photographed
 - drawn to scale, if temporally diagnostic.

4.4 Discovery of Suspected Human Remains

If suspected human remains are discovered, the COGNIZANT STAFF MEMBER will notify the TASK LEADER, who will follow procedures set forth in Section 3.3.2 of the Hanford Cultural Resources Management Plan (Chatters 1989).

4.5 Step-by-Step Instructions for Traditional Use Areas

Procedures for eliciting information on traditional use areas will follow National Park Service guidelines (Parker and King 1989). These include, but are not limited to, the review of ethnographic and ethnohistorical literature and interviews with representatives of Indian tribes.

4.5.1 Reviewing Ethnographic and Ethnohistorical Literature

Position Responsible: TASK LEADER OR COGNIZANT STAFF MEMBER

1. Review anthropological and historical literature on ethnic groups known to have used and to still reside in the vicinity of the project area to identify localities that have recorded significance to those groups.
2. Record findings in the project LRB.

The person entering information into the LRB must sign and date the entries.

HCRC SITE LOG

SITE TYPE	SURFACE COLLECTION?	DATE SITE FORM COMPLETED	COMMENTS	RECORDER AND DATE

FIGURE 7. (contd)

4.5.2 Interviewing Tribal Elders

Position Responsible: TASK LEADER OR COGNIZANT STAFF MEMBER

1. Contact the governments of Indian Tribes or leaders of ethnic communities with historic ties to the project area and request their collaboration in gathering traditional use information (as well as values placed by the tribes on areas of the site).
2. Conduct interviews with individuals identified by these leaders as knowledgeable of traditional uses of the project area. Subjects of the interviews will include place names, activities at named place, resources-gathering activities, and identification of cemeteries and other sacred places.
3. Record information obtained through those interviews in the LRB.

The person entering information in the LRB must sign and date the entries.

4.6 Evaluating Cultural Properties Identified During Literature Review or Survey

If an archaeological site, historic site, or traditional use area is discovered during Cultural Resource Identification activities, the TASK LEADER will evaluate it for eligibility to the National Register of Historic Places following procedures specified in Section 3.1.2 of the Hanford Cultural Resources Management Plan (Chatters 1989). Sites, objects, and landscapes that are eligible for the National Register of Historic Places are known as "historic properties."

4.7 Assessing and Mitigating Effects on Cultural Resources of Characterization and Remediation Activities

If a historic property is found to lie in the path of proposed earth disturbing activities, the TASK LEADER will perform a Finding of Effect and Finding of Adverse Effect as described in Section 3.1.3 of the Hanford Cultural Resources Management Plan (Chatters 1989).

If an earth disturbing activity is suspected to have a potential adverse effect, measures will be developed, in consultation with the State Historic Preservation Officer, Advisory Council for Historic Preservation, and other interested parties (e.g., Indian tribes, historical societies, individuals) to avoid or mitigate that effect.

5.0 RECORDS

Laboratory Record Books (LRBs) shall be used and maintained in accordance with an established procedure. All records generated shall be developed, maintained, stored, and dispositioned in accordance with an established procedure.

6.0 REFERENCES

- Chatters, J. C., ed. 1989. Hanford Cultural Resources Management Plan. PNL-6942, Pacific Northwest Laboratory, Richland, Washington.
- Hester, T. A., R. F. Heizer, and J. A. Graham, eds. 1975. Field Methods in Archaeology. 6th edition, Mayfield, Palo Alto, California.
- OAHF. 1988. Archaeological Survey and Reporting Guidelines. State of Washington, Office of Archaeology and Historic Preservation, Department of Community Development, Olympia, Washington.
- Parker, P. L., and T. F. King. 1989. Traditional Cultural Properties: Guidelines for Evaluation. National Register Bulletin 38, National Park Service, U.S. Department of the Interior, Washington, D.C.

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