EA QAPP-59
EA Project No. 10004.02

EA Engineering, Science, and Technology, Inc.

INSTALLATION RESTORATION PROGRAM

PHASE II STAGE 2

REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS)

AIR FORCE PLANT 59
JOHNSON CITY, NEW YORK

EA Engineering, Science, and Technology, Inc.
Hunt Valley/Loveton Center
15 Loveton Circle
Sparks, Maryland 21152

December 1988

QUALITY ASSURANCE PROJECT PLAN, JUNE-DECEMBER 1988

APPROVED FOR PUBLIC RELEASE:
DISTRIBUTION IS UNLIMITED

Prepared for

Headquarters Air Force Systems Command
Aeronautical Systems Division/Facilities Management (ASD/PMDA)
Wright-Patterson Air Force Base, Ohio 45433-6503

USAF Occupational & Environmental Health Laboratory
Technical Services Division (USAFOEHL/TS)
Brooks Air Force Base, Texas 78235-5501

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USAFOEHL TECHNICAL PROGRAM MANAGER

James W. Better

USAF Occupational & Environmental Health Laboratory
Technical Services Division ((USAFOEHL/TS)
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QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

1.1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) presents the policies, organization, objectives, functional activities, and specific quality assurance (QA) and quality control (QC) activities to ensure the validity of analytical data generated by EA Science and Technology. The objective of the QA/QC Program is to assess, ensure, and document that all data generated, stored, and reported by EA are scientifically valid, defensible, and of known precision and accuracy.

QC consists of a system of checks on field sampling and laboratory analysis (through the use of field blanks, duplicates, documentation of all sample movement, chain-of-custody records, etc.) to provide supporting information on the quality of the methods employed and the analytical data.

QA consists of overview checking to certify that the QC procedures have been properly implemented to produce accurate data.

All QA/QC procedures will be in accordance with applicable professional technical standards, U.S Environmental Protection Agency (USEPA) requirements, government regulations and guidelines, and specific U.S Air Force (USAF) project goals and requirements. This QAPP is prepared in accordance with all USEPA QAPP guidelines.

The QAPP incorporates the following activities:

- Sample collection, control, chain-of-custody, and analysis
- Laboratory instrumentation, analysis, and control
- Review of project deliverables.

Analytical samples will be collected in the field utilizing standard operating procedures (SOPs) and sent for analysis to EA Laboratories in Maryland. Duplicates, replicates, and spiked samples will be used to develop estimates of the quality of the analytical data. Field audits will be conducted to verify that proper sampling techniques and chain-of-custody procedures are followed. Field data compilation, tabulation, and analysis will be checked for accuracy. Calculations and other post-field tasks will be reviewed by project personnel in the Air Force's Installation Restoration Program.

Equipment used to take field measurements will be maintained and calibrated in accordance with established procedures (Section 1.7). Records of calibration and maintenance will be kept by assigned personnel. Field testing and data acquisition will be performed in standard fashion following strict guidelines.

Document control procedures will be used to coordinate the distribution, coding, storage, retrieval, and review of all data collected during all sampling tasks. These include, but are not limited to, the sampling of soil/sediment, ground water, and surface water. These procedures will ensure safeguarding of any sensitive materials generated or obtained during the study.

1.2 PROJECT DESCRIPTION

AFP 59 is located in Johnson City, New York, in an urban area with significant industrial activity (Figure 1-1). The current occupant of the plant is General Electric (GE), whose operations at the plant include the manufacture of flight control, laser weapons control, internal navigation, and guidance systems. These systems are used in various military and commercial aircraft. Between 1942 and 1945, the plant was occupied by Remington Rand for the manufacture of airplane propellers. From 1945 to 1949, the plant was idle; the USAF has occupied the site since 1949.

1.2.1 Previous Investigations

To date, Phase I and Phase II, Stage I studies have been conducted at AFP 59. The Phase I report identified one main area of the plant property suspected to be a potential source of contamination. During this Phase II investigation, a second potential source of heavy metal contamination from plating operations (contamination of the soil underneath the Plating Building) was identified (Figure 1-2). The field investigations and discussion of results were undertaken with the intent to fulfill the requirements of the USAF Phase II investigation philosophy.

1.2.2 Area No. 1 - Former Underground Waste Oil Storage Tanks

Area No. 1 was identified during the 1984 IRP Phase I - Records Search as a potential concern due to spillage associated with several underground oil storage tanks and the close proximity of municipal water supply wells. The Clinton Street-Ballpark Valley aquifer, the aquifer underlying the site, has been designated as a "sole source" aquifer in the Johnson City area. Historical data indicate that waste oils were routinely spilled in this area and could have caused ground-water contamination.

1.2.3 Area No. 2 - Plating Building

GE identified Area No. 2 as an area of concern at the beginning of the Phase II Stage I investigation. The potential source of contamination in this area is plating wastes, and is a concern because of the toxicity and persistence of the heavy metals found in plating wastes. GE personnel identified this area while repairing a leak in the underground sprinkler main beneath the plating building, when they observed discoloration in the soils. GE and USAF personnel expressed concern that heavy metal contaminants might be present and that these contaminants could migrate to the ground water. The influx of water from the leaking sprinkler main could accelerate the migration of these potential contaminants.

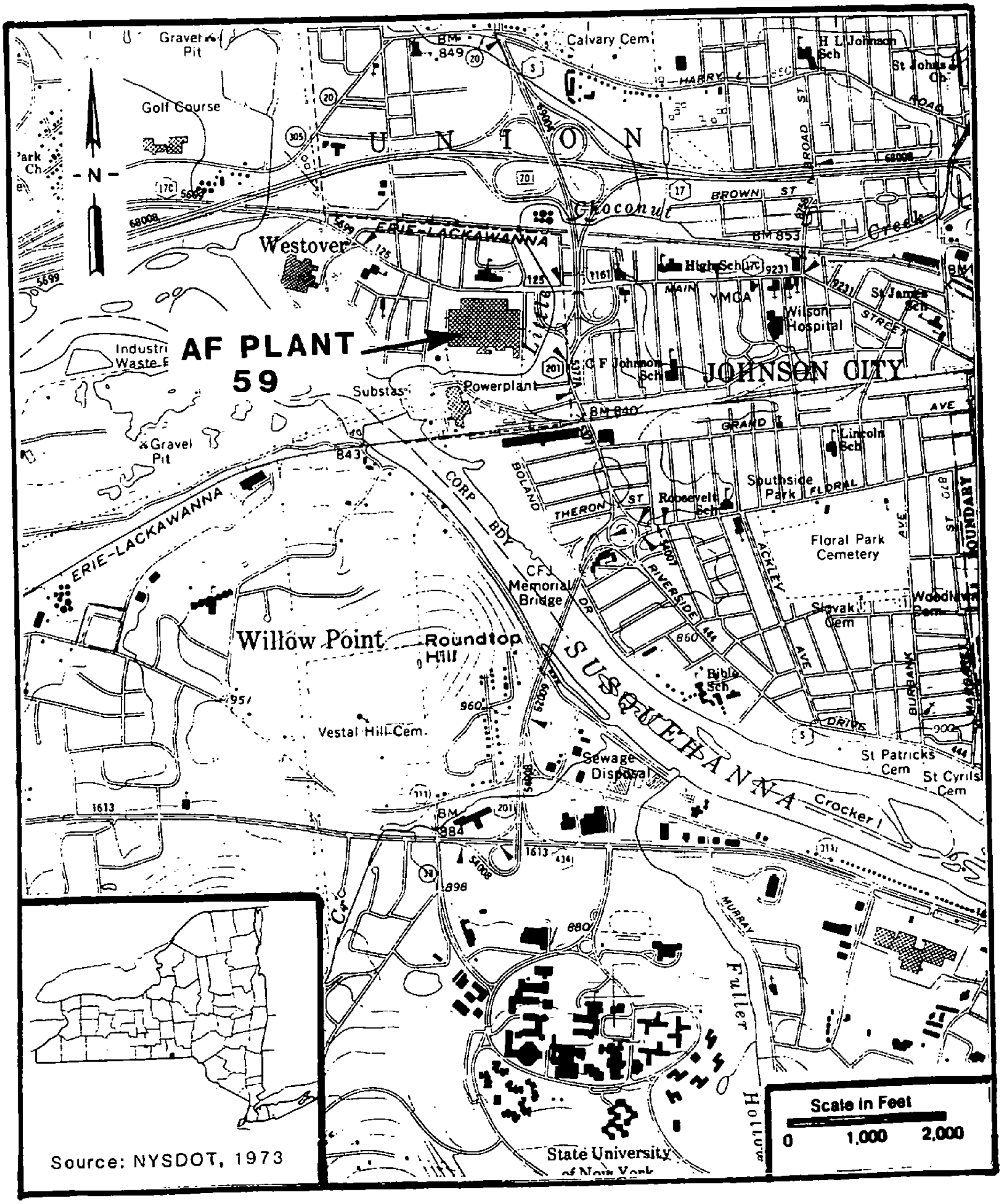


Figure 1-1. Location and vicinity map for AFP 59.

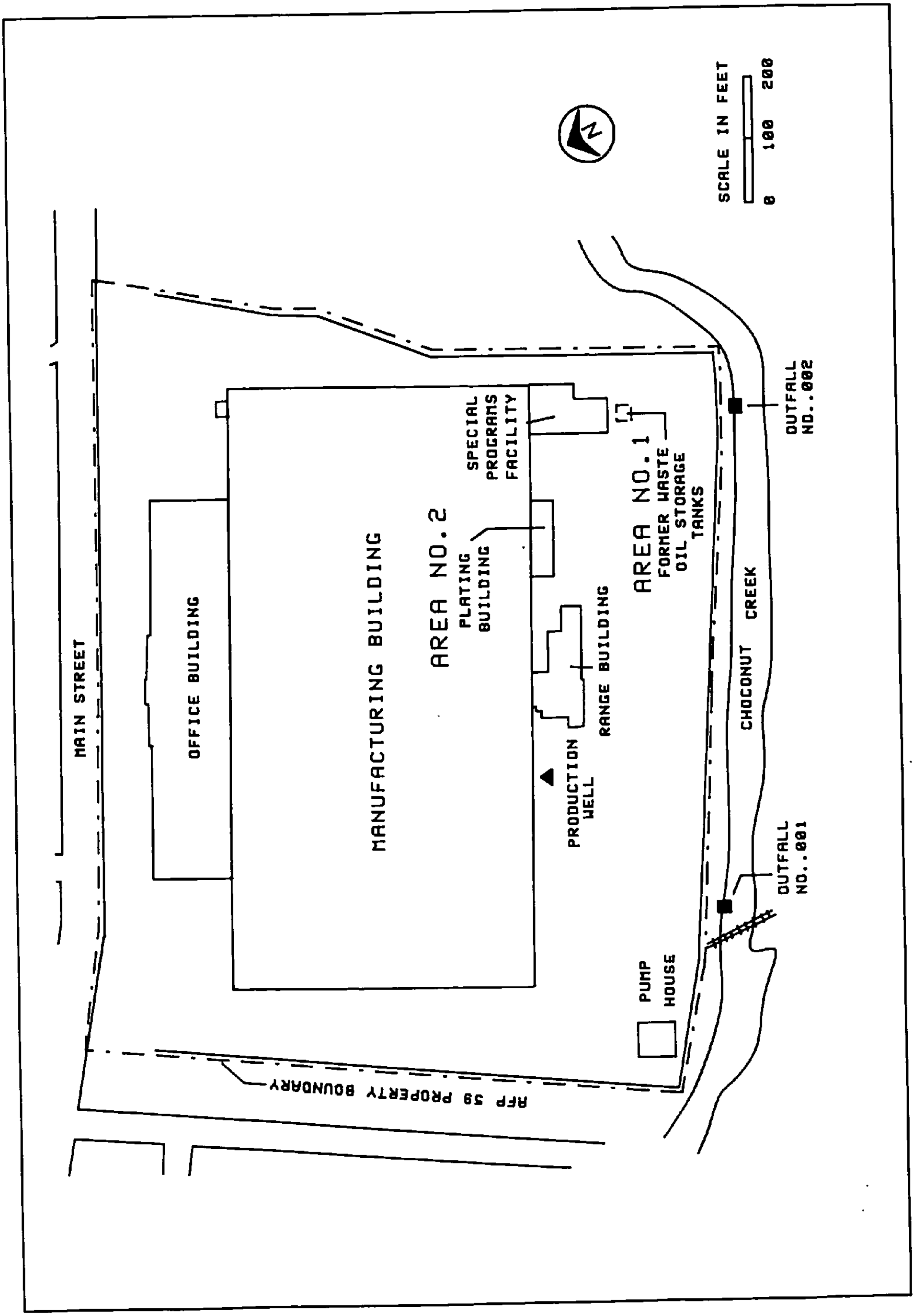


Figure 1-2. Site map of AFP 59.

1.2.4 Objectives of Present Investigation

The primary objective of the present Stage 2 work effort is to further the remedial investigation of the site at AFP 59 in order to provide information to conduct feasibility studies. This process involves determining which sites present a threat to human health and the environment and which sites do not.

The long-range objectives of the integrated remedial investigation and feasibility study at AFP 59 are to assess the extent and magnitude of contamination at past hazardous waste disposal and spill sites and to develop remedies consistent with the NCP for those sites that pose a threat to human health or the environment. The goals for the process of selecting the remedial alternatives are as follows:

- To select a remedy that will protect human health and the environment.
- To provide a cost-effective remedy.
- To attain New York and federal potentially Applicable or Relevant and Appropriate Requirements (ARARs) as an end result of remediation.
- To select a remedy that uses permanent solutions and alternative technologies to the maximum extent practicable.
- To consider the use of interim responses.
- To use onsite mitigation to the maximum extent possible

1.3 PROJECT ORGANIZATION AND RESPONSIBILITY

1.3.1 Quality Assurance and Laboratory Organization and Responsibility

This QAPP provides for the designated QA personnel to review products and provide guidance on QA matters. This QAPP also outlines the approach to be followed to ensure that products of sufficient quality are obtained. In accordance with EA's Corporate QAPP, experienced senior technical staff will be assigned to the project QA/QC functions. Figure 1-3 illustrates EA's Quality Assurance Program organization. The corporate management structure provides for direct and constant operational responsibility, clear lines of authority, and the integration of QA activities. The various QA functions are explained below.

Principal-in-Charge

The Principal-in-Charge will be C.R. Flynn who is responsible for overall project oversight including assisting the project manager in procuring staff assignments, ensuring that the field team and Subcontractor are responsive to the Quality Assurance and Health and Safety Officers, providing final technical review of work products and negotiating subcontract agreements.

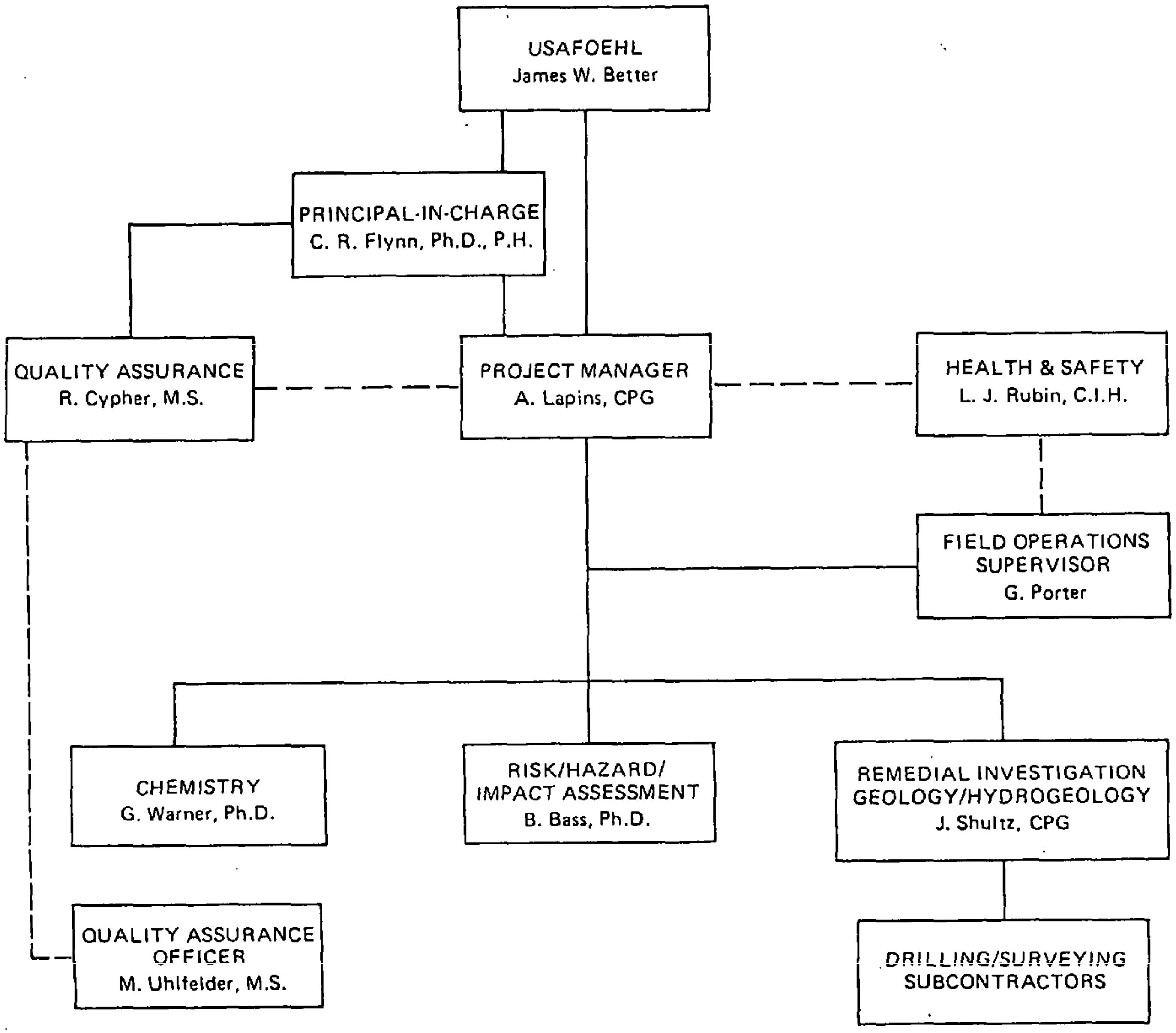


Figure 1-3. Project organization.

Project Manager

The project manager, Andris Lapins, will be responsible for implementing the project and will have the authority to commit the resources necessary to meet project objectives and requirements. The project manager's primary function is to ensure that technical, financial, and scheduling objectives are successfully achieved.

QA Director

The QA director will be R. Cypher. The QA director will remain independent of direct job involvement and day-to-day operations, and will have direct access to Corporate executive staff as necesary to resolve any QA dispute. He is responsible for implementing the QA Program in conformance with the demands of specific investigations, EA policies, and client requirements. Specific functions and duties include:

- Identifies and substantiates conformance and nonconformance conditions or situations found during quality audits and reviews to cognizant management.
- Initiates, recommends, or facilitates solutions to identified quality problems with responsible staff.
- Verifies the implementation of effective corrective actions.
- Provides assistance to the program manager on matters affecting quality of work for this project.
- Provides for the maintenance of a record of project audits, including discrepancies and their resolutions.
- Provides for the review of controlled quality-related documents for each technical discipline to ensure that all applicable quality requirements are addressed.
- Provides assistance to the QA officer during laboratory audits of the chemistry section related to this project.

QA Officer (QAO)

The QA officer will be M. Uhlfelder. She is responsible for maintaining quality assurance for the Analytical Chemistry Laboratory, and her specific functions and duties include:

- Performs facility/laboratory audits for compliance with the project requirements.
- Prepares detailed inspection reports, outlining problems encountered during audits and makes recommendations.
- Reviews procedures, methods, protocols, study and QA/QC plans for completeness, and provides written reports noting inconsistencies.

- Monitors daily QC activities to determine conformance to QA/QC Plan of project requirements.

  - frequency of control samples
  - instrument calibrations
  - quality control chart documentation

- Notifies laboratory and project management of out-of-control situations.

- Reviews on a scheduled basis all QC data and generates proficiency and status reports to management.

- Maintains noncomformance reports (NR). Monitors for completeness and follows up where appropriate. Uses NR for developing "trend analysis" of out-of-control situations.

- Maintain record of audits (internal and external), including discrepancies and their resolutions.

Analytical Chemistry Director

The director is G. Warner. He is responsible for all analytical work and works in conjunction with the QAO. He maintains liaison with the QA officer regarding QA and custody requirements.

Specific duties include:

- Ensures laboratory data quality
- Maintains laboratory staffing
- Develops laboratory budget
- Ensures laboratory safety
- Approves laboratory equipment acquisition
- Sets analytical priorities

EA Analytical Chemistry Facility

EA Laboratories is located in Maryland and will be handling the chemical analysis for this project. EA maintains a certified chemical laboratory staffed by full-time chemists and technicians which is equipped with state-of-the-art instrumentation for the full range of water, waste, sediment, and soil quality parameters.

All laboratory work is performed in accordance with guidelines established by USEPA, the Water Pollution Control Federation. In addition, QA and QC programs are maintained for the instruments and the analytical procedures used. EA Laboratories is certified by the New York State Department of Health (NYSDOH) for water supply and pollution and the New York State Department of Environmental Conservation (NYSDEC) for CLP metals, volatiles, and semivolatiles. In addition, EA is contracted to the USEPA for the analysis of organic samples under the Contract Laboratory Program (CLP).

1.4 QA OBJECTIVES FOR MEASUREMENT DATA

This section presents the QA objectives for the chemical data in terms of precision, accuracy, completeness, representativeness, and comparability. Tables 1-1 through 1-5 present this information for the various parameter groups.

1.4.1 Precision and Accuracy

As used here, precision and accuracy have the following definitions:

Precision--a measure of the mutual agreement among individual measurements of the same property, expressed as the standard deviation, s, of the measurements. The precision can also be expressed in dimensionless form as a percentage of the ratio of the standard deviation to the mean, x, of the measurements, 100 x/s (the percent relative standard deviation).

Accuracy--the ratio between a measured value, x, and the true value, T, when the latter is known or assumed, expressed as a percentage of the ratio, 100 x/T.

For the inorganic parameters, the accuracy and precision estimates are given in Tables 1-1 and 1-2. The accuracy figures represent the mean percent recovery and the two standard deviation (95 percent) limits from standard additions (spikes). The precision determination used in the laboratory is based on the standard deviation of replicate measurements of sample concentrations. The standard deviation generally increases as the concentration level of the measurements increases. The values given in the table are the 95 percent limits for the relative standard deviation at one-half the upper end of the calibration range.

For the organic priority pollutant parameters (Tables 1-3 through 1-5), the accuracy and precision are based on the surrogate standards. The accuracy is the percent recovery of the surrogates, and the precision is the standard deviation of successive percent recoveries. The results of samples for which the recovery of the surrogate standards does not fall within these limits will be qualified as being outside the control limits.

Non-priority pollutant organic compounds detected in the fractions analyzed by gas chromatography/mass spectrometry (GC/MS) will have their mass spectra subjected to a library search against the NBS/NIH/EPA Mass Spectral Data Base if their peak heights are greater than 25 percent of that internal standard. A maximum of 15 unknown peaks will be searched for the purgeable organic and base/neutral fractions and 10 for the acid extractables. The sample spectrum will be compared to the three best fitting library spectra. The sample spectrum must meet the following criteria to be considered a positive identification. If the criteria are not met, the compound will be reported as unknown. The criteria for identification are (1) all ions present in the library spectrum at a

TABLE 1-1 DATA QUALITY REQUIREMENTS FOR METALS

Parameter	Method Code[a]	Sample Matrix	Detection Limit (mg/L)[b]	Estimated Accuracy (%)	Estimated Precision (%)	Completeness (%)
Aluminum	D	Water	0.2	85-115	<10	>95
	F	Water	0.005	80-120	<20	>95
	I	Water	0.1	85-115	<10	>95
Antimony	D	Water	0.2	85-115	<10	>95
	F	Water	0.005	85-115	<15	>95
Arsenic	F	Water	0.002	80-120	<15	>95
	H	Water	0.002	80-120	<15	>95
	I	Water	1.0	85-115	<10	>95
Barium	D	Water	0.1	85-115	<10	>95
	F	Water	0.005	80-120	<15	>95
	I	Water	0.003	85-115	<10	>95
Beryllium	D	Water	0.01	85-115	<10	>95
	F	Water	0.001	85-115	<15	>95
	I	Water	0.003	85-115	<10	>95
Boron	I	Water	0.03	85-115	<10	>95

(a) Method codes:
D - Atomic Absorption - Direct Aspiration
F - Atomic Absorption - Furnace
H - Atomic Absorption - Hydride
I - Atomic Emission - ICP
V - Atomic Absorption - Cold Vapor
C - Colorimetric

(b) For soil matrix the detection limit will be 50 times higher.

TABLE 1-1 (Cont.)

Parameter	Method Code[(a)]	Sample Matrix	Detection Limit[(b)] (mg/L)	Estimated Accuracy (%)	Estimated Precision (%)	Completeness (%)
Cadmium	D	Water	0.01	85-115	<10	>95
	F	Water	0.0002	85-115	<15	>95
	I	Water	0.01	85-115	<10	>95
Calcium	D	Water	0.5	85-115	<10	>95
	I	Water	0.1	85-115	<10	>95
Chromium, Total	D	Water	0.05	85-115	<10	>95
	F	Water	0.002	85-115	<10	>95
	I	Water	0.01	85-115	<10	>95
Chromium, Hexavalent	C	Water	0.05	85-115	<10	>95
Cobalt	D	Water	0.02	85-115	<10	>95
	F	Water	0.002	85-115	<15	>95
	I	Water	0.01	85-115	<10	>95
Copper	D	Water	0.02	85-115	<10	>95
	F	Water	0.002	85-115	<10	>95
	I	Water	0.02	85-115	<10	>95
Iron	D	Water	0.02	85-115	<10	>95
	I	Water	0.01	85-115	<10	>95
Lead	D	Water	0.1	85-115	<10	>95
	F	Water	0.002	85-115	<10	>95
	I	Water	1.0	85-115	<10	>95
Magnesium	D	Water	0.05	85-115	<10	>95
	I	Water	0.04	85-115	<10	>95
Manganese	D	Water	0.02	85-115	<10	>95
	F	Water	0.001	85-115	<10	>95

TABLE 1-1 (Cont.)

Parameter	Method Code[(a)]	Sample Matrix	Detection Limit (mg/L)[(b)]	Estimated Accuracy (%)	Estimated Precision (%)	Completeness (%)
Mercury	V	Water	0.0002	80-120	<10	>95
Molybdenum	D	Water	0.2	85-115	<10	>95
	F	Water	0.001	85-115	<15	>95
Nickel	D	Water	0.05	85-115	<10	>95
	F	Water	0.002	85-115	<10	>95
	I	Water	0.02	85-115	<10	>95
Potassium	D	Water	0.1	85-115	<10	>95
	I	Water	0.2	85-115	<10	>95
Selenium	F	Water	0.002	80-120	<15	>95
	H	Water	0.002	80-120	<15	>95
	I	Water	0.4	85-115	<10	>95
Silver	D	Water	0.05	80-120	<15	>95
	F	Water	0.0005	80-120	<15	>95
	I	Water	0.1	80-120	<10	>95
Sodium	D	Water	0.05	85-115	<10	>95
	I	Water	0.4	85-115	<10	>95
Thallium	F	Water	0.002	85-115	<10	>95
Tin	F	Water	0.01	80-120	<15	>95
Vanadium	F	Water	0.005	85-115	<10	>95
	I	Water	0.01	85-115	<10	>95
Zinc	D	Water	0.005	85-115	<15	>95
	I	Water	0.01	85-115	<10	>95

TABLE 1-2 DATA QUALITY REQUIREMENTS FOR INORGANICS AND GENERAL ORGANICS

Parameter	Sample Matrix	Detection Limit (mg/L)	Estimated Accuracy (%)	Estimated Precision (%)	Completeness (%)
GENERAL ORGANICS					
Biochemical Oxygen Demand	Water	1.0	75-125	<20	>95
Chemical Oxygen Demand	Water	10.0	80-120	<15	>95
Oil and Grease	Water	1.0	80-120	<20	>95
Total Organic Carbon	Water	0.3	85-115	<10	>95
Total Phenolics	Water	0.05	80-120	<15	>95
Surfactants	Water	0.05	80-120	<15	>95
INORGANIC NONMETALS					
Acidity	Water	1.0	85-115	<10	>95
Alkalinity	Water	1.0	85-115	<10	>95
Bromide	Water	0.1	85-115	<10	>95
Chloride	Water	3.0	85-115	<10	>95
Chlorine Residual	Water	0.1	75-125	<20	>95
Total Cyanide	Water	0.01	80-120	<15	>95
Fluoride	Water	0.1	85-115	<10	>95
Total Hardness	Water	2.0	85-115	<10	>95
Ammonia-Nitrogen	Water	0.01	85-115	<15	>95
Total Kjeldahl Nitrogen	Water	0.1	80-120	<15	>95
Nitrate+Nitrite-Nitrogen	Water	0.01	85-115	<10	>95
Nitrite-Nitrogen	Water	0.01	85-115	<10	>95
Total Phosphorus	Water	0.1	85-115	<15	>95
Orthophosphate-Phosphorus	Water	0.01	85-115	<10	>95
Sulfate	Water	5.0	85-115	<10	>95
Sulfide	Water	1.0	80-120	<15	>95
Sulfite	Water	0.5	80-120	<15	>95
Silica	Water	0.1	85-115	<10	>95

TABLE 1-2 (Cont.)

Parameter	Sample Matrix	Detection Limit (mg/L)	Estimated Accuracy (%)	Estimated Precision (%)	Completeness (%)
PHYSICAL DETERMINATIONS					
True Color	Water	5 Units	85-115	<10	>95
Specific Conductance	Water	0.1 5s/cm	85-115	<10	>95
pH	Water	0.01 pH Units	0.1 pH Units	0.2 pH Units	>95
Total Residue	Water	5	80-120	<15	>95
Total Filterable Residue	Water	5	80-120	<15	>95
Total Nonfilterable Residue	Water	5	80-120	<15	>95
Total Volatile Solids	Water	5	80-120	<15	>95
Temperature	Water	0.05 deg	0.1 deg	0.1 deg	>95
Turbidity	Water	1 NTU	85-115	<10	>95

TABLE 1-3 DATA QUALITY REQUIREMENTS FOR PESTICIDES AND PCB

List(a)			Parameter	Detection Limit		Estimated Accuracy (%)	Estimated Precision (%)	Completeness (%)
D	P	H		(ug/L)	(mg/kg)			
	p	h	Aldrin	0.05	0.002	>60	<20	>95
	p	h	-BHC	0.05	0.002	>60	<20	>95
	p	h	-BHC	0.05	0.002	>60	<20	>95
	p	h	-BHC	0.05	0.002	>60	<20	>95
	p	h	Chlordane	0.5	0.020	>60	<20	>95
d			2,4-D	0.2	0.008	>60	<20	>95
	p	h	4,4'-DDD [p,p'-DDD]	0.1	0.004	>60	<20	>95
	p	h	4,4'-DDE [p,p'-DDE]	0.1	0.004	>60	<20	>95
	p	h	4,4'-DDT [p,p'-DDT]	0.1	0.004	>60	<20	>95
	p	h	Dieldrin	0.1	0.004	>60	<20	>95
	p	h	Endosulfan I	0.05	0.002	>60	<20	>95
	p	h	Endosulfan II	0.1	0.004	>60	<20	>95
	h	h	Endosulfan sulfate	0.1	0.004	>60	<20	>95
d	p	h	Endrin	0.1	0.004	>60	<20	>95
	p		Endrin aldehyde	0.1	0.004	>60	<20	>95
		h	Endrin ketone	0.1	0.004	>60	<20	>95
	p	h	Heptachlor	0.05	0.002	>60	<20	>95
	p	h	Heptachlor epoxide	0.05	0.002	>60	<20	>95
d	p	h	Lindane [-BHC]	0.05	0.002	>60	<20	>95
d		h	Methoxychlor	0.5	0.020	>60	<20	>95
d			2,4,5-TP [Silvex]	0.05	0.002	>60	<20	>95
d	p	h	Toxaphene	1	0.040	>60	<20	>95

(a) EPA list codes: d = primary drinking water; p = priority pollutant; h = hazardous substance.

TABLE 1-3 (Cont.)

List(a)			Parameter	Detection Limit		Estimated Accuracy (%)	Estimated Precision (%)	Completeness (%)
D	P	H		(ug/L)	(mg/kg)			
	p	h	Aroclor 1016	0.5	0.020	>60	<20	>95
	p	h	Aroclor 1221	0.5	0.020	>60	<20	>95
	p	h	Aroclor 1232	0.5	0.020	>60	<20	>95
	p	h	Aroclor 1242	0.5	0.020	>60	<20	>95
	p	h	Aroclor 1248	0.5	0.020	>60	<20	>95
	p	h	Aroclor 1254	1	0.040	>60	<20	>95
	p	h	Aroclor 1260	1	0.040	>60	<20	>95

TABLE 1-4 DATA QUALITY REQUIREMENTS FOR PURGEABLE ORGANICS

List[a]				Detection Limit		Estimated Accuracy	Estimated Precision	Completeness
D	P	H	Parameter	(ug/L)	(mg/kg)	(%)	(%)	(%)
		h	Acetone	10	0.010	>60	<20	>95
	p		Acrolein	100	0.10	>60	<20	>95
	p		Acrylonitrile	100	0.10	>60	<20	>95
	p	h	Benzene	5	0.005	>60	<20	>95
			Bromobenzene	5	0.005	>60	<20	>95
			Bromochloromethane	5	0.005	>60	<20	>95
d	p	h	Bromodichloromethane	5	0.005	>60	<20	>95
d	p	h	Bromoform	5	0.005	>60	<20	>95
	p	h	Bromomethane	5	0.005	>60	<20	>95
			tert-Butyl methyl ether (MTBE)	5	0.005	>60	<20	>95
		h	Carbon disulfide	5	0.005	>60	<20	>95
	p	h	Carbon tetrachloride	5	0.005	>60	<20	>95
	p	h	Chlorobenzene	5	0.005	>60	<20	>95
	p	h	Chloroethane	5	0.005	>60	<20	>95
	p	h	2-Chloroethyl vinyl ether	10	0.010	>60	<20	>95
d	p	h	Chloroform	5	0.005	>60	<20	>95
	p	h	Chloromethane	5	0.005	>60	<20	>95
			2-Chlorotoluene	5	0.005	>60	<20	>95
			4-Chlorotoluene	5	0.005	>60	<20	>95
d	p	h	Dibromochloromethane	5	0.005	>60	<20	>95
	p		1,2-Dichlorobenzene	10	0.010	>60	<20	>95
			[o-Dichlorobenzene]	5	0.005	>60	<20	
	p		1,3-Dichlorobenzene	10	0.010	>60	<20	>95
			[m-Dichlorobenzene]					

(a) EPA list codes: d = primary drinking water; p = priority pollutant; h = hazardous substance.

TABLE 1-4 (Cont.)

List[(a)] D	P	H	Parameter	Detection Limit (ug/L)	Detection Limit (mg/kg)	Estimated Accuracy (%)	Estimated Precision (%)	Completeness (%)
	p		1,4-Dichlorobenzene [p-Dichlorobenzene]	10	0.010	>60	<20	>95
			Dichlorodifluoromethane	5	0.005	>60	<20	>95
	p	h	1,1-Dichloroethane	5	0.005	>60	<20	>95
	p	h	1,2-Dichloroethane	5	0.005	>60	<20	>95
	p	h	1,1-Dichloroethene [1,1-Dichloroethylene]	5	0.005	>60	<20	>95
			cis-1,2-Dichloroethene	5	0.005	>60	<20	>95
	p	h	trans-1,2-Dichloroethene	5	0.005	>60	<20	>95
	p	h	1,2-Dichloropropane	5	0.005	>60	<20	>95
			1,3-Dichloropropane	5	0.005	>60	<20	>95
			2,2-Dichloropropane	5	0.005	>60	<20	>95
			1,1-Dichloropropene	5	0.005	>60	<20	>95
	p	h	cis-1,3-Dichloropropene	5	0.005	>60	<20	>95
	p	h	trans-1,3-Dichloropropene	5	0.005	>60	<20	>95
	p	h	Ethylbenzene	5	0.005	>60	<20	>95
			Ethylene dibromide (EDB) [1,2-Dibromoethane]	5	0.005	>60	<20	>95
			Isopropyl ether (IPE)	5	0.005	>60	<20	>95
		h	Methyl butyl ketone [2-Hexanone]	10	0.010	>60	<20	>95
	p	h	Methylene chloride [Dichloromethane]	5	0.005	>60	<20	>95
		h	Methyl ethyl ketone [2-Butanone]	10	0.010	>60	<20	>95
		h	Methyl isobutyl ketone [4-Methyl-2-pentanone]	10	0.010	>60	<20	>95

TABLE 1-4 (Cont.)

List[(a)] D	P	H	Parameter	Detection Limit (ug/L)	Detection Limit (mg/kg)	Estimated Accuracy (%)	Estimated Precision (%)	Completeness (%)
			Pentachloroethane	10	0.010	>60	<20	>95
			h Styrene	5	0.005	>60	<20	>95
			1,1,1,2-Tetrachloroethane	5	0.005	>60	<20	>95
	p	h	1,1,2,2-Tetrachloroethane	5	0.005	>60	<20	>95
	p	h	Tetrachloroethene	5	0.005	>60	<20	>95
	p	h	Toluene	5	0.005	>60	<20	>95
			1,2,3-Trichlorobenzene	10	0.010	>60	<20	>95
			1,2,4-Trichlorobenzene	10	0.010	>60	<20	>95
	p	h	1,1,1-Trichloroethane	5	0.005	>60	<20	>95
	p	h	1,1,2-Trichloroethane	5	0.005	>60	<20	>95
	p	h	Trichloroethene [Trichloroethylene]	5	0.005	>60	<20	>95
	p		Trichlorofluoromethane	5	0.005	>60	<20	>95
			1,2,3-Trichloropropane	10	0.010	>60	<20	>95
		h	Vinyl acetate	10	0.010	>60	<20	>95
	p	h	Vinyl chloride	10	0.010	>60	<20	>95
		h	m-Xylene	5	0.005	>60	<20	>95
		h	o-Xylene	5	0.005	>60	<20	>95
		h	p-Xylene	5	0.005	>60	<20	>95

TABLE 1-5 DATA QUALITY REQUIREMENTS FOR SEMIVOLATILE ORGANICS

List[(a)] D	P	H	Parameter	Detection Limit (ug/L)	Detection Limit (mg/kg)	Estimated Accuracy (%)	Estimated Precision (%)	Completeness (%)
	p	h	Acenaphthene	10	0.33	>50	<20	>95
	p	h	Acenaphthylene	10	0.33	>50	<20	>95
	p	h	Anthracene	10	0.33	>50	<20	>95
	p		Benzidine	100	3.3	>50	<20	>95
	p	h	Benzo[a]anthracene	10	0.33	>50	<20	>95
	p	h	Benzo[b]fluoranthene	10	0.33	>50	<20	>95
	p	h	Benzo[k]fluoranthene	10	0.33	>50	<20	>95
	p	h	Benzo[ghi]perylene	10	0.33	>50	<20	>95
	p	h	Benzo[a]pyrene	10	0.33	>50	<20	>95
		h	Benzoic acid	50	1.6	>50	<20	>95
		h	Benzyl alcohol	10	0.33	>50	<20	>95
	p	h	Benzyl butyl phthalate	10	0.33	>50	<20	>95
	p	h	Bis(2-chloroethoxy)methane	10	0.33	>50	<20	>95
	p	h	Bis(2-chloroethyl) ether	10	0.33	>50	<20	>95
	p	h	Bis(2-ethylhexyl) phthalate	10	0.33	>50	<20	>95
	p	h	Bis(2-chloroisopropyl) ether	10	0.33	>50	<20	>95
	p	h	4-Bromophenyl phenyl ether	10	0.33	>50	<20	>95
		h	4-Chloroaniline	10	0.33	>50	<20	>95
	p	h	4-Chloro-3-methylphenol [p-Chloro-m-cresol]	10	0.33	>50	<20	>95
	p	h	2-Chloronaphthalene	10	0.33	>50	<20	>95
	p	h	2-Chlorophenol	10	0.33	>50	<20	>95
	p	h	4-Chlorophenyl phenyl ether	10	0.33	>50	<20	>95
	p	h	Chrysene	10	0.33	>50	<20	>95
	p	h	Dibenzo[a,h]anthracene	10	0.33	>50	<20	>95
		h	Dibenzofuran	10	0.33	>50	<20	>95
	p	h	Di-n-butyl phthalate	10	0.33	>50	<20	>95
	p	h	1,2-Dichlorobenzene	10	0.33	>50	<20	>95

(a) EPA list codes: d = primary drinking water; p = priority pollutant; h = hazardous substance.

TABLE 1-5 (Cont.)

List(a)			Parameter	Detection Limit		Estimated Accuracy (%)	Estimated Precision (%)	Completeness (%)
D	P	H		(ug/L)	(mg/kg)			
	p	h	1,3-Dichlorobenzene	10	0.33	>50	<20	>95
	p	h	1,4-Dichlorobenzene	10	0.33	>50	<20	>95
	p	h	3,3′-Dichlorobenzidine	20	0.66	>50	<20	>95
	p	h	2,4-Dichlorophenol	10	0.33	>50	<20	>95
	p	h	Diethyl phthalate	10	0.33	>50	<20	>95
	p	h	2,4-Dimethylphenol	10	0.33	>50	<20	>95
	p	h	Dimethyl phthalate	10	0.33	>50	<20	>95
	p	h	2,4-Dinitrophenol	10	0.33	>50	<20	>95
	p	h	2,4-Dinitrotoluene	10	0.33	>50	<20	>95
	p	h	2,6-Dinitrotoluene	10	0.33	>50	<20	>95
	p	h	Di-n-octyl phthalate	10	0.33	>50	<20	>95
	p	h	Fluoranthrene	10	0.33	>50	<20	>95
	p	h	Fluorene	10	0.33	>50	<20	>95
	p	h	Hexachlorobenzene	10	0.33	>50	<20	>95
	h	h	Hexachlorobutadiene	10	0.33	>50	<20	>95
	p	h	Hexachlorocyclopentadiene	10	0.33	>50	<20	>95
	p	h	Hexachloroethane	10	0.33	>50	<20	>95
	p	h	Indeno[1,2,3-cd]pyrene	10	0.33	>50	<20	>95
	p	h	Isophorone	10	0.33	>50	<20	>95
	p	h	2-Methyl-4,6-dinitrophenol [4,6-Dinitro-o-cresol]	10	0.33	>50	<20	>95
		h	2-Methylnaphthalene	10	0.33	>50	<20	>95
		h	2-Methylphenol	10	0.33	>50	<20	>95
		h	4-Methylphenol	10	0.33	>50	<20	>95
	p	h	Naphthalene	10	0.33	>50	<20	>95
		h	2-Nitroaniline	50	1.6	>50	<20	>95
		h	3-Nitroaniline	50	1.6	>50	<20	>95
		h	4-Nitroaniline	50	1.6	>50	<20	>95

TABLE 1-5 (Cont.)

List[a] D	List[a] P	List[a] H	Parameter	Detection Limit (ug/L)	Detection Limit (mg/kg)	Estimated Accuracy (%)	Estimated Precision (%)	Completeness (%)
	p	h	Nitrobenzene	10	0.33	>50	<20	>95
	p	h	2-Nitrophenol	10	0.33	>50	<20	>95
	p	h	4-Nitrophenol	50	1.6	>50	<20	>95
	p		N-Nitrosodimethylamine	10	0.33	>50	<20	>95
	p	h	N-Nitrosodiphenylamine	10	0.33	>50	<20	>95
	p	h	N-Nitrosodi-n-propylamine	10	0.33	>50	<20	>95
	p	h	Pentachlorophenol	50	1.6	>50	<20	>95
	p	h	Phenanthrene	10	0.33	>50	<20	>95
	p	h	Phenol	10	0.33	>50	<20	>95
	p	h	Pyrene	10	0.33	>50	<20	>95
	p	h	1,2,4-Trichlorobenzene	10	0.33	>50	<20	>95
		h	2,4,5-Trichlorophenol	50	1.6	>50	<20	>95
	p	h	2,4,6-Trichlorophenol	10	0.33	>50	<20	>95

relative intensity greater than 10 percent must be present in the sample spectrum; (2) the relative intensities of the ions specified above must agree within ±20 percent between the library and sample spectra; and (3) ions greater than 10 percent in the sample spectrum but not present in the library spectrum must be considered and accounted for by the analyst.

Data representativeness is the degree to which data accurately and precisely represent a characteristic of a population or an environmental condition. It is a goal to be achieved rather than a characteristic which can be described in quantitative terms. The sampling program has been designed so that the field blank samples collected are as representative as possible of the medium being sampled.

Data comparability is a measure of the confidence with which one data set can be compared to another. It cannot be described in quantitative terms, but must be considered in designing the sampling plans, analytical methodology, quality control, and data reporting. The use of validated, USEPA-approved methods assures that the parameters being measured are comparable with data generated from other sources. Reporting of data in units used by other organizations also assures comparability.

To achieve the quality control objectives for completeness, every effort will be made to avoid sample loss through accidents or inadvertence. Accidents during sample transport or lab activities which cause the loss of the original sample will result in irreparable loss of data. Collection of sufficient sample allows reanalysis in the event of an accident involving a sample aliquot. The assignment of a set of continuous lab numbers to a batch of samples which have undergone chain-of-custody inspection makes it more difficult for the analyst to overlook samples when setting up a batch of samples for analysis. The continuous lab numbers also make it easy during the data compilation stage to pick out the samples which have not been analyzed and to order their analysis before the data are reported and before holding times have been exceeded. The completeness of each batch of samples will be calculated by dividing the total number of analyses completed by the number that should have been performed on that batch times 100.

1.4.2 Detection Limits

The analytical methods used in analyzing the designated parameters are presented in Table 1-6. These are the most frequently requested parameters; others are added with approved procedures on a project-by-project basis. A laboratory record is kept for all procedures performed on a sample. These records also include the project, date, analyst, sample identification, and comments. Additional records document daily instrument calibration.

Analytical instrument detection limits are determined periodically according to USEPA protocols. For nonchromatographic analyses, the detection limit is determined by multiplying by three, the average of the standard deviations obtained on three nonconsecutive days from the analysis of a standard solution (each analyte in reagent water) at a concentration between three and five times the estimated detection limit, with seven consecutive measurements per day.

TABLE 1-6 USEPA APPROVED ANALYTICAL METHODS FOR THE SDWA, NPDES, AND RCRA PROGRAMS

Parameter	Method Code(a)	USEPA Method Number: Drinking Water (SDWA)(b)	Water and Wastewater (NPDES)(c)	Solids and Hazard Wastes (RCRA)(d)	Other Methods(e)
ORGANICS					
Halogenated hydrocarbon pesticides	GCEC	509A(f)	608	8080	-
Polychlorinated biphenyls	GCEC	-	608	8080	-
Phenoxy acid herbicides	GCEC	515	509B(f)	8150	-
Organophosphorus pesticides	GCEC	-	509A(f)	8140	-
Volatile organic compounds	GCMS	524.1	624	8240	-
Volatile halogenated compounds	GCEL	502.1	601	8010	-
Volatile nonhalogenated compounds	GCFI	-	-	8015	-
Volatile aromatic compounds	GCPI	503.1	602	8020	-
Acid extractable organic compounds	GCMS	-	625	8270	-
Base-neutral extractable organic compounds	GCMS	-	625	8270	-
Phthalate esters	GCEC	-	606	8060	-
Trihalomethanes	GCEC	501.2	-	-	-
Polynuclear aromatic hydrocarbons	HPLC	-	610	8310	-
Total petroleum hydrocarbons	IR	-	-	-	418.1
Biochemical oxygen demand	ELEC	-	405.1	-	-
Chemical oxygen demand	COL	-	410.4	-	-
Oil and grease	IR	-	413.1	-	413.2
	GRAV	-	413.1	9070	-
Organic carbon	IR	-	415.1	9060	-
Total organic halogen	OTHR	-	-	9020	450.1

TABLE 1-6 (Cont.)

Parameter	Method Code[(a)]	USEPA Method Number Drinking Water (SDWA)[(b)]	Water and Wastewater (NPDES)[(c)]	Solids and Hazard Wastes (RCRA)[(d)]	Other Methods[(e)]
ORGANICS (Cont.)					
Phenolic compounds	AUTO	-	420.2	9066	-
Surfactants	COL	425.1	425.1	-	-
METALS					
Aluminum	AAD	-	202.1	-	-
	AAF	-	202.2	-	-
	ICP	-	200.7	6010	-
Antimony	AAD	-	204.1	7040	-
	AAF	-	204.2	7041	-
Arsenic	AAF	206.2	206.2	7060	-
	AAH	303E(f)	303E(f)	-	-
	ICP	200.7	200.7	6010	-
Barium	AAD	208.1	208.1	7080	-
	AAF	208.2	208.2	7081	-
	ICP	200.7	200.7	6010	-
Beryllium	AAD	-	210.1	7090	-
	AAF	-	210.2	7091	-
	ICP	-	200.7	6010	-
Boron	COL	-	212.3	-	-
	ICP	-	200.7	6010	-
Cadmium	AAD	213.1	213.1	7130	-
	AAF	213.2	213.2	7131	-
	ICP	200.7	200.7	6010	-
Calcium	AAD	-	215.1	-	-
	ICP	-	200.7	6010	-
Chromium, Total	AAD	218.1	218.1	7190	-
	AAF	218.2	218.2	7191	-
	ICP	200.7	200.7	6010	-
Chromium, Hexavalent	AAF	-	-	7195	218.5
	COL	-	1230-78(g)	7196	-

TABLE 1-6 (Cont.)

Parameter	Method Code[(a)]	USEPA Method Number Drinking Water (SDWA)[(b)]	Water and Wastewater (NPDES)[(c)]	Solids and Hazard Wastes (RCRA)[(d)]	Other Methods[(e)]
METALS (cont.)					
Cobalt	AAD	-	219.1	-	-
	AAF	-	219.2	-	-
	ICP	-	200.7	6010	-
Copper	AAD	220.1	220.1	7210	-
	AAF	220.2	220.2	7211	-
	ICP	200.7	200.7	6010	-
Iron	AAD	236.1	236.1	7380	-
	AAF	236.2	236.2	7381	-
	ICP	200.7	200.7	6010	-
Lead	AAD	239.1	239.1	7420	-
	AAF	239.2	239.2	7421	-
	ICP	200.7	200.7	6010	-
Lithium	AAD	-	-	-	303A(f)
	ICP	-	-	-	200.7
Magnesium	AAD	-	242.1	-	-
	ICP	-	200.7	6010	-
Manganese	AAD	243.1	243.1	7460	-
	AAF	243.2	243.2	7461	-
	ICP	200.7	200.7	6010	-
Mercury	AACV	245.1	245.1	7471	-
Molybdenum	AAD	-	246.1	-	-
	AAF	-	246.2	-	-
	ICP	-	200.7	6010	-
Nickel	AAD	-	249.1	7520	-
	AAF	-	249.2	7521	-
	ICP	-	200.7	6010	-
Potassium	AAD	-	258.1	-	-
	ICP	-	200.7	6010	-
Selenium	AAF	270.2	270.2	7740	-
	AAH	303E(f)	303E(f)	-	-
	ICP	-	200.7	6010	-

TABLE 1-6 (Cont.)

Parameter	Method Code$^{(a)}$	USEPA Method Number Drinking Water (SDWA)$^{(b)}$	Water and Wastewater (NPDES)$^{(c)}$	Solids and Hazard Wastes (RCRA)$^{(d)}$	Other Methods$^{(e)}$
METALS (cont.)					
Silver	AAD	272.1	272.1	7760	–
	AAF	272.2	272.2	7761	–
	ICP	200.7	200.7	6010	–
Sodium	AAD	273.1	273.1	7770	–
	ICP	–	200.7	6010	–
Strontium	AAD	–	303A(f)	–	–
	ICP	–	200.7	6010	–
Thallium	AAD	–	279.1	7840	–
	AAF	–	279.2	7841	–
Tin	AAD	–	282.1	–	–
	AAF	–	282.2	–	–
Titanium	AAD	–	283.1	–	–
	AAF	–	283.2	–	–
Vanadium	AAD	–	286.1	7910	–
	AAF	–	286.2	7911	–
	ICP	–	200.7	6010	–
Zinc	AAD	289.1	289.1	7950	–
	AAF	289.2	289.2	7951	–
	ICP	200.7	200.7	6010	–
INORGANIC NONMETALS					
Acidity	TITR	–	305.1	–	–
Alkalinity	TITR	310.1	310.1	–	–
	AUTO	–	310.2	–	–
Bromide	TITR	–	320.1	–	–
Chloride	AUTO	–	325.2	9251	–
	ION	300.0	–	–	–
Chlorine residual	TITR	–	330.1	–	–
Cyanide	AUTO	–	335.3	9010	–

TABLE 1-6 (Cont.)

Parameter	Method Code[(a)]	USEPA Method Number: Drinking Water (SDWA)[(b)]	Water and Wastewater (NPDES)[(c)]	Solids and Hazard Wastes (RCRA)[(d)]	Other Methods[(e)]
INORGANIC NONMETALS (Cont.)					
Fluoride	ELEC	340.2	340.2	-	-
Total hardness	AUTO	-	130.1	-	-
Iodide	TITR	-	-	-	345.1
Nitrogen, ammonia	AUTO	-	350.1	-	-
Nitrogen, total Kjeldahl	AUTO	-	351.2	-	-
Nitrogen, nitrate+nitrite	AUTO	353.2	353.2	-	-
Nitrogen, nitrate	ION	300.0	-	-	-
Nitrogen, nitrite	AUTO	-	4540-84(g)	-	-
Oxygen, dissolved.	ELEC	-	360.1	-	-
Phosphorus, total	AUTO	-	365.4	-	-
Phosphorus, orthophosphate	AUTO	-	365.1	-	-
Silica	COL	-	370.1	-	-
	ICP	-	200.7	6010	-
Sulfate	AUTO	-	-	9036	375.2
	TURB	375.4	375.4	9038	-
	ION	300.0	-	-	-
Sulfide	TITR	-	376.1	9030	-
Sulfite	TITR	-	428A(f)	-	-
PHYSICAL DETERMINATIONS					
Color	COL	110.2	110.2	-	-
Specific conductance	ELEC	-	120.1	9050	-
Ignitability (flash point)	OTHR	-	-	1010	-

TABLE 1-6 (Cont.)

Parameter	Method Code(a)	USEPA Method Number Drinking Water (SDWA)(b)	 Water and Wastewater (NPDES)(c)	 Solids and Hazard Wastes (RCRA)(d)	 Other Methods(e)
PHYSICAL DETERMINATIONS (Cont.)					
Corrosivity	OTHR	-	-	1110	-
Reactivity	OTHR	-	-	Sec. 7.3	-
Odor	OTHR	140.1	-	-	-
pH	ELEC	150.1	150.1	9040	-
Residue, settleable	OTHR	-	160.5	-	-
Residue, total	GRAV	-	160.3	-	-
Residue, total filterable	GRAV	160.1	160.1	-	-
Residue, total nonfilterable	GRAV	-	160.2	-	-
Residue, total volatile	GRAV	-	160.4	-	-
Temperature	THER	-	170.1	-	-
Turbidity	NEPH	180.1	180.1	-	-
RADIOLOGICAL					
Gross alpha	PROP	703(f)	703(f)	9310	-
Gross beta	PROP	703(f)	703(f)	9310	-
Radium-226, radium-228	PROP	705(f)	705(f)	9320	-
MICROBIOLOGICAL					
Coliforms, fecal	MTF	908C(f)	908C(f)	-	-
Coliforms, total	MTF	908A(f)	908A(f)	9131	-
SAMPLE PREPARATION					
U.S. EPA extraction procedure	OTHR	-	-	1310	-
Toxicity characteristic leaching procedure (TCLP)	OTHR	-	-	(h)	-

TABLE 1-6 (Cont.)

(a) Method codes are defined as follows:

AACV	Atomic Absorption – Cold Vapor	IR	Infrared Spectrometry
AAD	Atomic Absorption – Direct Aspiration	MTF	Multiple Tube Fermentation
AAF	Atomic Absorption – Furnace	NEPH	Nephelometry
AAH	Atomic Absorption – Hydride	OTHR	Other Specialized Methods
AUTO	Automated Colorimetry	PROP	Proportional Counting
COL	Colorimetry	THER	Thermometry
ELEC	Electrometry	TITR	Titrimetry
GCEC	Gas Chromatography – Electron Capture		
GCEL	Gas Chromatography – Electrolytic		
GCFI	Gas Chromatography – Flame Ionization		
GCMS	Gas Chromatography/Mass Spectrometry		
GCPI	Gas Chromatography – Photoionization		
GRAV	Gravimetry		
HPLC	High Performance Liquid Chromatography		
ICP	Atomic Emission – ICP		
ION	Ion Chromatography		

(b) Unless otherwise noted, the 500 series (organics) methods are from:
USEPA. 1985. Methods for the Determination of Organic Compounds in Finished Drinking Water and Raw Source Water. U.S. EPA, Cincinnati, Ohio.
and the others from:
USEPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA 600/4-79-020. U.S. EPA, Cincinnati, Ohio.

(c) Unless otherwise noted, the 600 series (organics) methods are from:
USEPA. 1986. Methods for organic chemical analysis of municipal and industrial wastewater. 40 CFR Part 136, Appendix A.
and the others from:
USEPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA 600/4-79-020. U.S. EPA, Cincinnati, Ohio.

(d) Unless otherwise noted, the methods are from:
USEPA. 1986. Test Methods for Evaluating Solid Waste. Physical/Chemical Methods. EPA SW-846, 3rd edition. USEPA, Washington, D.C.

(e) Unless otherwise noted, the methods are from:
USEPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA 600/4-79-020. U.S. EPA, Cincinnati, Ohio.

(f) American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1985. Standard Methods for the Examination of Water and Wastewater, 16th edition. APHA, Washington, D.C.

(g) United States Geological Survey. 1979. Methods for Determination of Inorganic Substances in Water and Fluvial Sediments. Chapter A1, Book 5 in Techniques of Water-Resources Investigations. U.S. GS, Washington, D.C.

(h) USEPA. 1986. Hazardous waste management system; land disposal restrictions; final rule, in Federal Register 51(216):40572-40654.

For chromatographic anlayses, the detection limit is determined by multiplying by three, the standard deviation obtained from three analyses of a standard solution (for all analytes being measured) at a concentration three to five times the estimated or required detection limits.

Sample detection limits are highly matrix dependent. The instrument detection limits represent the lowest possible values and may not be achieveable in actual samples.

As with detection limits, the accuracy or percent recovery of each method combination needs to be determined. The percent recovery can be determined by the following procedure:

1. Spike a blank water sample with the compounds of interest at approximately five times the detection limit.
2. Determine percent recovery for each compound, i.e.,

$$\% \text{ recovery} = \frac{\text{observed amount} - \text{background correction}}{\text{spiked amount}} \times 100$$

3. Analyze a blank spike on a regular basis.
4. Analyze a matrix spike regularly to check recovery in a specific sample matrix.

The precision of each method shall be determined. The following procedure can be used to determine precision:

1. Prepare and analyze the samples in duplicate (pick sample that contains some of the compounds of interest).
2. Determine precision as relative percent difference (RPD). The absolute value of their difference divided by their sum multiplied by 100 yields the RPD and is equivalent to precision of the applied protocol, i.e.,

$$\text{RPD} = \frac{\text{Value}_1 - \text{Value}_2}{(\text{Value}_1 + \text{Value}_2)} \times 200$$

3. Analyze duplicates on a regular basis.

1.4.3 Method Blanks

Method blanks shall be included with the preparation and analysis of all parameters. Blanks should check for the presence of contamination in the following areas:

- Organic extractions - phthalates
- Volatiles - methylene chloride and other volatile organic compounds
- Metals - background metals contamination

1.4.4 Control Samples

Control samples shall be included with sample batches on a regular basis. Results shall be documented for the analysis of quality control check samples. Control samples can be in the form of USEPA check samples or other reference samples.

1.4.5 Matrix Spike/Matrix Spike Duplicate

Please refer to Section 1.10.2, Quality Control Requirements.

1.4.6 Second-Column Gas Chromatography (GC) Confirmation

For those methods which employ gas chromatography as the analytical technique (e.g., SW8010, SW8020, SW8080, SW8150) positive confirmation of identity is required for all analytes having concentrations higher than the LOD. Conduct positive confirmations by second-column GC, however, gas chromatography/mass spectroscopy (GC/MS) can be used for positive confirmation if the quantity of each analyte to be confirmed is above the detection level of the GC/MS instrument.

1.5 SAMPLING PROCEDURES

The accuracy of any analytical effort begins prior to collection of the sample with defining the purpose of the analysis and planning to achieve that purpose. The sample collection and handling phase begins after the planning, and includes sample container preparation, sample collection, preservation, handling, sample receiving, and chain-of-custody documentation. The procedures described here are designed to obtain samples which are proper representation of the matrix being sampled. Trace contaminants from sources external to the sample must be eliminated by using good sampling techniques.

1.5.1 Sample Collection and Handling

The first consideration in sampling is to assess the nature of the sample matrix, solid, liquid, gas, or biological. The sampling effort must conform to project needs. The number and location of sampling points and sampling methods (grab samples, manual compositing, or automated compositing) must be identified. This information allows adequate preparation for the sampling effort by identification of the number of personnel required and the equipment necessary to adequately perform the sampling task.

A worksheet must be developed to be used as a guide for selecting the equipment needed for a sampling. It includes sample containers for various categories of pollutants, miscellaneous supplies which may be needed for sampling, onsite preservation of sample, and sample shipment. Also, safety equipment needed should be given due consideration.

Quality assurance in sampling is critical to the production of useful data because it must be assured that the acquired sample is representative of the process or effluent stream under investigation. Sampling activity must be carried out so as to provide laboratory personnel with sufficient material for analysis which is representative of the sample source and to do so without compromising sample integrity. In order to accomplish these ends, good sampling practices must be combined with a quality control program and these in turn must be monitored for effectiveness through the quality assurance program.

1.5.2 Sample Container and Equipment Preparation

Procedures for preparing sample containers are the first step in assuring valid analytical results. Sample container cleanness protocol is designed to minimize the possibility of contamination of the sample at the time of acquisition and during shipment to the laboratory. The basic considerations in this protocol are materials selection for sampling hardware and sample containers and incorporation of effective cleaning procedures for these items. The containers in which samples are held for inorganic analysis must be made of high-density linear polyethylene and amber glass bottles for organic analysis.

When both organic and inorganic substances are expected to be present, separate samples should be taken. New sample bottles must be cleaned according to the procedure presented below; reuse of sample containers is expressly prohibited. The procedures for cleaning the glass and polyethylene containers and their caps are as follows:

Polyethylene Bottles and Polyethylene Caps

1. Rinse bottles and lids with 5 percent sodium hydroxide.
2. Rinse with de-ionized water.
3. Rinse with 5 percent Ultrex (or equivalent) nitric acid in de-ionized water.
4. Rinse with de-ionized water.
5. Drain and air dry.

Amber-Glass Bottles or 40-ml Vials

1. Scrub and wash bottles in detergent.
2. Rinse with copious amounts of distilled water.
3. Rinse with acetone.
4. Rinse with methylene chloride (Nanograde or equivalent).
5. Rinse with hexane (Nanograde or equivalent).
6. Finally, rinse with liberal amount of Nanograde methanol.
7. Air dry.
8. Heat to 200 C.

9. Allow to cool.

10. Cap clean caps with Teflon liners.

Bottle Caps

1. Remove paper liners from caps.
2. Wash with detergent.
3. Rinse with distilled water.
4. Dry at 40 C.

Teflon Liners (avoid contact with fingers); all caps for containers holding organic analysis materials are to be lined with Teflon.

1. Wash with detergent.
2. Rinse with distilled water.
3. Rinse with acetone.
4. Rinse with hexane (Nanograde or equivalent).
5. Finally, rinse with liberal amount of methanol (Nanograde).
6. Air dry.
7. Place liners in cleaned caps.
8. Heat to 40 C for 2 hours.
9. Allow to cool.
10. Use to cap cleaned sample bottles.

All portions of the sampling apparatus that come into contact with the sampled stream should be cleaned using the same procedure (as appropriate) used in cleaning the container for the associated sample. Such cleaning is to be performed both before the sampling apparatus is used for the first time and after a sample is acquired. After the apparatus has been cleaned and dried, it will be stored in boxes in a contaminant-free environment.

1.5.3 Sample Collection

The project manager will gather information prior to sampling to determine how sampling is to be performed and to identify the equipment required. Additional information must be gathered at a briefing at the sampling site with client personnel before sampling, and recorded in detail by the sampling crew to ensure that the results of analyses can be adequately evaluated. The sampling crew should request a diagram of the facility or site map and a tour with a client representative to identify processes, discharge points, or site conditions in relation to potential sampling locations. A physical description of the site or facility should be recorded.

There are three basic types of sampling which may be performed: (1) grab, (2) composited grab, and (3) automated compositing. The most simple sampling technique is grab sampling. It is important to ascertain that the collection container is of a material that will not contaminate the sample and has been precleaned by an appropriate method.

Sample collection will be initiated at the least contaminated well and progress to the most contaminated well.

Manual compositing of water samples can be performed by collection of multiple grab samples in a large, precleaned container. If a 24-hour manual composite is to be collected, a minimum of six aliquots of each volume will be collected at 4-hour intervals. The minimum aliquot is 600 ml. In some instances, it may be expeditious to collect aliquots in the final sample container. The soil grab samples may be manually composited by aliquoting equal amounts from each sample into a single container, and mixing this composite thoroughly before analysis.

Automatic compositing should be performed with a minimum of 30 minutes between aliquots. The minimum aliquot should be 100 ml. Teflon tubing should be used in the sampler (do not use Tygon or plastic tubing).

All field sampling equipment will be thoroughly cleaned prior to use in field collections and rinsed with water of known purity or approved water sources (located at a site) prior to reuse in the field. An approved water source may be an uncontaminated well located at the sampling site. The approved water source will be analyzed for all project-specific analytes at the time of sampling or if the water supply is changed in subsequent samplings.

1.5.4 Volatiles

Due to the unstable nature of volatile organic compounds, special care must be taken in collection of composite samples for determination of this class of contaminants. Automatic compositing is inappropriate for volatile organics due to the potential for loss. Therefore, discrete samples should be collected in the field and composites prepared in the laboratory immediately prior to analysis. Precautionary measures in VOA samples include:

- Acquiring the sample with equipment that minimizes direct gas pressure or vacuum on the water.
- Avoiding aeration or agitation of the sample to the greatest possible extent.
- Filling vials to capacity, taking care that no air bubbles are trapped in the vial.
- Storing the sample inverted at 4 C.

- Analyzing the sample as soon as possible, and never exceeding the prescribed holding time.

- Never allowing a volatile sample to freeze.

- Never filtering the sample.

The sampling method for volatiles in soil or sediment will depend on the chemical analysis procedure and the nature of the soil or sediment. Portions of soil may be placed in empty vials or in vials containing the extraction solvent. In other instances, sealed cores may be shipped to the laboratory for subsampling.

The primary considerations for acquiring samples for volatiles, either in the field or in the laboratory, include the following:

- Samples stored at 4 C.

- Sample handling should be minimized.

- Sample/air contact should be minimized.

- Air-tight seals on all containers used in shipment or laboratory workup.

- The sample or subsample should be placed in an air-tight container immediately after collection.

1.5.5 Ground Water

All ground-water sampling will occur after the wells have been developed according to specific geotechnical requirements specified in the contract. Because drilling and well construction disturb the natural ground-water system, the maximum possible length of time (two weeks nominal) shall pass between well development and sampling to allow the ground-water system to return to chemical equilibrium. All samples from the test wells will be collected in Teflon bailers that are thoroughly decontaminated prior to sampling. All down-hole equipment used during the purging and sampling of the test wells will be carefully washed with laboratory-grade soap (alconox), rinsed with drinking quality, ASTM Type II water, rinsed with pesticide-grade methanol, and finally rinsed with pesticide grade hexane.

All field equipment will be rinsed with approved water sources. At least one sample of the rinsing water may be submitted to the laboratory and be analyzed for all analytes of interest.

Sampling equipment must be protected from ground surface contamination. Clean plastic sheeting spread around the well is one means of protecting the equipment. Aluminum foil may be used to protect against contamination (organic analyses samples only). The shiny side will be on the outer side. New protective sheeting should be used at each sampling location. Sampling efforts shall preclude wind-blown particles from contaminating the sample or sampling equipment.

The following procedures incorporate the necessary aspects of sampling and shall be used each time a monitor well is sampled:

- Measure the depth from the top of the well casing (not protective casing) to the top of the water and record the depth in the sampling logbook or field data records.
- Measure and record the depth from the top of the casing to the bottom of the well.
- Subtract the depth to top of the water from the depth to the bottom of the well to determine the height of standing water in the casing.
- Remove a quantity of water from the well equal to four times the calculated volume of water in the well casing.
- If the well goes dry during pumping or bailing one is assured of removing all water which had prolonged contact with the well casing or air. If the recovery rate is rapid, allow the well to recover to its original level and evacuate a second time before sampling. If recovery is very slow, samples may be obtained as soon as sufficient water is available.
- Obtain a sample of ground water for temperature, conductivity, and pH measurements. Record these measurements in the sampling logbook or field data records.
- Obtain samples for chemical analysis.
- Filter samples for dissolved metals.
- Check that appropriate preservative has been added to sample containers and fill with samples.
- All samples must be placed in containers that have been cleaned according to proper protocols. Samples for organic analyses shall be placed in clean amber-glass bottles with Teflon-lined lids. Samples for inorganic chemical analyses shall generally be placed in clean polyethylene bottles. Samples for volatile organics shall be placed in septum-sealed vials.
- Cap each filled sample container securely and wipe external surface of container thoroughly.
- Label samples in accordance with standard procedures.
- Complete chain-of-custody record for labeled samples.
- Place sample bottle(s) in a temperature controlled (4 C) chest immediately after sampling and deliver to the laboratory as soon as possible.

1.5.6 Surface Water

Surface water samples may be obtained under many different circumstances. At the time of sampling, the site-specific procedures are followed. Before sampling, sample collection equipment shall be rinsed downflow or away from the sampling point, taking care not to disturb sediments at the sampling point. After sampling each location, any equipment used in collection of the samples shall be rinsed with an approved water source.

All samples are placed in containers that have been cleaned according to the standard procedures. Samples for organic chemical analyses shall be placed in clean amber-glass bottles with Teflon-lined lids. Samples for inorganic chemical analyses generally shall be placed in clean polyethylene bottles. Samples for volatile organics shall be placed in septum-sealed glass vials of 40 ml capacity. If site-specific protocols require pre-rinsing of sample containers with sample water, add the appropriate preservative in the specified quantity and cap securely. The sample must be labeled and placed in a temperature controlled (4 C) chest immediately after sampling and delivered to the laboratory as soon as possible.

It is standard procedure to acquire sample containers to which the appropriate type and amount of preservative has been added. A sample container rinsing requirement would specifically exclude the use of sample containers to which preservatives were added to bottles before they are shipped to the sampling site. In these cases, the sampling team must have available the correct preservatives and be trained in handling and dispensing the preservatives.

1.5.7 Soils

The sampling team is responsible for collecting representative samples that can be analyzed as received from the field. The Site Investigation Team Leader or Sampling Team Leader, must train the sampling team in the types of soils to be collected, the components of interest in the samples, and how to collect the sample that will represent the matrix of interest. Specifically, the sampling team is trained to remove all items that are not integral components of the matrix of interest.

The sampling locations must have been chosen to be representative of the areas being investigated. A large area may require collecting and compositing multiple samples into a single sample to represent the area. Individual samples may be collected and analyzed to describe the sampling points within the area.

All sampling points must be marked with a stake that is labeled with the appropriate site identification. Prior to sampling, surface vegetation, rocks, pebbles, leaves, twigs, and debris that would obstruct collection of a representative soil sample will be cleared from the sample point.

All equipment will be thoroughly cleaned between use at different sampling locations to prevent cross-contamination of samples. When required, equipment shall be scrubbed to remove evident particulate material and rinsed with an approved water source.

Soil samples will be collected in containers that have been cleaned according to the standard protocols. Samples for organic and inorganic chemical analytes shall be placed in clean, wide-mouth, amber-glass bottles with Teflon-lined lids. Samples for volatile organics shall be placed in septum-sealed glass vials or containers appropriate for the analytical method. Wide-mouth glass jars with Teflon-lined lids can be used for this purpose. Samples must be labeled properly and placed in a temperature controlled (4 C) chest immediately after sampling and delivered to the laboratory as soon as possible.

1.5.8 Sediment

The sampling team is responsible for collecting representative samples that can be analyzed as received from the field, or composited in the lab. The Site Investigation Team Leader or Sampling Team Leader will instruct the sampling team in the types of sediments to be collected, the components of interest in the sample, and how to collect the sample that will represent the matrix of interest. Specifically, the sampling team will have training to remove all items that are not integral components of the matrix of interest.

The type of sampler to be used will depend on the nature, as well as the accessibility, of the sediments. In addition, the type of sampler chosen should be appropriate for obtaining the desired sample, e.g., a core sampler should not be used to obtain top sediment.

Prior to sampling sediment in a stream, the sampling device will be rinsed with stream water at a point downstream from the sampling location to avoid disturbing the sediment at any sampling point. Also, sampling shall be accomplished upstream of any disturbances in the stream caused by the sampler or sampling team. Twigs, leaves, pebbles, and debris that are not intergral components of the matrix of interest should be excluded from the sample by the sampling team.

All equipment will be thoroughly cleaned between use at different sampling locations to prevent cross-contamination of samples. In the event that sampling equipment is to be reused, the equipment shall be scrubbed to remove any evident particulate matter and rinsed with approved water.

Sediment samples must be collected in containers that have been cleaned according to the standard protocols. Samples for organic and inorganic chemical analytes shall be placed in clean, wide-mouth, amber-glass bottles with Teflon-lined lids. Samples for volatile organics shall be placed in septum-sealed glass vials or containers appropriate for the analytical method. Samples are labeled and placed in a temperature controlled (4 C) chest immediately after sampling and delivered to the laboratory as soon as possible.

1.5.9 Sample Preservation

The purpose of sample preservation is to prevent or retard the degradation/ modification of chemicals in samples during transit and storage. Efforts to preserve the integrity of the samples starts at the time of sampling and continues until analyses are performed. Preservation and storage requirements are provided in Table 1-7. Sample holding time requirements

TABLE 1-7 USEPA RECOMMENDATION FOR SAMPLING AND PRESERVATION OF SAMPLES ACCORDING TO MEASUREMENT[a]

Measurement	Volume Required (ml)	Container[b]	Preservative	Recommended Holding Time[c]
Physical Properties				
Color	50	P, G	Cool, 4 C	48 hours
Specific conductance	100	P, G	Cool, 4 C	28 days(d)
Hardness	100	P, G	Cool, 4 C HNO3 to pH <2	6 months(e)
Odor	200	G only	Cool, 4 C	24 hours
pH	25	P, G	None required	Analyze immediately
Residue				
Filterable	100 (200)	P, G	Cool, 4 C	7 days
Nonfilterable	100 (200)	P, G	Cool, 4 C	7 days
Total	100 (200)	P, G	Cool, 4 C	7 days
Volatile	100 (200)	P, G	Cool, 4 C	7 days
Settleable matter	1,000	P, G	Cool, 4 C	48 hours
Temperature	1,000	P, G	None required	Analyze immediately
Turbidity	100	P, G	Cool, 4 C	48 hours

(a) Fed. Regist. 1984. 49(209): 43260–43261.

(b) Polyethylene (P) or Glass (G). For metals, polyethylene with a polypropylene cap (no liner) is preferred.

(c) Holding times are recommended for properly preserved samples based on currently available data are based on the date of receipt in the laboratory. For some sample types, extension of these times may be possible whereas for other types, these times may be too long. Where shipping regulations prevent the use of the proper preservation technique or the holding time is exceeded, such as the case of a 24-hour composite, the final reported data for these samples should indicate the specific variance.

(d) If the sample is stabilized by cooling, it should be warmed to 25 C for reading, or temperature correction made and results reported at 25 C.

(e) Where HNO_3 cannot be used because of shipping restrictions, the sample may be initially preserved by icing and immediately shipped to the laboratory. Upon receipt in the laboratory, the sample must be acidified to a pH <2 with HNO_3 (normally 3 ml 1:1 HNO_3/L is sufficient). At the time of analysis, the sample container should be thoroughly rinsed with 1:1 HNO_3 and the washings added to the sample (volume correction may be required).

TABLE 1-7 (Cont.)

Measurement	Volume Required (ml)	Container$^{(b)}$	Preservative	Recommended Holding Time$^{(c)}$
Physical Properties (Cont.)				
Metals				
Dissolved	200	P, G	Filter onsite HNO3 to pH <2	6 months(e)
Suspended	200		Filter onsite	6 months
Total	100 (200)	P, G	HNO3 to pH <2	6 months(e)
Chromium (VI)	200	P, G	Cool, 4 C	24 hours
Mercury	250	P, G	HNO3 to pH <2	28 days
Inorganics, Non-metallics				
Acidity	100	P, G	Cool, 4 C	14 days
Alkalinity	100	P, G	Cool, 4 C	14 days
Bromide	100	P, G	None required	28 days
Chloride	50	P, G	None required	28 days
Chlorine, total residual	200	P, G	None required	Analyze *immediately*
Cyanides	500	P, G	Cool, 4 C NaOH to pH >12	14 days
Fluoride	300	P	None required	28 days
Iodide	100	P, G	Cool, 4 C	24 hours
Nitrogen				
Ammonia	400 (100)	P, G	Cool, 4 C H_2SO_4 to pH <2	28 days

TABLE 1-7 (Cont.)

Measurement	Volume Required (ml)	Container[b]	Preservative	Recommended Holding Time[c]
Inorganics, Non-metallics (Cont.)				
Kjeldahl, total	500 (200)	P, G	Cool, 4 C H_2SO_4 to pH <2	28 days
Nitrate plus nitrite	100 (50)	P, G	Cool, 4 C H_2SO_4 to pH <2	28 days
Nitrate	100	P, G	Cool, 4 C	48 hours
Nitrite	50	P, G	Cool, 4 C	48 hours
Dissolved oxygen				
Probe	300	G only	None required	Analyze immediately
Winkler	300	G only	Fix onsite and store in dark	8 hours
Phosphorus				
Orthophosphate, dissolved	50	P, G	Filter onsite Cool, 4 C	48 hours
Hydrolyzable	50	P, G	Cool, 4 C H_2SO_4 to pH <2	24 hours
Total	50	P, G	Cool, 4 C H_2SO_4 to pH <2	28 days
Total, dissolved	50	P, G	Filter onsite Cool, 4 C H_2SO_4 to pH <2	28 days

TABLE 1-7 (Cont.)

Measurement	Volume Required (ml)	Container(b)	Preservative	Recommended Holding Time(c)
<u>Inorganics, Non-metallics (Cont.)</u>				
Silica	50	P only	Cool, 4 C	28 days
Sulfate	50	P, G	Cool, 4 C	28 days
Sulfide	500	P, G	Cool, 4 C Zinc acetate NaOH to pH >9	27 days
Organics				
BOD	1,000 (750)	P, G	Cool, 4 C	48 hours
COD	50 (100)	P, G	H_2SO_4 to pH <2	28 days
Oil and grease	1,000	G only	Cool, 4 C H_2SO_4 to pH <2	28 days
Total petroleum hydrocarbons	1,000	G only	Cool, 4 C H_2SO_4 to pH <2	28 days
Organic carbon	24 (50)	P, G	Cool, 4 C H2SO4 or HCl to pH <2	28 days
Phenolics (colorimetric)	500	G only	Cool, 4 C H_3PO_4 to pH <4 1.0 g $CuSO_4$/L	28 days
Surfactants	250	P, G	Cool, 4 C	48 hours
Extractables (including phthalates, nitrosamines,	4,000	G, teflon-lined cap	Cool, 4 C (0.008% $Na_2S_2O_3$)	5 days until extraction

TABLE 1-7 (Cont.)

Measurement	Volume Required (ml)	Container[b]	Preservative	Recommended Holding Time[c]
organochlorine pesticides, PCBs, nitroaromatics, isophorone, polynuclear aromatic hydrocarbons, haloethers, chlorinated hydrocarbons, and TCDD)				40 days after extraction
Extractables (phenols)	2,000	G, teflon-lined cap	Cool, 4 C H_2SO_4 to pH <2 (0.008% $Na_2S_2O_3$)	5 days until extraction 40 days after extraction
Pesticides	2,000	G, teflon-lined cap	Cool, 4 C pH 5-9	5 days until extraction 40 days after extraction
Purgeables (halocarbons and aromatics)	--	G, teflon-lined septum	Cool, 4 C 0.008% $Na_2S_2O_3$	10 days
Purgeables (acrolein and acrylonitrile)	--	G, teflon-lined septum	Cool, 4 C 0.008% $Na_2S_2O_3$	10 days
Radiological				
Alpha, beta, and radium	--	P, G	HNO_3 to pH <2	6 months
Bacteria				
Coliform, fecal and total	50	P, G	Cool, 4 C 0.008% $Na_2S_2O_3$	6 hours

TABLE 1-7 (Cont.)

Measurement	Volume Required (ml)	Container[b]	Preservative	Recommended Holding Time[c]
Fecal streptococci	50	P, G	Cool, 4 C 0.008% $Na_2S_2O_3$	6 hours

apply to all samples. Samples are saved after analysis until the Project Manager determines that they can be disposed or 30 days has elapsed since the final data report is submitted to the project manager.

1.6 SAMPLE CUSTODY

1.6.1 Field Sampling Operations

1.6.1.1 Documentation

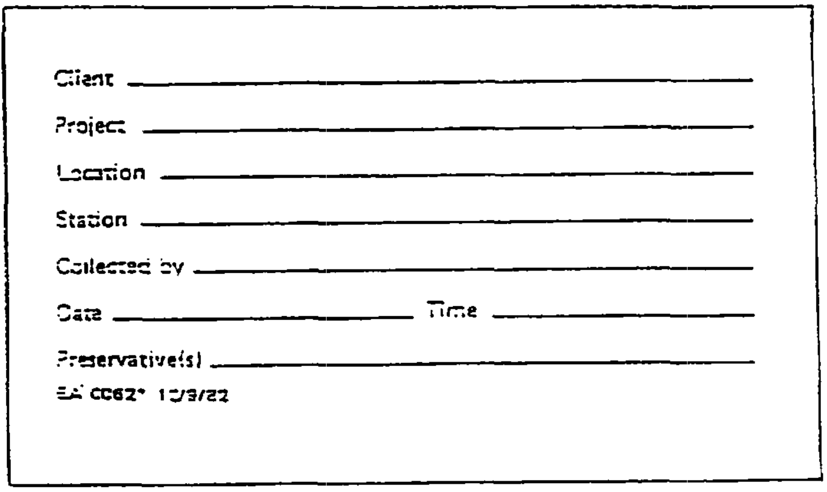
Field notebooks used by EA personnel will be bound or maintained in a 3-ring notebook. All pertinent information regarding the site and sampling procedures must be documented. Notations should be made in log book fashion, noting the time and date of all entries. Information recorded in this notebook should include, but not be limited to the following: place or site of investigation or interest, exact location; date and time of arrival and departure; affiliation of persons contacted; name of person keeping log; names of all persons on site; purpose of visit; all available information on site (processes or products, waste generation, nature of spilled material); composition and concentration of substance, if known; description of sampling plan; field instrument calibration information; location of sampling points (including justification); number of samples taken; volume of samples taken; method of sample collection and any factors that may affect its quality; date and time of sample collection; name of collector; all sample identification numbers; description of samples; weather conditions on the day of sampling and 48 hours previous; and any field observations. All data entries will be made in indelible ink and all corrections to the data will be a single-line cross out, dated, and initialed.

1.6.1.2 Sampling

The samples will be collected by trained, experienced teams who will be alerted to any special considerations necessary to ensure collection of representative samples. After the samples are collected, they will be split as necessary among containers and preservatives appropriate to the parameters to be determined. Each container will be affixed with a sample label (Figure 1-4) which will be filled out at the time of collection. At this time, a chain-of-custody form (Figure 1-5) will be initiated. The collected samples will be cooled, if necessary, and returned to the laboratory by the most expedient means to ensure that holding times will be met. The chain-of-custody form will be signed and dated as necessary as the samples pass from the collectors to those persons responsible for their transportation.

1.6.1.2.1 Sample Labeling

The importance of sample labeling cannot be overstated. Improperly or inadequately labeled samples are of little value in a monitoring program. Improperly labeled samples lead to questions with regard to location, project, sampling station, date sampled, and sampler. All of this information is essential for proper sample handling.



Client ______________________________

Project ______________________________

Location ______________________________

Station ______________________________

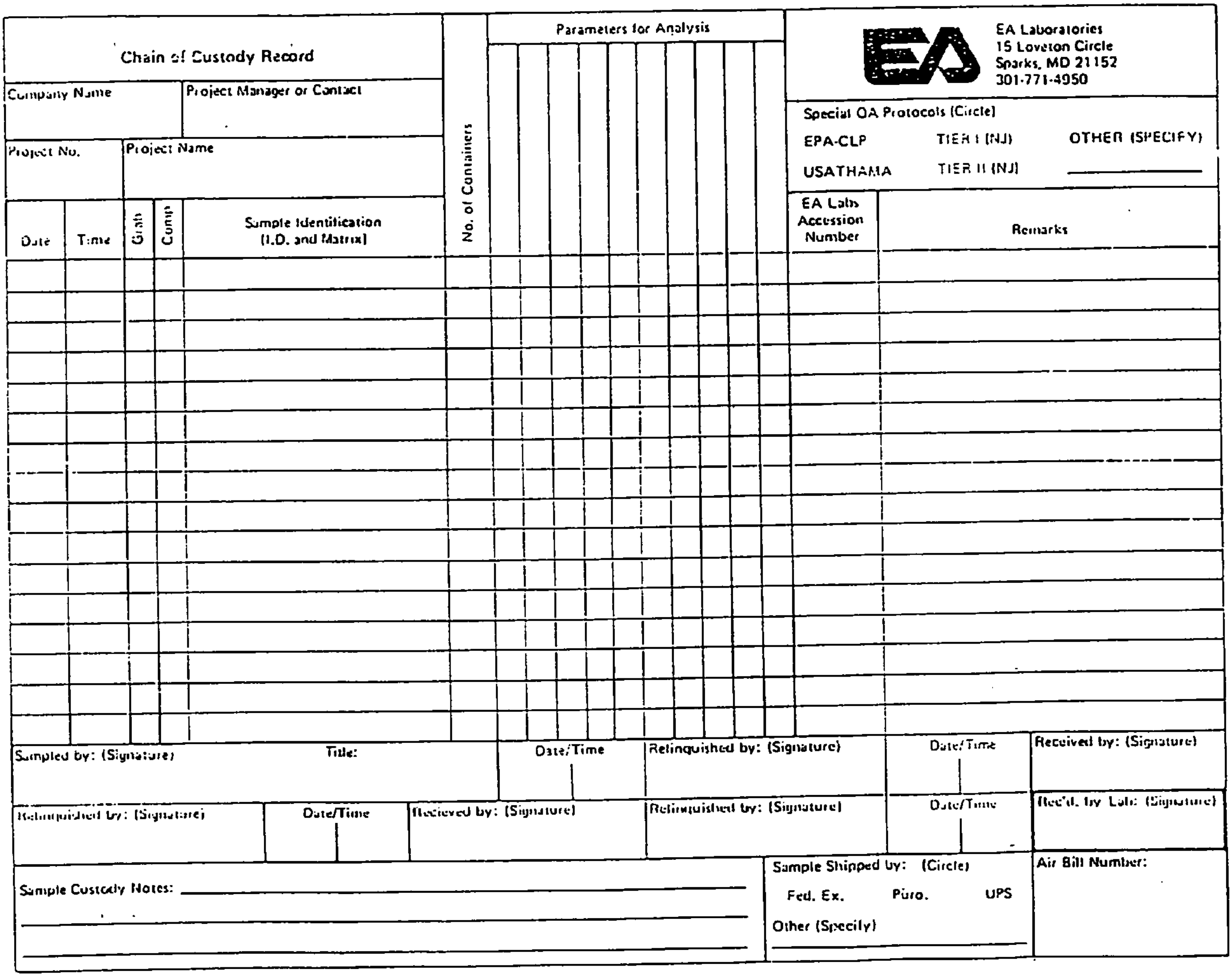
Collected by ______________________________

Date ______________ Time ______________

Preservative(s) ______________________________

EA 0062* 10/3/82

Figure 1-4. Sample bottle label.



Chain of Custody Record

EA Laboratories
15 Loveton Circle
Sparks, MD 21152
301-771-4950

Company Name	Project Manager or Contact
Project No.	Project Name

Special QA Protocols (Circle)
EPA-CLP TIER I (NJ) OTHER (SPECIFY)
USATHAMA TIER II (NJ) ____________

Date	Time	Grab	Comp	Sample Identification (I.D. and Matrix)	No. of Containers	Parameters for Analysis										EA Labs Accession Number	Remarks

Sampled by: (Signature)	Title:	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Recieved by: (Signature)	Relinquished by: (Signature)	Date/Time	Rec'd. by Lab: (Signature)

Sample Custody Notes: ____________________

Sample Shipped by: (Circle)
Fed. Ex. Puro. UPS
Other (Specify) ____________

Air Bill Number:

Figure 1-5. Sample Chain-of-Custody form.

The following information, at a minimum, is required on each sample label:

Client	Date collected
Project number	Time collected
Location	Collected by
Station	Preservative(s)

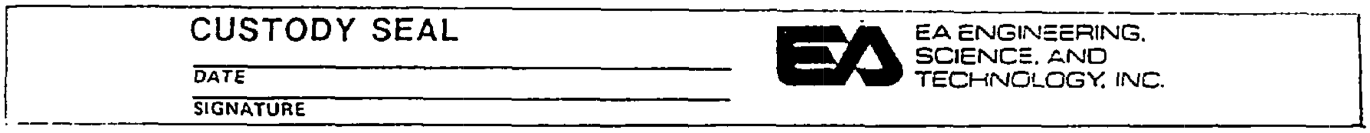
Pre-printed pressure-sensitive labels are available from the laboratory.

Failure to provide the requested information may result in wasted time and resources if it is necessary to discard samples because of inadequate information.

1.6.1.3 Sample Packing/Transportation Requirements

The following summarizes the sample packing and transportation protocol that will be followed for this project.

- Waterproof metal (or equivalent strength plastic) ice chests or coolers only.
- After filling out the pertinent information on the sample label and tag, put the sample in the bottle or vials and screw-on the lid. For bottles other than the VOA vials, secure the lid with strapping tape. (Tape on VOA vials may cause contamination.) Secure the string from the numbered approved tag around the lid.
- Mark volume level on bottle with grease pencil.
- Place about 3 in. of inert cushioning material, such as vermiculite, in the bottom of the cooler.
- Enclose the bottles in clear plastic bags through which sample tags and labels are visible, and seal the bag. Place bottles upright in the cooler in such a way that they do not touch and will not touch during shipment.
- Put in additional inert packing material to partially cover sample bottles (more than half-way). Place bags of ice around, among, and on top of the sample bottles.
- Fill cooler with cushioning material.
- Put paperwork (Chain-of-Custody Record) in a waterproof plastic bag and tape it with masking tape to the inside lid of the cooler.
- Tape the drain shut.
- Secure lid by taping and applying a custody seal (Figure 1-6). Wrap the cooler completely with strapping tape at a minimum of two locations. Do not cover any labels.
- Attach completed shipping label to top of the cooler.



CUSTODY SEAL

DATE ____________________

SIGNATURE ____________________

EA ENGINEERING,
SCIENCE, AND
TECHNOLOGY, INC.

(Reduced size)

Figure 1-6. Custody seal.

- Put "This Side Up" labels on all four sides and "Fragile" labels on at least two sides.
- Affix numbered and signed custody seals on front right and back left of cooler. Cover seals with wide, clear tape.

Remember that each cooler cannot exceed the weight limit set by the shipper.

1.6.1.3.1 Shipment of Samples

The following procedures are to be followed in the shipment of samples that are taken either from the ground or in the form of water or sediment that may be contaminated.

A Restricted Article Airbill is required. This airbill is available at Federal Express offices. EA will supply forms pre-printed to the extent possible. The format of this airbill may vary with other carriers. However, the following designations should be entered on the airbill:

1. Indicate either HAZARDOUS SUBSTANCE LIQUID -- NOS (this means "NOT OTHERWISE SPECIFIED") or HAZARDOUS SUBSTANCE SOLID -- NOS. You must designate either liquid or solid. As combining a shipment with both liquid and solid will not be accepted by the carrier.
2. Under "Classification" indicate ORM-E.
3. The third item to be filled out under "ID Number" is NA 9188. This interpretation (9188) alludes to environmental sediment or sample.
4. The fourth item that is needed is the "Quantity" in pints or quarts approximately, or if it is a solid in ounces or pounds.
5. Cross out "Cargo Aircraft Only" unless you are shipping radioactive material or material in the gallons, whereby you must cross out "Passenger Aircraft Only" as large volumes of contaminated material or radioactive material are not allowed on passenger aircraft.
6. You must repeat the information under "Proper Shipping Name, Classification, and Identification No." on the box you are shipping in with a square drawn around the information in the event the airbill is separated from the shipment.

1.6.2 Laboratory Operations

The laboratory has a designated sample custodian. This individual is responsible for receiving samples in the laboratory, opening the coolers and checking the sample integrity and the custody seal, logging samples into the laboratory system, and controlling the handling and storage of samples while in the laboratory.

1.6.2.1 Duties and Responsibilities of Sample Custodian

The duties and responsibilities of the sample custodian shall include but not be limited to the following:

- Receiving samples.
- Inspecting sample shipping containers for presence/absence and condition of:
  - Custody seals, locks, "evidence tape," etc.
  - Container breakage and/or container integrity
- Recording condition of both shipping containers and sample containers (bottles, jars, cans, etc.) in appropriate logbooks or on appropriate forms.
- Signing appropriate documents, shipped with samples (i.e., airbills, chain-of-custody records, etc.).
- Verifying and recording agreement or nonagreement of information on sample documents (i.e., sample tags, chain-of-custody records, traffic reports, airbills, etc.) in appropriate logbooks or on appropriate forms. If there is nonagreement, recording the problems, and notifying appropriate laboratory personnel for contacting the Project Manager for direction.
- Initiating the paperwork for sample analyses on appropriate laboratory documents (including establishing case and sample files and inventory sheets) as required for analysis or according to laboratory standard operating procedures.
- Marking or labeling samples with laboratory sample numbers as appropriate and cross-referencing laboratory numbers to client numbers and sample tag numbers as appropriate.
- Placing samples, sample extracts, and spent samples into appropriate storage and/or secure areas.
- Controlling access to samples in storage and assuring that laboratory standard operating procedures are followed when samples are removed from and returned to storage.
- Monitoring chain-of-custody of samples in the laboratory. Samples are physical evidence and should be handled according to certain procedural safeguards. For the purposes of some types of legal proceedings, a showing to the court that the laboratory is a secure area may be all that is required for the analyzed evidence to be admitted. However, it is anticipated that in some cases, the court may require a showing of the hand-to-hand custody of the samples while they were at the laboratory. In the event that the court requires such a comprehensive chain-of-custody demonstration, the

laboratory must be prepared to produce documentation that traces the in-house custody of the samples from the time of receipt to the completion of the analysis.

The National Enforcement Investigations Center (NEIC) of USEPA defines custody of evidence in the following ways:

- It is in your actual possession; or
- it is in your view, after being in your physical possession; or
- it was in your possession and then you locked or sealed it up to prevent tampering; or
- it is in a secure area.

- Assuring that sample tags are removed from the sample containers and included in the appropriate sample file; accounting for missing tags in a memo to the file or documenting that the sample tags are actually labels attached to sample containers or were disposed due to suspected contamination.

- Monitoring storage conditions for proper sample preservation such as refrigeration temperature and prevention of cross-contamination.

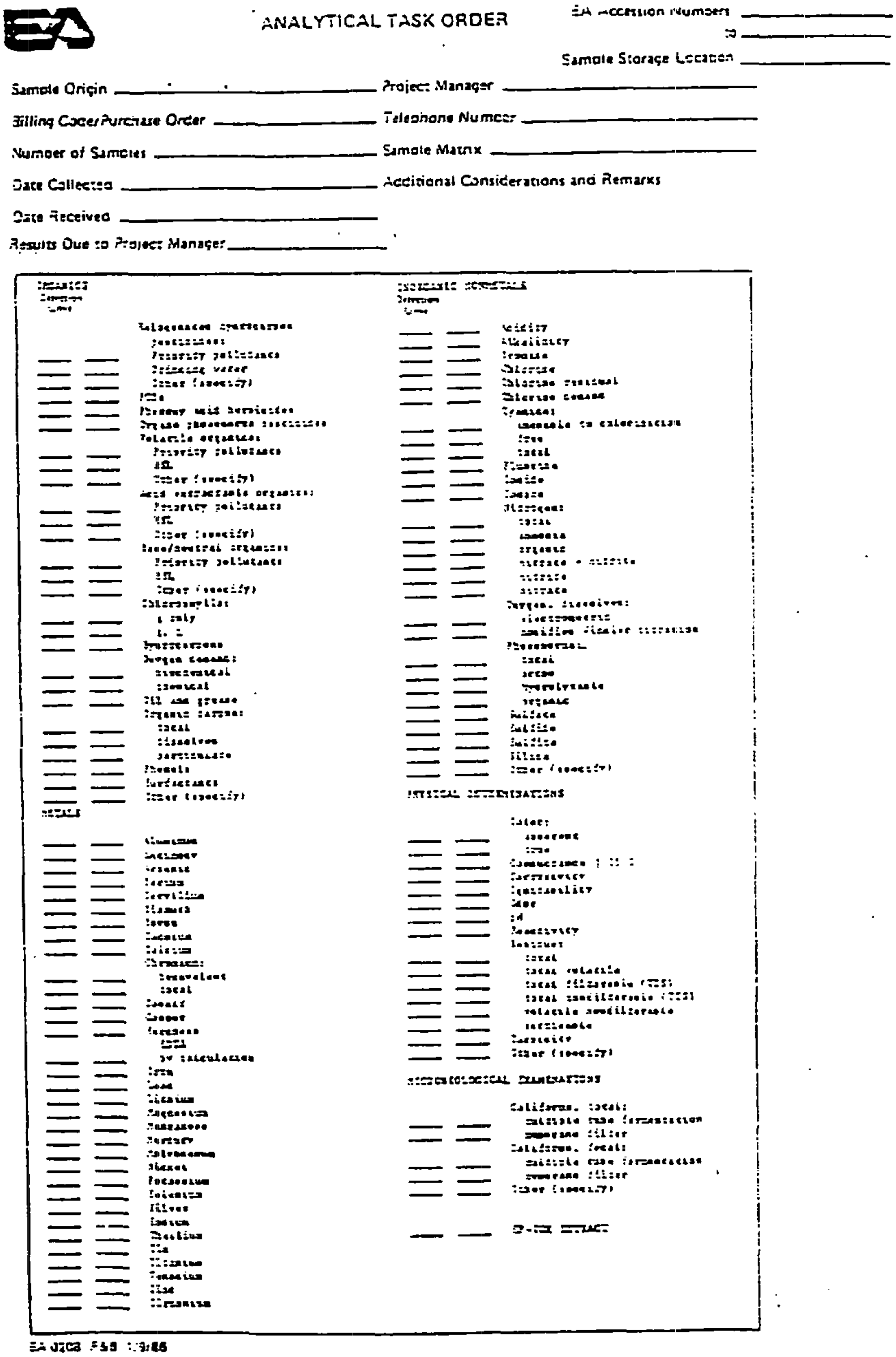
- Returning shipping containers to the proper sampling teams.

1.6.2.2 Sample Receipt and Logging

After samples have been collected and labeled and the Chain-of-Custody Forms initiated, the project manager completes the reverse side of the Chain-of-Custody Form, which is an Analytical Task Order Form (Figure 1-7). This form provides sample-specific information and a listing of the parameters required on each sample, along with the required analytical sensitivity. The Chain-of-Custody/Analytical Task Order Form is sealed in a water-tight plastic envelope and shipped with the samples to the laboratory.

Upon receipt at the laboratory, the sample custodian inspects the samples for integrity and checks the shipment against the Chain-of-Custody/Analytical Task Order Form. Discrepancies are addressed at this point and documented on the Chain-of-Custody Form. When the shipment and the chain-of-custody are in agreement, the custodian enters the samples into the Laboratory Log (Figure 1-8) and assigns each sample a unique laboratory number. This number is affixed to each sample bottle. The custodian then prepares an Analytical Assignment Form for each technician to be involved in the analyses and delivers same, along with a properly preserved aliquot, to the appropriate technicians for analysis.

When analysis is complete, the analyst dates and initials the Analytical Assignment Form. The forms are given to the laboratory manager. He retains them until the final data report is sent to the client, then discards the forms.



ANALYTICAL TASK ORDER

EA Accession Numbers ____________
ID ____________
Sample Storage Location ____________

Sample Origin ____________
Project Manager ____________
Billing Code/Purchase Order ____________
Telephone Number ____________
Number of Samples ____________
Sample Matrix ____________
Date Collected ____________
Additional Considerations and Remarks
Date Received ____________
Results Due to Project Manager ____________

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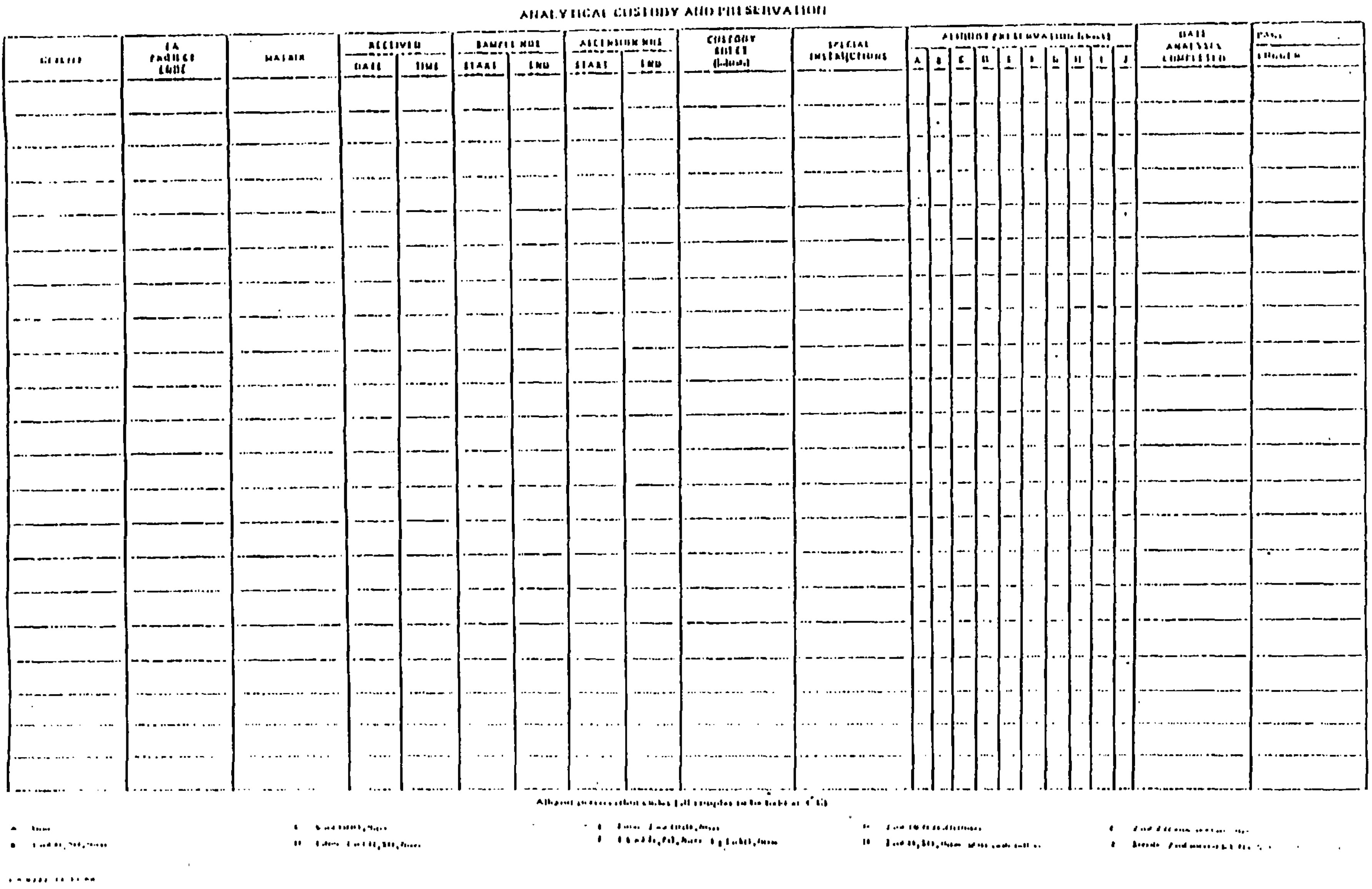
Figure 1-7. Analytical Task Order form.



ANALYTICAL CUSTODY AND PRESERVATION

CLIENT	EA PROJECT CODE	MATRIX	RECEIVED		SAMPLE NOS		ACCESSION NOS		CUSTODY SHEET (Initials)	SPECIAL INSTRUCTIONS	ALIQUOT PRESERVATION (Initials)										DATE ANALYSIS COMPLETED	PAGE LOGGER
			DATE	TIME	START	END	START	END			A	B	C	D	E	F	G	H	I	J		

[illegible]

A [illegible]
B [illegible]
C [illegible]
D [illegible]
E [illegible]
F [illegible]
G [illegible]
H [illegible]
I [illegible]
J [illegible]

[illegible]

Figure 1-8. Laboratory Log.

1.6.2.3 Sample Storage and Security

While in the laboratory, the samples and aliquots that require storage at 4 C are maintained in a refrigerator unless they are being used for analysis. Samples for purgeable organics determinations are stored in a separate refrigerator from other samples, sample extracts, and standards.

All the refrigerators in the laboratory are numbered and dedicated to specific types of samples, as shown in the following table:

Refrigerator No.	Location	Sample Type
(1) Walk-in	Sample receiving area	Organic extractables
(2) Walk-in	Sample receiving area	Inorganics and organics
(3) Under-the-counter	GC laboratory	Organic VOA
(4 and 5) Under-the-counter	GC/MS laboratory	BNA extracts and standards

Similarly, there are refrigerators designated for extracts and standards. Samples that are required to be frozen are stored in a freezer. The sample storage areas are within the laboratory to which access is limited to laboratory chemists and controlled by doors with combination locks. The samples are routinely retained at the laboratory for 30 days (or longer if required by the project) after the data have been forwarded to the client so that any analytical problems can be addressed. The samples are discarded at the end of 30 days.

Specific tasks for sample storage are the following:

- Samples and extracts will be stored in a secure area.
- The secure area will be designed to comply with the storage method(s) defined in the contract.
- The samples will be removed from the shipping container and stored in their original containers unless damaged.
- Damaged samples will be disposed in an appropriate manner and this disposal will be documented.
- The storage area will be kept secure at all times. The sample custodian will control access to the storage area. (Duplicate keys for locked storage areas should be maintained only by the appropriate personnel.)
- Whenever samples are removed from storage, this removal will be documented. All transfers of samples can be documented on internal chain-of-custody records.

- Samples and extracts will be stored after completion of analysis in accordance with the contract or until instructed otherwise by the project manager.

- The location of stored extracts will be recorded.

- VOA samples will be stored separately from other samples.

- Standards will not be stored with samples or sample extracts.

- The sample storage area will be described.

- So that the laboratory may satisfy sample chain-of-custody requirements, the following SOPs for laboratory/sample security are used:

  - Samples will be stored in a secure area.

  - Access to the laboratory will be through a monitored area. Other outside-access doors to the laboratory will be kept locked.

  - Visitors will sign a visitor's log and be escorted while in the laboratory.

  - Refrigerators, freezers, and other sample storage areas will be securely maintained or locked.

  - Only the designated sample custodian and supervisory personnel will have keys to locked sample storage area(s).

  - Samples will remain in secure sample storage until removed for sample preparation or analysis.

  - All transfers of samples into and out of storage will be documented on an internal chain-of-custody record.

  - After a sample has been removed from storage by the analyst, the analyst is responsible for the custody of the sample. Currently, the laboratory is not tracking the internal movement of samples because the laboratory is secured and accessible only to chemists.

1.7 CALIBRATION PROCEDURES AND FREQUENCY

1.7.1 Field Test Equipment

1.7.1.1 Equipment Identification

A unique identification number shall be assigned to each piece of testing equipment. The equipment identification number shall be recorded by the user on appropriate calibration, field and/or laboratory data sheets, or on other record forms. This procedure will serve as a basis for determining past performance of equipment.

1.7.1.2 Equipment Calibration

The frequency of calibration for each piece of equipment (Table 1-8) is based upon the type of equipment, the degree of usage, the required accuracy, stability characteristics, and on other conditions affecting measurement control.

1.7.1.3 Equipment Handling

Users of the equipment are responsible for its proper use and care. Any equipment whose calibration is suspect because of damage or mishandling will not be used. The equipment will be stored, handled, and transported in a manner that will best preserve accuracy.

1.7.2 Laboratory Test Equipment

1.7.2.1 Calibration Identification

Instruments past due for calibration or maintenance will be labeled and not used for analysis. The labeling and recording system extends to calibration or maintenance services provided to the Laboratory by outside vendors. Certifications and reports furnished by them will be filed and made a part of the required recordkeeping system.

1.7.2.2 Calibration Standards

All physical or electronic measurements or calibrations (excluding chemical calibration curves) performed by or for the Laboratory will be traceable, directly or indirectly, through an unbroken chain of properly conducted calibrations (supported by reports or data sheets) to the NBS. Up-to-date reports for each reference standard and each subordinate standard used for calibration of test and measurement equipment will be maintained. When calibration services are performed by outside organization, copies of reports and records showing traceability to the NBS should be obtained and presented during laboratory audits.

1.7.2.3 Calibration Frequency

The operations manager maintains a calibration schedule for all laboratory instrumentation requiring calibration. The schedule indicates (1) when calibration is due, (2) when calibration is completed, (3) when a unit is out of service, and (4) when an out-of-service unit has been repaired.

The operations manager is responsible for scheduling and monitoring all calibrations. For external calibration services, he notifies the calibrating agencies with sufficient lead time to ensure that calibration deadlines are met. He performs or directs others under his supervision to perform the internal calibrations. Appropriate documentation for the calibration is placed in the instrument files.

Any instrument for which the calibration is past due is marked with an "out of calibration" sign. An "out of calibration" sign is also placed on any instrument found to be out of calibration specifications before the

TABLE 1-8 CALIBRATION/MAINTENANCE OF FIELD EQUIPMENT

Instrument	Frequency	Calibration/Maintenance Procedure	Reference Standard Used
pH meter	1. Each use	1. Standardize with at least two standard buffers (pH 4.0, pH 7.0, or pH 10.0) before each use. 2. Compensate for temperature with each use.	1. Commercially prepared buffers are used.
		NOTE: spare electrodes kept on hand.	
Conductivity meter	1. Each use	1. Checked against a known resistance using a resistor	1. Usually an internal instrument check.
	2. Monthly	2. Checked against known conductance solution.	2. NaCl solution used.
Thermometer	1. Annually	1. Calibrated against a known temperature	1. NBS certified or or traceable thermometer
	2. Each use	2. Clean after each use and maintain in protective covering.	
Foxboro OVA Flame Ionization Detector	1. Each use	1. Check response with organic vapor source.	1. NBS traceable bottled vapor source used.
	2. Annually	2. Maintenance by outside service.	
HNU Photoionization Detector	1. Each use	1. Calibrated against known concentration of isobutylene.	1. NBS traceable bottled vapor source used.
TIP Photoionization Detector	1. Each use	1. Calibrated against know concentration of isobutylene.	1. NBS traceable bottled vapor source used.
Draeger Sampling Pump	1. Each use	1. Calibrated air volume with burette.	
	2. Annually	2. Replace seals and apply lubricant.	
Combustible Gas Indicator /Oxygen Analyzer	1. Each use	1. Calibrated against known concentration of methane or propane.	1. NBS traceable bottled vapor source used.
	2. Annually	2. Replace sensor.	

scheduled calibration date. Instruments requiring repairs or maintenance which preclude their use as a data generating instrument are marked "out-of-service."

The following are the data generating laboratory instruments which require annual calibration as described in Section 1.12.

a. Analytical Balance

The following are the data generating laboratory instruments which require semi-annual calibration, as described in Section 1.12.

a. UV-VIS Spectrophotometer

The following are the data generating laboratory instruments which adhere to quality control requirements in Section 1.10.

a. The first group are the instruments for which the calibration procedure is the establishment of a calibration curve.

   (1) UV-VIS Spectrophotometer (when used for relative analyses)
   (2) Technicon Autoanalyzer
   (3) Total Organic Carbon Analyzer
   (4) Atomic Absorption Spectrophotometer
   (5) IR Spectrophotometer
   (6) Selective Ion Meter

b. The second group are instruments for which the calibration procedure is the measurement of standard response factors. The documentation of the calibration is the record of standard concentrations and responses stored in the files of the standard runs.

   (1) Gas Chromatograph
   (2) Gas Chromatograph/Mass Spectrometer

c. The third group are instruments for which the calibration procedure consists of the measurement of one or two standards. From the standard measurements either the instrument is set to read the appropriate value or a calibration factor is calculated. The results of the standard measurements are recorded on the laboratory data sheets.

   (1) pH Meter
   (2) Selective Ion Meter (when used for pH measurements)
   (3) Conductivity Meter
   (4) Dissolved Oxygen Meter
   (5) Turbidimeter/Nephelometer

1.7.2.4 Calibration Curve

For all "relative" analyses, a calibration or standard curve is required to calculate sample concentrations from the measured instrument responses. A calibration curve is prepared by measuring the instrument responses for a series of standard solutions of the analyte. The sample concentrations are then calculated by interpolating between the standard points. One means to perform these calculations is to use regression analysis to fit a curve through the standard data. The sample concentrations can then be calculated using the resulting regression equation. The regression analysis also provides parameters which can be used to assess the condition of the analysis. The majority of analyses in the laboratory give linear calibration curves or can be transformed to a linear form. Other analyses can be fitted to a parabolic curve. The following sections discuss specific details of linear and parabolic regression and their uses.

1.7.2.5 Linear Regression

In linear regression analysis, the standard data are fitted to an equation of the form

$$y = a + bx$$

where

y = instrument response
x = concentration or amount of analyte
a = y-intercept
b = slope of the line (sensitivity)

After the regression equation has been computed, the sample concentrations (x) can be calculated from the response readings (y) by rearranging the regression equation to give $x = (y-a)/b$. Because of the possibility of nonlinear response outside the range of the standards, caution should be exercised when sample responses are greater than that of the highest standard. No sample concentration should be calculated for final data when the sample response is more than 1.2 times the response of the highest standard. When the sample response is outside this range, the sample should be diluted and re-analyzed, or a higher standard can be run to extend the calibration curve.

The correlation coefficient (r), or the square of the correlation coefficient (r^2), is a regression parameter which is a measure of how well the equation fitted to the data actually approximates the data. The closer the correlation coefficient is to a value of 1.000, the better the fit. With linear regression analysis, the correlation coefficient is influenced by two factors: (1) how linear the data are, and (2) how much scatter there is among replicate measurements. For most laboratory analyses, it should be possible to obtain correlation coefficients for the calibration curves of 0.995 ($r^2 = 0.990$). No analyses should be continued if the r is less than 0.990 ($r^2 < 0.980$) without consulting the laboratory manager or chief chemist.

When the value of the correlation coefficient does not meet the criteria stated above or when the value is lower than is generally encountered for a given analysis, it is helpful to prepare a graph of the standard curve. Visual inspection of the curve can often indicate the reason for the r value. The response may not be linear over the range measured. There may be a large amount of scatter among the data. One set of standard values may be out of line with the others--possibly improperly prepared. Possible remedial action should be discussed with the laboratory manager or chief chemist before the analysis is continued.

After regression analysis has been completed, it is often useful to compare the y-intercept of the regression line with the standard blank values. Since the y-intercept is the value of y (the response) when x (the concentration) equals zero, the y-intecept is the regression fitted blank. A large discrepancy between the y-intercept and the average blank readings can indicate a problem with either the blanks or the standard preparation. It could also indicate curvature of the response at low concentrations, which can significantly affect calculations in this region.

1.7.2.6 Parabolic Regression

Although curvilinear responses can indicate problems in analyses which are expected to give linear responses, there are some analyses which routinely give curvilinear responses. Parabolic regression has been found useful for preparing calibration curves for some of these analyses. In parabolic regression, an equation of the form

$$y = a_0 + a^1 x + a x^2$$

where

y = instrument response
x = amount or concentration of the analyte
a_0, a_1, a_2 = parabolic constants

is fitted to the data. The sample concentrations are calculated from the instrument responses by solving the parabolic equation for x. An equation of the form

$$x = \frac{4a_2 \ (y-a_0) + a_1^2 \ ^{1/2} \ - a_1}{2a_2}$$

is obtained. (This equation represents only one root of the parabolic equation, corresponding to the leg of the parabola to which the data are fitted.)

For curvilinear response functions, the curve shape beyond the range of the standards cannot be predicted. For this reason, no sample response greater than that of the highest standard can be used to calculate a concentration. Although a parabolic curve may fit the standards very well over the range measured, the tendency of the parabolic fit is to curve sharply beyond the highest standard, creating the possibility of large error if that region is used for calculation. The parabolic correlation coefficient (r) has the same meaning and criteria as discussed above for linear regression. The r values are often not as high as for linear regression because the response is only approximated by a parabola; the actual form is generally unknown.

1.7.2.7 Tuning and GC/MS Mass Calibration

Prior to initiating any ongoing data collection, it is necessary to establish that a given GC/MS meets the standard mass spectral abundance criteria. This is accomplished through the analysis of decafluorotriphenylphosphine (DFTPP) or p-bromofluorobenzene (BFB). The ion abundance criteria for each calibration compound MUST be met before any samples, blanks, or standards can be analyzed.

Decafluorotriphenylphosphine (DFTPP)

Each GC/MS system used for the analysis of semivolatile or pesticide compounds must be hardware-tuned to meet the abundance criteria for a 50-ng injection of decafluorotriphenylphosphine (DFTPP). DFTPP may be analyzed separately or as part of the calibration standard. The criteria must be demonstrated daily or for each 12-hour period, whichever is more frequent. DFTPP must be injected to meet this criterion. Post-acquisition manipulation of ion abundance is NOT acceptable. Documentation of the calibration is provided in the form of a mass listing (Table 1-9).

p-Bromofluorobenzene (BFB)

Each GC/MS system used for the analysis of volatile compounds must be hardware-tuned to meet the abundance criteria for a maximum of a 50-ng injection of BFB. Alternately, 50 ng of BFB solution is added to 5.0 ml of reagent or standard solution and analyze. This criterion must be demonstrated daily or for each 12-hour period, whichever is more frequent. Post-acquisition manipulation of ion abundance is NOT acceptable. Documentation of the calibration is provided in the form of a mass listing (Table 1-10).

DFTPP and BFB criteria MUST be met before any samples, sample extracts, blanks, or standards are analyzed. Any samples analyzed when tuning criteria have not been met may require reanalysis at no cost to the client.

Definition: The 12-hour period for tuning and calibration criteria begins at the moment of injection of the DFTPP or BFB analysis that the laboratory submits as documentation of compliant tune. The period ends after 12 hours according to the system clock.

1.8 ANALYTICAL PROCEDURES

Analytical methods to be utilized for the sampling tasks are referenced in USEPA documents: Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, Appendix A to Part 136 (40 CFR Part 136), October 1984; Test Methods for Evaluating Solid Waste (Physical/Chemical Methods), SW-846, Third Edition, Revised September 1986; and Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.

Included in Tables 1-1 to 1-5 are detection limits for the analytical methods for the organic and inorganic analyses.

Table 1-6 lists by parameter, method code, method number, and references for the analytical methods to be used in the analysis of samples.

TABLE 1-9 DFTPP KEY IONS AND ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
51	30.0 - 60.0 percent of mass 198
68	less than 2.0 percent of mass 69
70	less than 2.0 percent of mass 69
127	40.0 - 60.0 percent of mass 198
197	less than 1.0 percent of mass 198
198	base peak, 100 percent relative abundance
199	5.0 - 9.0 percent of mass 198
275	10.0 - 30.0 percent of mass 198
365	greater than 1.00 percent of mass 198
441	present but less than mass 443
442	greater than 40.0 percent of mass 198
443	17.0 - 23.0 percent of mass 442

NOTE: Whenever the Laboratory takes corrective action which may change or affect the tuning criteria for DFTPP or BFB (e.g., ion source cleaning or repair, etc.), the tune must be verified irrespective of the 12-hour tuning requirements.

TABLE 1-10 BFB KEY IONS AND ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
50	15.0 - 40.0 percent of the base peak
75	30.0 - 60.0 percent of the base peak
96	5.0 - 9.0 percent of the base peak
173	less than 1.00 percent of the base peak
174	greater than 50.0 percent of the base peak
175	5.0 - 9.0 percent of mass 174
176	greater than 95.0 percent but less than 101.0 percent of mass 174
177	5.0 - 9.0 percent of mass 176

NOTE: Whenever the Laboratory takes corrective action which may change or affect the tuning criteria for DFTPP or BFB (e.g., ion source cleaning or repair, etc.), the tune must be verified irrespective of the 12-hour tuning requirements.

1.9 DATA REDUCTION, VALIDATION, AND REPORTING

1.9.1 Data Flow

The data flow (Figure 1-9) starts with the client contact and follows through from sample collection, shipping, receipt in chemical analysis, data compilation and validation and issuing of report to the client.

1.9.2 Data Collection

For inorganic and general organic analyses, the raw data are instrument responses in the form of meter, recorder, or printer output. The technician performing the analysis enters the bench-generated data in a laboratory workbook specific for each parameter. An example of a photometric data sheet is shown in Figure 1-10. These data consist of instrumental responses (absorbances, percent transmittances, etc.), standard and spike concentrations, sample numbers, and any other pertinent information. The workbooks are under the control of the laboratory manager who is responsible for their security.

For chromatographic organic analyses, the raw data are instrument responses in the form of chromatograms, integrator output, or computer-generated data files. The chromatograms and printer output are stored in project-specific files. The data files are archived on magnetic tape.

1.9.3 Data Reduction

For general "relative" analyses, a calibration or standard curve is used to calculate sample concentrations from the measured instrument responses. The calibration curve is prepared by measuring the instrument responses for a series of standard solutions of the analyte. Regression analysis is used to fit a curve through the standard data (Section 1.7.2). The sample concentrations can then be calculated using the resulting regression equation. The regression analysis also provides parameters which can be used to assess the condition of the analysis. The regression analyses are performed using verified calculator or computer programs.

For gravimetric and titrimetric analyses, the calculations are performed according to equations given in the standard operating procedures for the method. For chromatographic analyses, the unknown concentrations are determined using response factors with either internal or external standardization. Use of the internal standard method requires the determination of response factors (RF), which are calculated from the following:

$$RF = (A_s C_{is})/(A_{is} C_s)$$

where

A_s = area of the characteristic ion of the standard for the target compound
A_{is} = area of the characteristic ion of the internal standard
C_{is} = amount of the internal standard
C_s = amount of the target compound standard

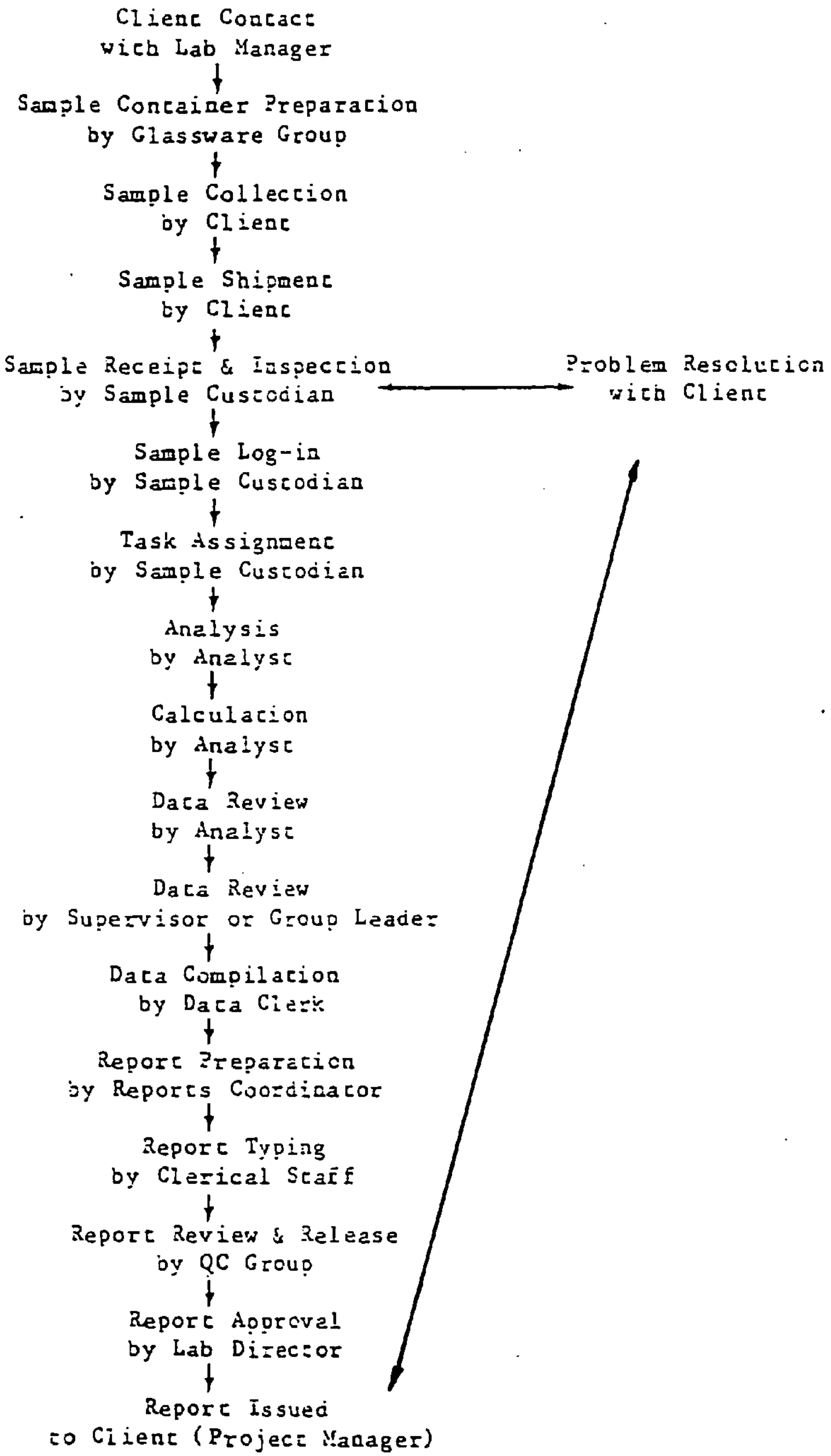
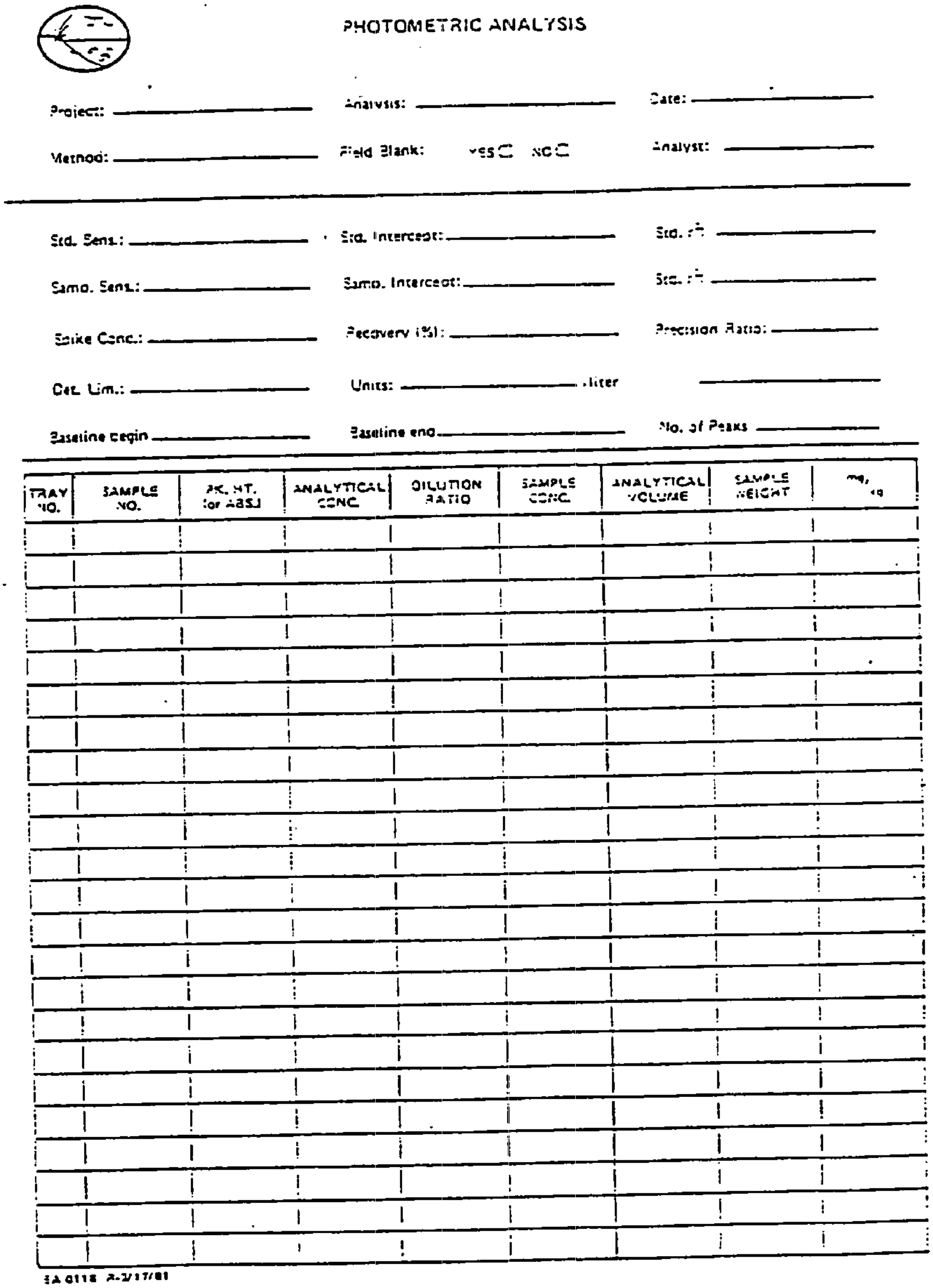


Figure 1-9. Laboratory data flow.



PHOTOMETRIC ANALYSIS

Project: ____________ Analysis: ____________ Date: ____________

Method: ____________ Field Blank: Yes ☐ No ☐ Analyst: ____________

Std. Sens.: ____________ Std. Intercept: ____________ Std. r²: ____________

Samp. Sens.: ____________ Samp. Intercept: ____________ Std. r²: ____________

Spike Conc.: ____________ Recovery (%): ____________ Precision Ratio: ____________

Det. Lim.: ____________ Units: ____________/liter ____________

Baseline begin ____________ Baseline end ____________ No. of Peaks ____________

TRAY NO.	SAMPLE NO.	PK. HT. (or ABS.)	ANALYTICAL CONC.	DILUTION RATIO	SAMPLE CONC.	ANALYTICAL VOLUME	SAMPLE WEIGHT	mg/kg

SA 0118 R-2/17/81

Figure 1-10. Photometric analysis data sheet.

When the compound has been identified, the quantitation of that compound is based on the integrated abundance of the primary ion(s). If the sample produces an interference for the primary ion, a secondary ion is used to quantify. The concentration in the sample is calculated using the response factor (RF).

$$\text{Concentration (ug/L)} = (A_s C_{is})/(A_{is})(RF)$$

where

A_s = area of the characteristic ion for the target compound
A_{is} = area of the characteristic ion for the internal standard
C_{is} = concentration of the internal standard

Quantitation by the external standard technique involves calculation of the concentrations of the target compound from the sample response and the response of a standard solution of the compound.

$$\text{Concentration (ug/L)} = (A_i C_s V_f)/(A_s V_i)$$

where

A_i = peak size of target compound
A_s = peak size of matching standard
V_i = initial volume of sample extracted (ml)
C_s = concentration of standard (ug/L)
V_f = final volume of extracted sample (ml)

The calculations are generally performed by the associated computerized data systems. The data are transferred to summary tables which are given to the laboratory manager.

1.9.4 Reporting

After the calculations are completed, the data are checked by the group supervisor and entered into the Laboratory Information Management System (LIMS) database. When the sample analyses are complete, the data is returned by the reports group and forwarded to the project manager.

1.9.5 Data Validation

Validation of the laboratory data is the prime responsibility of the laboratory QA officer and laboratory supervisors who address the following areas:

- Proper chain-of-custody and sample handling procedures followed
- Parametric holding times met
- Samples prepared and analyzed according to specified methods
- Instrumentation calibrated according to specified methods

- Spike (surrogate or standard) recoveries within specified ranges
- Blanks prepared and analyzed as required
- Calculations performed correctly and verified
- Transcription of raw and final data correct
- Detection limits determined correctly and within required limits

Any problems discovered during the review and correction actions necessary to resolve potential problems will be communicated to the project manager, who will discuss their contents for final data approval with the project director.

1.10 INTERNAL QUALITY CONTROL CHECKS FOR FIELD AND LABORATORY OPERATION

1.10.1 Field Operations

To assess the samples decontamination procedures and the affects of the sample handling process, trip (or travel), ambient and equipment blanks along with duplicate and replicate samples are taken to measure the control within the sample collection system. Blank samples include the following.

Trip Blank

The purpose of a trip blank is to place control on the sample handling, transport, and storage and indicate any contamination that may have occurred in transit or in the laboratory.

The trip blank consists of a set of sample containers filled with laboratory demonstrated analyte-free water which is analyzed in the same manner as the samples acquired that day. The sample containers themselves are not opened in the field. Rather, they just travel with the sample collector.

One (1) trip blank will accompany every batch of Volatile Organic Compound (VOC) samples (both soils and water) sent to the laboratory.

Ambient Blank

The purpose of an ambient conditions blank is to note the ambient sampling atmosphere at the site.

The ambient blank consists of analyte-free water being poured into a sample container at the site, then is handled like a sample and sent to the laboratory.

One (1) ambient conditions blank will accompany every VOC sampling round (water).

Equipment Blanks

The purpose of equipment blanks is to provide a check on the integrity of equipment decontamination procedures. At the site location, analyte-free water will be passed through clean (decontaminated) sampling equipment, transferred to the sample bottle and sent to the laboratory.

One (1) set of equipment blanks will be collected for every day of groundwater sampling (all parameters analyzed).

Duplicate

Field duplicates are two samples collected independently at a sampling location during a single act of sampling.

Ten (10) percent field duplicates (all parameters analyzed) for water samples. The field duplicates will be disguised so that laboratory personnel performing the analyses will not be able to determine which samples are duplicates.

Replicates

Replicate is a single sample (e.g., one bailer volume, one grab sample) collected, then divided into two equal parts for the purpose of analysis. Replicate samples are often called "Splits." Ten (10) percent field replicates (all parameters analyzed) for soil/sediment samples. Field replicates will be disguised so that laboratory personnel performing the analyses will not be able to determine which samples are replicates.

1.10.2 Laboratory Operations

Quality control documentation will be prepared in accordance with the Analytical Chemistry QC requirements for each analysis method. Control samples will be introduced into every batch of samples, as required by the specific method, to monitor the performance of the analytical system. Requirements beyond these are made through the operations manager and/or QA officer. The laboratory control samples are prepared by EA Laboratories and are used in the same manner as the USEPA control samples.

QC Documentation

QC Data are maintained for the following parameters:

Inorganics (Metals and Cyanide)

- Initial and continuing calibration verification
- Blanks
- Spike sample recovery
- Duplicates
- Instrument detection limits and laboratory control sample
- Standard addition results

Organics (Volatiles, Base/Neutrals, and PCBs)

- Water surrogate percent recovery summary
- Soil surrogate percent recovery summary
- Water matrix spike/matrix spike duplicate recovery
- Soil matrix spike/matrix spike duplicate recovery
- Method blank summary
- GC/MS tuning and mass calibration (BFB)
- GC/MS tuning and mass calibration (DFTPP)
- Initial calibration data - volatile compounds
- Initial calibration data - semivolatile compounds
- Continuing calibration check - volatile compounds
- Continuing calibration check - semivolatile compounds
- PCB standards summary
- PCB identification

QC Requirements

The following are the minimum quality control analyses that are to incorporated in the EA QA Program:

	Metals, Technicon, Phenols, Cyanide, Hex Chrome	Frequency
a)	Five-point calibration curve.	daily/batch
b)	Blank (calibration)	daily/batch
c)	Check (verification) standard, except hex chrome	daily/batch
d)	Method blank (taken through preparation procedure)	daily/batch
e)	Matrix spike and matrix spike duplicate	1/20 for each matrix
f)	Laboratory control sample in duplicate (except phenols, cyanide-2/mo, hex chrome)	daily/batch
g)	Analytical spike (after preparation step)	as needed
h)	Analytical duplicate (replicated after preparation step)	as needed

NOTE: For Hg, laboratory control sample and check sample are the same.

Oil and Grease

a)	IR calibration	daily/batch
b)	Laboratory control sample in duplicate	daily/batch

Solids

a)	Replication	1/20 batch

TOC

a)	Matrix spike, matrix spike duplicate	daily batch
b)	Five-point calibration	daily/batch
c)	Laboratory control sample in duplicate	daily/batch

Chlorophyll

a) Calibration curve	each batch

pH

a) Two-point calibration	daily/batch
b) Laboratory control sample	daily/batch

BOD

a) Three dilutions	batch
b) Seed blank	batch
c) Laboratory control sample of standard mix	batch

Surfactants

a) Calibration curve	batch
b) Blank	batch

GC/MS

a) Method blanks in duplicate (with surrogates)	VOA-daily BNA-batch
b) Matrix spike in duplicate (selected analytes)	1/20 for each matrix
c) Reference calibration check (all analytes) (all CCC analytes ±40%; SPCC response factors for BNAs 0.05; SPCC response factors for VOAs 0.3)	daily
d) Five-point calibration curve	as needed
e) Standard tuning compound (VOA, BNA)	daily

GC, HPLC

a) Method blank (with surrogate)	daily/batch
b) MS, MSD selected analytes	1/20 to each matrix
c) Reference calibration check	daily/batch
d) Three-point calibration (all single component analytes)	as needed
e) One-point calibration (multicomponent analytes)	as needed
f) Samples using single-point calibration must be diluted to between -50 and +100% of the calibration point	

Extractions

a) Method blank (with surrogate) in duplicate	batch
b) Matrix spikes in duplicate	batch
c) Laboratory control sample in duplicate (all analytes)	2/mo.

QC Glossary

In many cases, there will be additional QC measures required depending on the individual project. It is important that these additional requirements or procedures be followed as well. Enclosed is a short glossary of terms so that we have a common understanding of terminology.

Calibration Standard: A material of known concentration or composition used to establish analyte-response relationship. It is usually not processed through the whole analytical scheme.

Calibration Blank: A material or mixture of materials used to dilute the calibration standard. Its function is to ensure the absence of any analyte except for the calibration standard material. It is also called an analytical blank.

Method Blank: A sample composed of all elements of the analytical procedures except analyte containing material. Its purpose is to demonstrate the absence of any interference with the analytical scheme; frequently called reagent blank or just blank.

Replicate: A pair of subsamples from the same original sample taken through the whole analytical scheme. It is used to evaluate the precision of the method.

Matrix Spike: A subsample of the original material that has a known amount of a standard added to it. It is used to evaluate recovery (accuracy) and to demonstrate freedom from interferences. It is also called sample matrix spike or just spike.

Laboratory Control Sample: A sample of standard material with a matrix similar to the samples taken through the whole analytical scheme. It is used to demonstrate that the method is in control.

Analytical Spike: A spike of an already prepared sample with a standard. It is used to verify instrument response.

Batch: A group of samples prepared together, or analyzed together, in a contiguous sequence; typically, a day's work.

QC Acceptance Criteria

Method Blank - Acceptable if:

1. Any analyte detected is less than 1/10 the concentration of the same analyte in any sample to which the blank is applicable. This implies that any analyte having a concentration of less than ten times the detection limit will show no background.

2. In the case of selected organic analytes, the blank must be less than 5 times the method detection limit (phthalates, methylene chloride, acetone, toluene, methanol, carbon disulfide).

Matrix Spike and Duplicate - Acceptable if:

1. For volatile components the Relative Percent Difference is less than 20%, or for semivolatile components and Pesticides the r.p.d. is less than or equal to those in USEPA SOW February 1987.

NOTE: Native samples containing the spiking materials are evaluated on an individual basis.

Precision and Recovery - Acceptable if:

1. For GC and GCMS systems, the Surrogate recoveries are within the USEPA guidelines (USEPA SOW February 1987).

2. For all other methods the laboratory control sample and its duplicate are within the control limit.

3. The laboratory control sample or its duplicate is inside the warning limit and the other is outside the control limit the system is in marginal control.

4. The laboratory control sample or its duplicate is outside the control limit while the other is outside either the warning or control limit the method is out of control.

Holding Time - Acceptable if:

1. A sample is reextracted after analysis and past the holding time, provided the original extraction was accomplished within the required holding time.

External Standards Accuracy Tests

The Analytical Services Laboratory receives standard reference materials from three sources.

- ERA, a commerical reference standards source
- USEPA
- National Bureau of Standards

The matrices available include sediment, water, soil, urban dust, and animal and plant tissue.

1.11 PERFORMANCE AND SYSTEM AUDITS

The Analytical Chemistry Laboratory will participate in the analysis of performance samples provided by external sources. Internal performance audits or quality reviews are performed on a regularly scheduled basis over the calendar year to determine the accuracy of the measurement system. These auditing activities are reported to the Laboratory Director.

System audits will be conducted during the sample acquisition-and-analysis phase. The internal audits will be conducted in accordance with procedures specified in EA's QA Program by the QA director and/or the Analytical Chemistry QA Officer with the assistance and involvement of responsible laboratory and project personnel designated in Figure 1-3. These audits are meant to augment and enhance project technical quality that is routinely subject to quality control procedures managed by these individuals.

Internal systems audits will be conducted using a standard auditing procedure that includes the following attributes. An audit checklist will be developed to identify documentation of the sample collection, handling, analysis, testing, and management of the resulting data. Questions developed will be designed to establish the degree to which prescribed quality control procedures are being implemented. The lists will be covered with the laboratory director, and project manager who will supply representative evidence that procedures are being followed as stated. The responses to each checklist item covered during the audit will be noted as satisfactory, unsatisfactory, or not applicable with explanations of the notation made as applicable.

EA participates in the USEPA Water Pollution Laboratory Performance Evaluation Program. Samples are acquired and results reported semiannually.

1.12 PREVENTIVE MAINTENANCE

All instruments and equipment will be maintained under service agreements with the manufacturers and will be serviced and maintained only by qualified personnel. All repairs, adjustments, and calibrations will be documented in an appropriate logbook or data sheet that will be kept on file. EA maintains a sufficient number of spare parts for all instruments, and in many cases, double instrumentation to minimize downtime of instruments and delays in analyses.

All equipment used by EA in the field is subject to standard preventive maintenance schedules established by corporate equipment protocols. All equipment is inspected at least twice daily, once before start-up in the morning and again at the end of the work shift prior to overnight storage or return to the charging rack. Regular maintenance such as cleaning lenses, replacement of in-line filters, and removal of accumulated dust is to be conducted according to manufacturer's recommendations and in-field need, which ever is appropriate. All preventive maintenance performed will be entered in the individual equipment's logbook and the site safety logbook.

In addition to preventive maintenance procedures, daily calibration checks will be performed at least once a day in the morning prior to use and duly recorded in the respective logbooks. Additional calibration checks will be performed as required.

The field equipment to be used at AFP 59 is subject to EA's standard preventive maintenance schedule includes the following:

- Photoionization and/or flame ionization detectors
- pH and conductivity meters

- All personal protection equipment
- Drilling equipment

1.12.1 Laboratory Instrumentation

This section addresses the procedures for laboratory instrument maintenance and service contracts for test and measurement systems.

Chromatographic Instruments

The Hewlett Packard GC/MS/DS is maintained on a service contract which provides for four preventive maintenance visits per year. The services provided on these visits include: changing the oil and filter/drier on the mechanical pumps; cleaning the heads on the magnetic tape drive; cleaning and aligning the heads on the disk drive; changing air filters and checking the operation on the disk drive. The oil in the turbopumps is changed once a year. In-house maintenance includes cleaning the source and the quaropoles as required. The following spare parts are routinely kept on hand: filaments, elecron multiplier, source parts, repeller assembly, O-ring seals, and pump oils. The maintenance contract assures the malfunctions are addressed in a priority manner, thereby minimizing instrument downtime and providing greater assurance that sample turnaround requirements are met.

The Finnigan GC/MS is maintained on an in-house service schedule. This service includes: changing mechanical pump oil every three months; changing turbopump oil every six months; changing air filters every three months; cleaning the heads of the nine-track magnetic tape drive and the streamer tape drive every six months; checking the cooling fans on the turbopump, printer, chromatograph, electronics module and computer monthly; cleaning the printer head every six months; cleaning the source levery month or as required; cleaning the quadropoles every six months or as required. The following spare parts are routinely kept on hand: a spare EI Source, filaments, miscellaneous source parts, pump oils, and air filters.

Gas chromatograph maintenance is performed as follows:

Area or Assembly	Type of Maintenance	Interval
Moisture Trap	Conditioning	2 months, or when gas source is changed
Moisture Trap	Repacking	Every 10 conditionings
Carrier Gas	Leak Check	As required
Injection Port	Cleaning	As required
Septum	Replacement	As required
Electron Capture Detector (ECD)	Frequency Check	1 day
ECD	Carrier Gas Evaluation	When carrier gas is changed
ECD	Leak Check	When column is changed
ECD	Thermal Clean	1 month or as required
ECD	NRC Wipe Test	6 months

Spare parts for the gas chromatographs include: ferrules, septa, injection port liners, syringes and needles, and column packing materials.

Analytical Balances

Virtually every analytical procedure requires the use of side-loader and/or top-loader balances. Many of these requirements involve standards preparation and are therefore crucial to accurate determination. The Mettler side-loading analytical balances are maintained on a service contract. This contract includes annual servicing and calibration by a Mettler engineer. A calibration status label is affixed to each balance after calibration.

Temperature Control Systems

Accuracy and stability of temperature control are usually specified by individual analytical SOPs. This section will deal only with general practices and precautions which, if ignored, could result in partial or complete re-analysis or incorrect data.

As with all other temperature control devices, adequate warm-up and stabilization time must be allowed. This time requirement will vary with the system. Manufacturers' instructions may be of help; otherwise, start the warm-up as early as possible and check the temperature frequently for stability.

Any time a temperature control device requires calibration, temperatures throughout the chamber or bath must be checked and compared to nominal temperatures. The need for calibration is to be derived from review of temperature grid data in the respective equipment notebook. Grid data should be checked for obvious drifts, especially drifts resulting in nominal temperature isolines approaching the center of walls of the chamber (or both if applicable).

Available ovens are of two types--convective circulation and mechanical circulation. Mechanical circulation ovens must not be used for drying easily blown or easily contaminated samples. Such samples should be dried in convective circulation ovens.

The most stable and accurate temperature control requirements encountered in the analytical laboratory involve incubators and water baths used for biochemical oxygen demand. Calibration checks must therefore be performed using an NBS calibrated or traceable thermometer.

Thermometers in incubators must be "mounted" in a stoppered water bottle such that conditions in samples are reproduced and temperature checks may be made without rapid changes due to short-term influx of room air. The water serves as an insulator and also mimics the sample.

Water bath temperatures must be checked with each analytical run for temperature accuracy and recorded. This is true of fixed or variable control baths. Both types are available in the laboratory. BOD incubators and sample storage refrigerators and freezers must be checked daily and the results of the checks recorded.

Temperature control systems must be calibrated on a regular basis. Ovens must be checked daily when in use and the temperature recorded on the sheet on the oven door. Water baths also must be checked daily when in use and the temperatures recorded. Refrigerators and freezers used for sample storage must be checked daily and the temperatures recorded.

General Use Spectrophotometers

Three types of spectrophotometers are available. The Beckman model 24/25 and Acta recording spectrophotometers serve general functions, such as direct analysis, standard checks, spectral traces for interference identification, photosynthetic and accessory pigment purity determinations, and fluorometer calibrations and cross-checks; control of functional quality of this instrument is therefore important to general laboratory operation. The smaller "portable" grating-type spectrophotometer (a Bausch and Lomb Spectronic 20) is used in analyses where extreme versatility and sensitivity are not required but where, for fume control, it is necessary that all operations be performed in a hood (e.g., analyses involving pyridines). This instrument requires little space while performing adequately when proper analytical QC procedures are followed.

Special Notes

1. The analyst should bear in mind that proper and complete analytical quality control (in the form of blanks, standards, spikes, and replicates) will cancel out small errors in wavelength settings, high absorbance scaling, and high absorbance nonlinearity, provided samples, standards, blanks, and spiked samples are treated exactly alike.

2. Functional accuracies in small spectrophotometers are determined in the same manner as for the Beckman 24/25 except that peak wavelengths and absorbances are not determined by recorder traces but by manual recordings of output.

3. Wavelength settings should always be approached from the "high" end.

4. Handle cuvettes and cells for any type of spectrometric analysis carefully, clean according to manufacturers' instructions, and keep in original storage containers when not in use. Cleaning procedures should be adjusted to the analysis to be performed.

5. It should not be assumed that the wavelength indicator setting is correct; rather, adjusting the wavelength dial to maximum absorbance readings near the wavelength of interest, using a high standard, is much preferred.

Atomic Absorption Spectrophotometer

General Considerations

For every analytical setup, the following precautions must be considered.

1. Perform lamp alignment with great care, as it is possible to achieve a false optimization (peak lamp energy) with totally erroneous alignment.

2. It is always preferable to use single-element lamps rather than multi-element lamps due to the potential for signal drift, noisy baselines, short lamp lifespan (multi-element), and reduced overall sensitivity.

3. Where possible and whenever detection limits may be at issue, use electrodeless discharge lamps (EDLs) because of their generally lower noise/signal ratios relative to hollow cathode lamps (HCLs).

4. Detection limits are also much lower, generally speaking, for analyses using the graphite furnace as compared to flame aspiration analyses. Any method using an open flame (even inductively coupled arc plasma) will have a baseline noise component due to the relative instability of the flame (compared to the partially closed conditions in a graphite tube).

5. Follow the manufacturer's recommendations for lamp currents (HCLs) and wattages (EDLs) as closely as possible, with close attention paid to cautionary notes.

6. Whenever a new lamp is received, record the date of receipt on the lamp level.

7. Inspect lamps closely, before installation, for possible damage between uses.

8. Excessive "silvering" of lamps (HCLs) may occasionally serve as an indicator of shortening lifespans, although this is by no means a definitive guideline. Increased baseline noise, reduced sensitivity, large changes in background corrector (BC) balance settings, or the inability to achieve BC balance are definite indicators of lamp deterioration.

9. As a rule, if high metal concentrations are anticipated or known to exist in certain samples, the better choice will be flame aspiration due to the reduced sensitivity and concurrent smaller dilution ratios necessary. The large dilution ratios frequently encountered when determining sodium, potassium, magnesium, calcium, and zinc will result in reduced precision and accuracy unless extreme care is taken in the dilution process.

10. The Perkin-Elmer Spectrophotometers are double-beam instruments and therefore is not greatly subject to lamp and electronic warm-up problems, but it is still advisable to allow a few minutes warm-up. This is not lost time because alignment and instrument settings for the analysis to be performed must still be made after the instrument is powered up.

11. Never assume that the wavelength dial indication is correct; peak lamp output (energy) must be determined at every setup. This precaution eliminates errors due to minor misadjustments in dial/wavelength alignments. The program reference card file is to be consulted for the proper wavelength setting and that wavelength <u>double-checked</u> before analysis begins.

12. Exercise care in the alignment of burners and furnaces; a small misalignment can seriously reduce overall system energy and analytical sensitivity.

13. Perform alignment of the AS-1 automatic injection system for the HGA-2100A graphite furnace with extreme care, as inconsistent placement of the sample aliquot in the tube, due to the injection tube brushing the graphite tube opening, can result in major reductions in precision. The tube can also be damaged by heat or abrasion, resulting in sudden, unnoticed shifts in response due to redirected injection.

14. If there is any aspect of instrument operation with which the analyst is unfamiliar, this should be remedied by consulting the instruction manual, the laboratory director, or, in possible cases of malfunction, the manufacturer's maintenance representative.

Technicon Autoanalyzers

Because Technicons are composite systems, quality control procedures appropriate to individual components, as well as the total system, are necessary.

1. Colorimeter electronics and optics. The major area of internal colorimeter adjustment is in optical alignment. This also, by virtue of influences on the two photocells, is the major internal electronic adjustment. The procedures for these adjustments are available in instruction manuals. The following adjustments are checked monthly and the results logged into appropriate notebooks.

    a. When flow cells must be replaced

    b. When light sources must be replaced

    c. When colorimeters must be transported or exchanged

    d. When repairs involving partial or complete dismantling of colorimeter optical "bench" are necessary

2. Before every analysis, the analyst should double check that the proper optical filters are used.

3. The analyst must clear the flow cell of small air bubbles. This is done by pinching the outlet tube for 5 seconds and quickly releasing it.

4. The following recorder-related checks are performed before and after each day's analyses

    a. Colorimeter zero

    b. Colorimeter full scale

    c. Recorder zero

5. The filters can be "traced" on the Beckman 24/25 spectrophotometer and the traces compared to the nominal wavelengths.

6. Properly place reference photocell covers to eliminate stray light input.

7. Check flow cells for cleanliness or defects.

8. Leave the colorimeter on continuously, especially during regular use periods, as temperature stability within the upper housing will control photocell stability.

9. Check pump tubes at least weekly for pinch-wear, scuffing, reduced resiliency, imminent perforation, or other damage and replaced as needed.

10. Leave heating baths on continuously and maintain at temperature unless extended downtime is expected. Allow a minimum of 24 hours to reach a stable temperature.

11. The analyst double checks the presence of the proper cam in the autosampler.

12. The analyst should be familiar with the recorder trace form and peak shapes pertinent to the analysis to be performed; often, a change in peak shape can serve as an indicator of a change in system performance.

Hydrogen Ion (pH) Meters

The most common cause of problems with pH meters is a faulty electrode, especially the reference electrode. To prevent "death" or malfunction of an electrode, the following practices should be adhered to.

1. Immerse the electrode continually in pH 7.00 buffer when not in use.

2. Inspect the reference electrode wick or junction and clean of debris, if necessary, (with extreme caution not to injure the glass electrode membrane) before each day's use.

3. Check electrode resistance.

4. Never leave the electrode in very alkaline solutions and thoroughly rinse with a squirt bottle immediately after each use to prevent poisoning of the glass membrane.

5. Keep the reference electrode full of the appropriate KCl solution.

6. When the sensitivity of an electrode begins to decrease, it can often be revived by immersion in a hot 1-M trisodium phosphate solution for 5-10 minutes. If the sensitivity of the electrode is still low, a 1-2 minute immersion in 0.1 M ammonia bifluoride followed by rinsing and soaking in distilled water for 3-4 hours should restore electrode sensitivity; if not, the electrode must be replaced.

7. The sensitivity of the electrode can be readily assessed by immersion in serial 10:1 dilutions of pH 10.00 buffer and comparing the drift from a reading of 10 to that previously recorded (significant drift before 10^5:1 suggests the need for electrode replacement).

8. Spare electrodes should always be on hand.

Rapid checks can be made to identify or isolate a potential problem.

1. With shorting strap inserted and meter in pH mode, turn calibration knob from one extreme to the other and determine if equal deflection from 7.0 results in both directions.

2. With calibration set to yield a 7.0 reading, turning the temperature compensation knob should produce no needle movement.

3. With calibration set to yield any value 4-5 units away from 7.0, turning the temperature compensation knob should produce a pronounced deflection.

Additional general use notes should be kept in mind when making pH measurements.

1. Always be certain the solution to be measured is aqueous.

2. Always measure pH with sample stirring, but be sure to isolate the sample from heat sources such as hot plates and overheating stirrer motors. A thin asbestos pad is a good idea.

3. The filling hole <u>must</u> be open when making measurements.

4. A 2-point calibration is always best (e.g., pH 7.0 and pH 4.0).

5. Most commonly used electrodes exhibit a "sodium error" at pH values above 10.0. Generally, electrode manufacturers include correction information with electrodes. This correction must be made for very alkaline samples.

Conductivity Meters

The most commonly used meter in this laboratory is a null balance type. As with the pH meters, the electronic systems must be checked in the absence of the probe to isolate potential problems.

Perform cell constant checks (1) any time a new cell is attached, (2) after prolonged inactivity, (3) weekly during regular use, and (4) any time irregular or inconsistent results of standard or sample measurements are observed.

Dissolved Oxygen (DO) Meters

Before each use, visually check the DO probe for membrane damage, bubbles, looseness, wrinkles, excessive anode blackening, or physical damage (especially to the cathode). The analyst should also verify that the circulator functions properly.

The major quality control check for DO meters must always be the ease and accuracy of calibration since isolation of the probe from the electronics package is difficult. Accordingly, if problems appear, and if normal troubleshooting procedures (as given in the instrument manual) are not helpful, then the instrument should be set aside for return to the manufacturer (for repair) and another machine used.

The quickest and most reliable check of general calibration range and accuracy is to keep the probe stored in a BOD bottle half-filled with water such that by simply turning the machine on, one can check the temperature and compare the observed DO reading to expected (tabular) values. Perform this general check before each use; this also allows adequate probe polarization before beginning calibration.

Turbidimeter

The primary concern during general use of the instrument is prevention of particulate contamination of samples. A single piece of lint can produce widely varying results. Therefore, cleanliness of the work area is of paramount importance in this type of analysis.

The newly developed AMCO standards are not used in calibrating this instrument. These standards have excellent stability but must be refrigerated after opening.

Exercise extreme caution in cleaning the turbidimeter cells. No abrasive TReatment or rough handling is allowed.

Instrument stability can be assessed by comparing readings between ranges over time. Standards near the end of ranges will be readable on two ranges. The degree of comparability between readings, as compared to previous readings will serve as the stability index. When range differences can no longer be corrected, the machine should be attended to by a manufacturer's representative.

Dispensing Devices

Several very accurate and practical small volume dispensing devices are available commercially and some of these are available in the laboratory. These are useful in improving analytical efficiency, accuracy, and precision, especially during standards preparation and sample spiking. Before using any such device, the manufacturer's claims, instructions, and recommendations must be taken into consideration.

Adjustable Volume Pipetters

Several of these devices are available in the laboratory with ranges varying from (ostensibly) zero to 5 ml, 50 ul, and 200 ul, and from 5 ml to 10 ml.

The most important precautions to be observed in using these devices are

1. Do not use any pipetter outside the range established as within ±1 percent of the nominal value.
2. Do not use any pipetter outside the range established as most precise (±2 standard deviations shall not exceed the ±1 percent boundaries established above at any point in the full pipetting range).
3. In general terms, the above limitations will prohibit use of adjustable pipetters near range extremes (outside the 10-90 percent of full volume range).
4. Be sure not to draw samples or reagent into tips so rapidly that metal parts are wetted.
5. Verify volume delivery settings before using adjustable pipetters, especially if using these to dispense standard volumes for serial dilution.

Interchangeable-Stop Pipetters

These devices have distinct advantages over continually adjustable devices in that settings are fixed by threaded sleeves. Analytical set-up time savings are thus possible.

Miscellaneous Dispensing Devices

Assorted fixed column pipetters are also available in the laboratory. These devices are checked quarterly for delivery, accuracy, and precision. Large- volume dispensers are also available for appropriate needs. Exercise care to clean these dispensers properly when going from one reagent solution to another or when replacing outdated reagent solutions. Refer to manufacturers' instructions for cleaning suggestions. These should be adjusted to match analytical requirements.

1.13 ASSESSMENT OF DATA ACCURACY AND PRECISION

1.13.1 Application of Controls

The statistical tests necessary to verify proper analytical function are performed as soon as practicable after the measurements on which they are based are available. The results of the tests are compared with the control limits to determine if the data can be used. If the limits are exceeded, the analyst's supervisor is notified and a decision is made concerning the appropriate action to be taken. If the problem cannot be corrected, the laboratory manager or chief chemist is consulted.

1.13.2 Control Charts for Precision and Accuracy

The daily accuracy and precision data are plotted on control charts to determine if bias is developing or if the precision is less than expected. The vertical axis of the control charts is the value of the parameter being plotted, and the horizontal axis is the date of the determination. A control chart is characterized by a central line, warning limits, and control limits. The central line is the mean, theoretical, or most probable value for the parameter measured. The limits are values on either side of the central line with which are associated probabilities that measured values will exceed the value of the limits. The warning limits are the 2 or 95 percent limits; i.e., if the analysis is operating correctly and only random scatter is observed, only one point in 20 should fall outside the warning limits. The control limits are the 3 or 99 percent limits; only one point in a hundred should fall outside these limits by chance alone.

Accuracy QC Charts

The accuracy QC charts (Figure 1-11) are based on an adaptation of the classic Shewhart X charts (USEPA 1979). The parameter plotted on the charts is the percent recovery, calculated as

$$\%\ \text{recovery} = 100 \times \frac{\text{found value}}{\text{true value}}$$

The central line is a mean percent recovery (%R) calculated from 20 to 30 values of the percent recovery. In addition, the standard deviation (S_R) associated with the percent recovery data is also determined. The limits for the control chart are calculated as follows

Upper Control Limit (UCL) = $\%R + 3S_R$
Lower Control Limit (LCL) = $\%R - 3S_R$
Upper Warming Limit (UWL) = $\%R + 2S_R$
Lower Warning Limit (LWL) = $\%R - 2S_R$

QC Chart

Analyte ______________________ Method ______________________ True Value ______________________ Material (Lot No.) ______________________.

% Recovery = $\frac{X}{T.V.} \times 100$

Precision (as RPD) RPD = $200\,\frac{|X_1 - X_2|}{(X_1 + X_2)}$

			LCL −3SD	LWL −2SD	−1SD	Mean	+1SD	UWL +2SD	UCL +3SD		Mean	WL 2.18 x Mean	CL 3.27 x Mean	
Date	Initial													

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Figure 1-11, QC chart.

The values for %R, UCL, LCL, UWL, and LWL for each analysis are recorded at the top of the chart.

As the analyst calculates each percent recovery from an analytical run, the value is entered onto the chart in the column corresponding to where the value falls with respect to the mean in units of standard deviations.

Precision QC Chart

The precision control charts are based on the relative percent difference (RPD) of duplicate measurements. The central line of the chart is based on the mean RPD calculated from 20 to 30 duplicate measurements. The limits for the charts are constants calculated using formulae given by ASTM (1951). The constant for the m limit is given by (1+mk), where $k = 1-C_4^2$ $/_4C_4$. The constant C is a function of the number of replicates and is based on the statistics of estimating the standard deviation of a population having a normal distribution. Values for C_4 are tabulated in Duncan (1974). For the upper control limit, the 3 value of 3.27 is used. This constant in control chart terminology is referred to as B_4; values for B_4 as a function of the number of replicates are tabulated in the USGS manual (Friedman and Erdmann 1982), as well as in ASTM (1951) and Duncan (1974). The upper warning limits are taken from the 2 value of 2.18.

For duplicate measurements, the lower control and warning limits are zero.

Out-of-Control Situations

As the analysts plot points on the control charts, they make decisions about whether a plotted value is in or out of control. The following conditions are used with the control charts to indicate that an out-of-control situation has possibly occurred

1. Any point outside the control limits

2. Any two consecutive points between the warning and control limits

3. Seven successive points on the same side of the central line

When an analyst observes that an out-of-control situation has occurred, the analyst's supervisor is notified, and the appropriate corrective action procedures are initiated. No further analyses are performed until the situation is remedied. If the problem cannot be identified or corrected, the laboratory manager or QA officer is notified.

1.13.3 Quality Assurance

Four general areas of QA documentation are addressed

- In-house documentation
- In-house data checks
- Interlaboratory comparison
- Existing database comparisons

Database comparisons indicate general representativeness of the data.

In-house documentation includes all aspects of the analytical process from reagent preparation to statistical summaries and control charts. The bulk of this section deals with these procedures and subsequent in-house data checks.

Reagent and Titrant Preparation

The SOP for each analysis includes the procedures for reagent/titrant preparation, including concentration, storage, and discard information. After a reagent/titrant is prepared, information regarding (1) its intended use, (2) concentration, (3) preparation date, (4) storage, (5) discard date, and (6) preparer is entered on a label affixed to the storage bottle. For titrimetric analyses, the SOP includes directions for standardizing the titrant, and the laboratory data sheets include space for titrant standardization data.

Standards Preparation

Figure 1-12 shows the Standard Preparation Sheet that is filled out whenever intermediate and working standards are prepared from a stock standard solution. The preparation of the stock standard solution is recorded on the Stock Standard Preparation Sheet shown in Figure 1-13. This sheet is also used for the preparation of standard solutions against which titrants are standardized (e.g., potassium bi-iodate for sodium thiosulfate standardization). These forms must be completed by the appropriate analyst. The finished form is given to the laboratory manager with all other associated analytical documentation.

Data Workup

The parameter book for each analysis includes data sheets providing data workup and calculation space. Appropriate calculations are to be completed at the end of the analysis with as little delay between analysis and calculation as possible. Several programmable calculators are available in the laboratory and the atomic absorption spectrometry room. Magnetic card programs also perform most of the necessary calculations. Calculation of gas chromatography and GC/MS data presents a special case. Much of the calculation process is performed by associated data systems. Data are derived from the printed reports accompanying individual GC traces. Due to the bulk of printouts, GC data are transferred to summary sheets which are then entered into project files.

General data workup sheets and GC and GC/MS summary tables are placed in the laboratory supervisor IN box to be entered into the appropriate project file. All calculator and recorder printouts and traces are also placed in the laboratory supervisor IN box and entered into the appropriate project file.

Standard Preparation

Project: ____________________ Analysis: ____________________

Analysis Date: ____________________ Analyst(s): ____________________

Collection Date: ____________________

1. Stock solution concentration (mg/ℓ) ____________________

2. Substandard solution V_{STOCK} (mℓ) ____________________

Final Volume (mℓ) ____________________

Concentration (mg/ℓ) ____________________

3. Working standards

#	V_{SUBSTD} (mℓ)	Final Volume (mℓ)	(mg/ℓ)
B			
1			
2			
3			
4			
Spike			

4. Remarks: ____________________

____

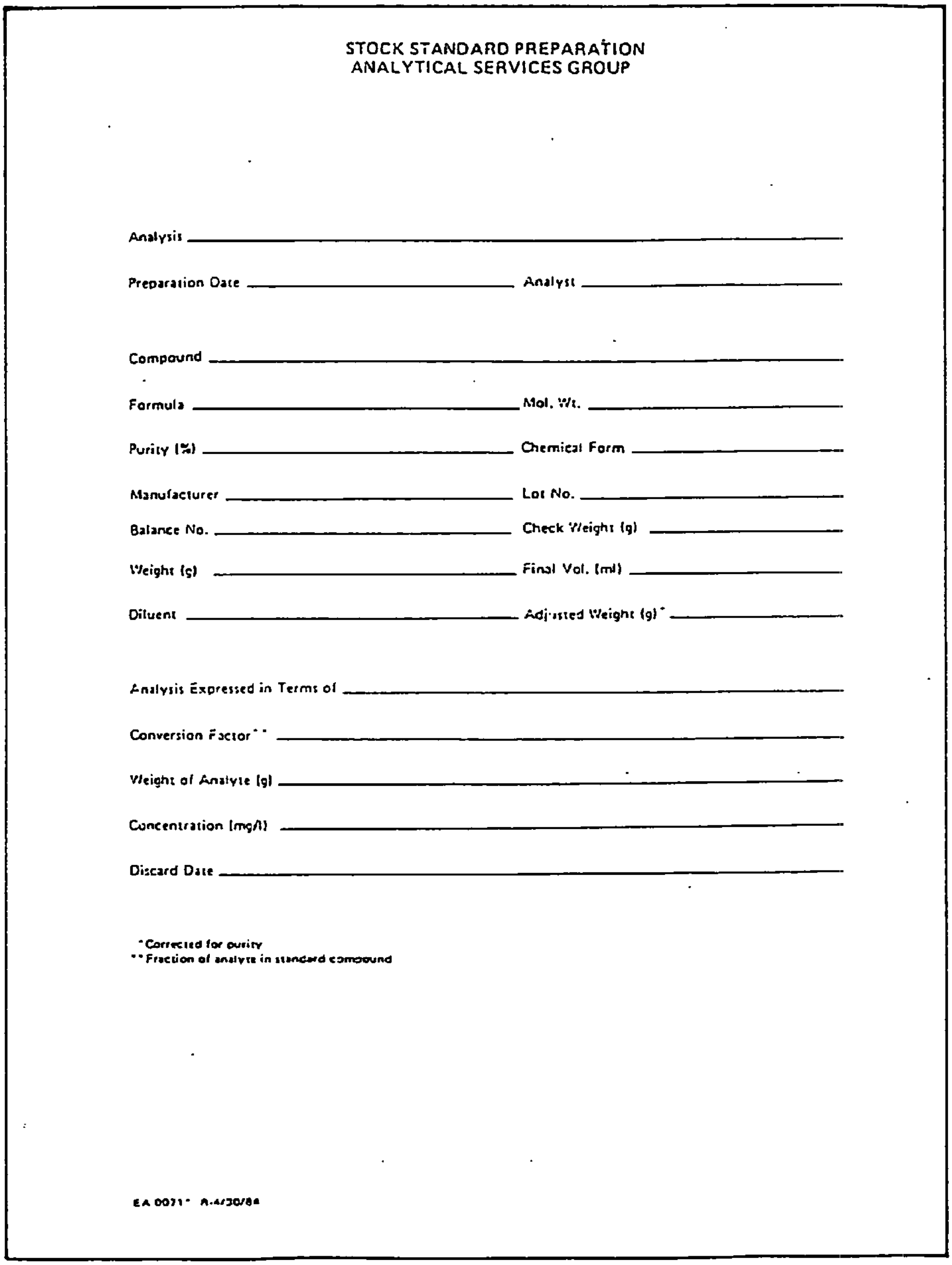
____

____

____

Analyst: ____________________

Figure 1-12. Standard preparation form.



STOCK STANDARD PREPARATION
ANALYTICAL SERVICES GROUP

Analysis ______________________________

Preparation Date ______________ Analyst ______________

Compound ______________________________

Formula ______________ Mol. Wt. ______________

Purity (%) ______________ Chemical Form ______________

Manufacturer ______________ Lot No. ______________

Balance No. ______________ Check Weight (g) ______________

Weight (g) ______________ Final Vol. (ml) ______________

Diluent ______________ Adjusted Weight (g)* ______________

Analysis Expressed in Terms of ______________________________

Conversion Factor** ______________________________

Weight of Analyte (g) ______________________________

Concentration (mg/l) ______________________________

Discard Date ______________________________

*Corrected for purity
**Fraction of analyte in standard compound

EA 0071* R-4/30/84

Figure 1-13. Stock standard preparation form.

Outlier Identification

There are no absolute guarantees against nonrepresentative data points. Therefore, all personnel involved in sampling, sample handling, analysis, and data management must be alert to potential contamination and procedural errors. However, if nonrepresentative data points appear in the final stages of analysis, there is a mechanism for identifying apparently or obviously erroneous or nonrepresentative data (outliers). The following procedures are primary methods for outlier identification and represent the type of logic to be applied to situations or parameters not specifically dealt with here.

Outlier Identification

Interrelated Data Cross Checks

1. Inorganic carbon species and pH. The carbonate equilibrium dictates that (1) below a pH of 8.2-8.3, bicarbonate is completely dominant with only undetectable amounts of carbonate (and hydroxide) present, and (2) below a pH of 4.2-4.5, only CO_2 should exist in detectable amounts.

   These interactions are used as cross-checks for alkalinity determinations involving speciation.

2. Phase change speciations. Any suite of analyses involving total, particulate, or dissolved speciation will generally be subject to comparisons between parameters (e.g., total vs. dissolved metals concentrations). Obviously, dissolved concentrations should not exceed total concentrations (disregarding combined precision effects when true total and dissolved concentrations are the same or very similar).

   All such speciation analyses must be checked for such impossible situations before final data sign-off. For all parameters with short holding times, these determinations must be made as soon as possible. For this reason, it is often advisable for the analyst(s) to perform certain analyses concurrently (e.g., ammonia and total Kjeldahl nitrogen, total and dissolved phosphorus, and total oxidized nitrogen and nitrate). Frequently, similarity of variances is increased, thus improving the reliability of comparisons (and differences).

3. Residue analyses. Analyses for total dissolved residue and similar analyses are also a type of speciation and are therefore subject to comparisons similar to those mentioned above. For instance, total residue should exceed all other species values, at least within the combined effects of individual analysis precisions.

4. Biological/toxicity data. When a project is multidisciplinary (i.e, involves biological, chemical, and possibly hydrological data), literature values for toxicity of specific analyses to

specific organisms can be used to identify impossible concentrations. Obviously, this applies only to toxics for which toxicity data are sufficient to make such judgements.

Comparison to Existing Databases

Often, rather extensive databases are available for the system studied (previous environmental studies, STORET data, NAWDEX data, USGS publications, USEPA publications, academic literature). These data may be useful in "flagging" questionable or nonrepresentative data points before such data points are incorporated into models or are used as major decision tree components.

Analytical Services has accumulated a considerable amount of such data for interpretation and verification purposes. The analyst is urged to consider this availability and use the data as a cross-check when possible (and when agreed to by the appropriate project manager).

Correction/Elimination Procedures

If simple errors (i.e., miscalculations) cannot be identified, the analysis must be performed again (with the project manager's knowledge). Obvious corrections due to miscalculation may be made with the knowledge of the laboratory manager.

1.14 CORRECTIVE ACTIONS

When, as a result of audits or QC sample analysis, sampling or analysis systems are shown to be unsatisfactory, a corrective action shall be implemented. Also ontime corrective actions are taken during the course of analysis by chemists when the routine QC check criteria, e.g., GC/MS tuning, daily calibration, surrogate recovery, are not met. The project manager, laboratory manager, QA officer, and analyst may be involved in the corrective action. If previously reported data are affected by the situation requiring correction or if the corrective action will impact the project budget or schedule, the action should directly involve the project manager and the client project officer.

When, as a result of an out-of-control event that takes place in the field, the project manager or site supervisor will fill out a Field Nonconformance Report (Figure 1-14). In the laboratory, on-time corrective actions are taken during the course of analysis by chemists when the routine QC check criteria, e.g., GC/MS tuning, daily calibration, surrogate recovery, are not met. The chemist will fill out a Nonconformance Record (Figure 1-15). The project manager, laboratory manager, QA officer, and analyst may be involved in the corrective action. If previously reported data are affected by the situation requiring correction or if the corrective action will impact the project budget or schedule, the action should directly involve the project manager and the client project officer. Corrective actions are of two kinds:

FIELD NONCONFORMANCE REPORT

SITE NAME: ______________________

PROJECT NO: ______________________

DATE OF OCCURRENCE: ______________________

DETAILED DESCRIPTION OF NONCONFORMANCE EVENT OBSERVED

____

____

____

____

____

SIGNATURE OF ORGINATOR ______________________ DATE __________

____

CORRECTIVE ACTION TAKEN

____

____

____

SIGNATURE OF PERSON RESPONSIBLE ________________ DATE __________

DATE OF COMPLETION ______________________

ACKNOWLEDGEMENT BY PROJECT MANAGER ________________ DATE ________

Figure 1-14. Field Nonconformance Report.

EA LABORATORIES

LABORATORY NONCONFORMANCE RECORD

Nonconformance

Instrument	Sample(s)	
Test	Method	Date of Occurence

___ Failed tuning
___ Failed calibration
___ Instrument instability
___ Instrument malfunction

___ Power failure
___ Broken or lost aliquot
___ Insufficient volumne of aliquot
___ Poor aliquot preservation

___ Exceeded holding time
___ Matrix interference
___ Out-of-control QC parameter
___ Missing QC parameter
___ Other

Detailed Description

Signature of Originator	Date

Corrective Action

___ Instrument retuned
___ Instrument recalibrated
___ Instrument serviced

___ Sample(s) re-prepared
___ Sample(s) reanalyzed
___ Laboratory management notified
___ Other

Detailed Description

	Date of Completion
Signature of Person Responsible	Date

Verification of Nonconformance and Corrective Action

Signature of Supervisor	Date

Notification

Client contact required ? ___ Yes ___ No	Date of contact

Detailed Description

Signature of Notifier	Date

Acknowledgement

Signature of Laboratory Quality Control Officer	Date

Figure 1-15. Laboratory nonconformance record.

1. Immediate, to correct or repair nonconforming equipment and systems. The need for such an action will most frequently be identified by the analyst as a result of calibration checks and QC sample analyses.

2. Long-term, to eliminate causes of nonconformance. The need for such actions will be identified by audits. Examples of this type of action include:

   - Staff training in technical skills or in implementing the QA/QC Program;

   - Rescheduling of laboratory routine to ensure analysis within allowed holding times;

   - Identifying vendors to supply reagents of sufficient purity; or

   - Reassessment of field or laboratory operation procedure's and/or personnel.

For either immediate or long-term corrective actions, steps comprising of closed-loop corrective action system are as follows:

- Define the problem.

- The QA officer or project manager assigns responsibility for investigating the problem.

- Investigate and determine the cause of the problem.

- Determine a corrective action to eliminate the problem.

- Assign and accept responsibility for implementing the corrective action.

- Establish effectiveness of the corrective action and implement the correction.

- Verify that the corrective action has eliminated the problem.

Depending on the nature of the problem, the corrective action employed may be formal or informal. In either case, occurrence of the problem, corrective action employed, and verification that the problem has been eliminated are routinely documented and maintained in the project files.

1.15 QUALITY ASSURANCE REPORTS

QA reports will be prepared by the QA officer and submitted to the project manager, the manager of the audited group, and project sponsor to ensure that QA/QC objectives are met. Items to be included in the reports will include the results of performance and system audits and, where appropriate:

- An assessment of the precision, accuracy, and completeness of each sample batch.
- Significant quality control problems and the status of the corrective actions.
- Any changes to the QAPP.

The audit-reporting process will include a summary of audit results that will be developed from audit reports by the QA officer. These summaries will be distributed quarterly to the project manager during periods when sampling and laboratory analyses are underway.

2. FIELD SAMPLING METHODS/PROTOCOLS

The field investigation program is intended to provide for timely and cost-effective collection of data for valid site characterization for use in evaluating potential risks to human health and the environment from the presence and migration of contaminants, and to support feasibility studies and remedial alternative assessment during future phases of the IRP.

The types, location, and number of samples to be collected have been selected based on existing background data from previous IRP investigations. The sampling locations are identified in Figure 2-1. Whenever possible, sampling locations will be documented by photographs and indicated on a site sketch in the field logbook. The number of samples and the analytical parameters are summarized in Table 2-1. Ground-water elevation data, stratigraphic logs (visual and geophysical), and pump test data will also be collected. Field measurements will be made for all ground-water samples collected (pH, conductivity, and temperature). Organic vapor analyzers will be used to monitor the atmosphere and soil during all drilling and sampling operations.

This section describes the procedures to be followed by all personnel performing sample collections, field measurements, and field tests. The procedures presented are designed to ensure that:

- All sample and field measurements are consistent with project objectives.
- Samples are identified, preserved, and transported in such a manner as to ensure that samples are not lost during transport and that data are legally valid.
- Field measurements are collected in such a manner as to allow for comparisons between existing and newly collected data so as to provide as complete a database as possible for achieving the objectives of this phase of the remedial investigation.

The objectives will be achieved by conforming to SOPs during designing and constructing monitoring wells, logging boreholes, measuring water levels, sampling, and performing pumping tests (Appendix A).

2.1 GEOLOGIC AND HYDROLOGIC TECHNIQUES

The techniques for acquiring and documenting geologic and hydrologic data as identified and described in the Work Plan for AFP 59 are presented in the following sections and detailed in Appendix A.

2.2 PRE-DRILLING ACTIVITIES

Before entering the field to drill and install ground-water monitoring wells, drilling specifications will be prepared and submitted to qualified drilling subcontractors for bid solicitation. A qualified

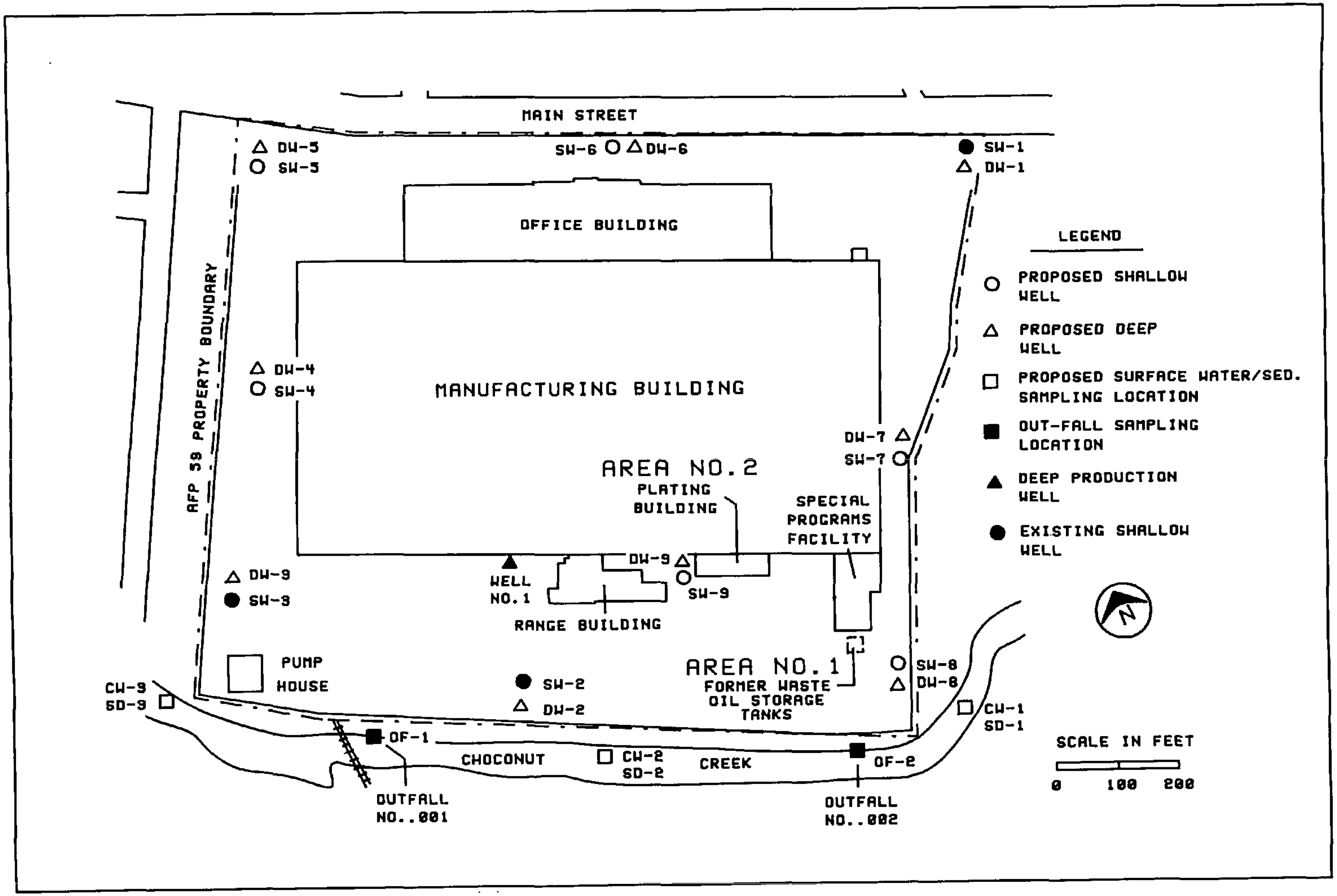


Figure 2-1. Site map of AFP 59 showing proposed Phase II Stage 2 monitoring locations.

TABLE 2-1 SAMPLING AND ANALYTICAL SUMMARY, IRP PHASE II STAGE 2, AFP 59

Activity/Parameter*	Number of Samples			
	Soil/Sediment	Water	Total	Second Column Concentration (VOC)
Borehole Drilling				
Priority Pollutants (Estimated)	9		9	4
Permeability	33		33	
Grain Size Distribution	24		24	
Choconut Creek Sample				
Priority Pollutants	3	5	8	4
Temperature	3	5	8	
pH	3	5	8	
Specific Conductivity	3	5	8	
Ground Water Sample				
Priority Pollutants		19	19	10
Temperature		19	19	
pH		19	19	
Specific Conductivity		19	19	
Aquifer Testing				
VOC		10	10	5
Metals (Total)		10	10	
Temperature		13	13	
pH		13	13	
Conductivity				
Waste (Drum) Sample (Estimated)				
Metals (EP TOX)	9		9	
Total Metals (Priority Pollutants)		10	10	
VOC	9	10	10	5
BNA	9	10	19	
QA/QC				
Field Blank (Prior Pollutants)		5	5	2
Bailer Wash (Prior Pollutants)		18	18	9
Duplicate (Prior Pollutants)	1	3	4	1

---

* Priority Pollutants = U.S. EPA Priority Pollutant Compounds; VOC = Volatile Organic Compounds; BNA = Base/Neutral and Acid Extractable Organic Compounds.

driller will be licensed in New York State, will have experience working on similar projects (this shall apply to both the individual drillers in the field and the drilling company as a whole), and will have the necessary equipment capabilities.

Prior to initiating the drilling program, appropriate state and local agencies will be contacted to obtain any necessary permits. Drilling activities and monitoring well construction will comply with regulatory and AFP 59 requirements regarding access, drilling, and ground-water extraction.

Within two weeks of initiating field activities, a preliminary site visit will also be conducted to identify sampling and monitoring locations and prepare the site for drilling activities. The following activities will be performed during the preliminary site visit:

- Meet with plant officials to present/discuss proposed field work activities, obtain a briefing on plant rules, obtain passes, and register vehicles and field personnel.
- Identify and stake final well and sampling locations, and access routes for approval by plant officials.
- Establish staging area for drilling equipment and supplies. Establish decontamination area; identify water source(s).
- Establish/identify staging area for drummed drilling waste material (cuttings, liquids, etc.).
- Clear well locations for the presence of underground utility lines.
- Establish a working schedule/plan with plant officials that will be least disruptive to ongoing plant activities.

2.3 DRILLING AND WELL CONSTRUCTION

After the preliminary site visit activities are accomplished, well drilling activities begin, and will follow the drilling/well installation protocol presented in the following sections.

2.3.1 Monitoring Well Installation

Presently, there is an existing deep aquifer production well and three shallow aquifer monitoring wells at AFP 59. Because of the limited number and positioning of these wells relative to the prevailing ground-water flow direction, the potential effects of past activities at AFP 59 on ground-water quality could not be adequately assessed.

In order to adequately quantify the potential effect of past activities at AFP 59 on ground-water quality, a total of 15 monitoring wells, to include 3 individual deep wells (located within 10 ft of the existing 3 shallow wells) and 6 well clusters (a shallow and deep well positioned within a 10-ft radius from one another) will be installed at AFP 59 in order to:

- Determine whether AFP 59 is contributing to ground-water contamination in the area.

- Determine and further define the nature of contaminants leaving the plant.

- Determine the extent (rate and direction) of contaminant migration.

- Provide more precise information on the physical characteristics of underlying geology and ground-water flow direction and rates.

- Provide analytical data for evaluating potential sources of contaminants present in the deep aquifer.

- Provide site-specific quantitative information upon which recommendations regarding further actions can be made.

The proposed monitoring network is shown in Figure 2-1. The monitoring well network is designed to characterize upgradient (background) and downgradient water quality within both the upper and lower water-bearing zones of the Clinton Street-Ballpark Valley aquifer, and is designed to monitor and accommodate natural variations in ground-water movement and induced shifts in ground-water flow directions which may occur as a result of alternate water use and pumping at Johnson City's municipal water supply well field (located within 1,000 ft to the northwest and southeast of AFP 59) and the plant's production well.

Water quality data obtained from Monitoring Wells SW-9 and DW-9, located downgradient of the former underground waste oil storage area (Area No. 1) and the plant's electroplating building (Area No. 2), will provide for a determination of whether ground-water quality and the plant's production well have been impacted by past activities in these areas. Perimeter monitoring wells will provide for an assessment of water quality changes as it enters and exits the facility as a whole. Lithologic data obtained during borehole drilling combined with water level and aquifer test data will provide for an assessment of the hydraulic properties of the shallow and deep water-bearing zones and their degree of interconnection, and the rate and direction of ground-water flow. Based on this information and the results of sampling analyses, predictions can then be made concerning the extent contaminants may have migrated using ground-water flow/contaminant transport modeling.

The following sections detail the well installation, aquifer testing, sampling, and analytical methods and procedures that will be implemented.

2.3.2 Shallow Monitoring Well Installation

A total of six shallow monitoring wells will be installed at a depth interval coincident with that of previously installed wells in order to monitor the uppermost portion of the Clinton Street-Ballpark Valley aquifer. Each of the shallow wells will be completed to an average depth of approximately 35 ft below ground surface and screened 7 ft into the prevailing water table. The wells will be installed with a truck-mounted drill rig using 4.25 in. ID hollow-stem augers.

Drilling will not be performed until the selected site has been cleared for drilling by AFP 59 (GE) officials and without the supervision of an EA geologist. Borehole drilling will proceed without the use of water, if possible, to avoid the introduction of foreign materials into the aquifer. If the use of water is necessary during drilling (e.g., to prevent sand from heaving up inside the augers), water from an approved potable water source will be used. The volume of water introduced into the well will be recorded by the supervisory geologist and approximately five times this amount will be purged from the well during well development. For the purposes of lithologic descriptions, split-spoon samples will be obtained at 5-ft intervals to the water table, then continuously through the saturated interval to the completion depth using the Standard Penetration Test (ASTMD-1586). All split-spoon samples and soil cuttings of the well will be monitored for the presence of organic compounds with a photionization meter (HNu) or an Organic Vapor Analyzer (OVA).

All auger cutting descriptions, water level readings, air monitoring readings, and other pertinent observations will be logged by the EA supervisory geologist. All split-spoon samples of unconsolidated sediment will be collected and visually identified by the supervisory geologist using the Unified Soil Classification System. Standard identification practices detailed in ASTM D 2488 will be followed. The following information, at a minimum, will be recorded by the supervisory geologist.

- Sediment sample interval
- Sampling hammer weight and distance of fall
- Blow count (per 6-in. interval)
- Amount of sample recovered
- Sample color
- Sample texture
- Sample moisture content (dry, moist, wet)
- Organic vapor readings
- Any unusual characteristics
- Depth to water
- Drill rig behavior and penetration rate

Representative sediment samples from each sampled interval will be placed in glass jars with screw-type lids for future reference. Each sample container will be labeled with the site name and the boring and sample number. No geotechnical data will be written on the container that is not specified on the boring log. Jars will be stored in cardboard boxes and kept from freezing.

Shallow monitoring well installation will be accomplished through in-place hollow-stem augers. Each well will be constructed of Schedule 40, threaded (glue not allowed), flush-joint 2-in. diameter PVC, and will include 10 ft of 2-in. diameter machine-slotted PVC screen bottom-plugged (installed 3 ft above and 7 ft below the water table) with a slot size of 0.01 in. Clean silica sand backfill, suitable for the formation and screen slot size (e.g., No. 1 well gravel), will be placed around the screen to 2 ft above the screen. A 5-ft bentonite seal will be placed immediately above the silica sand and the annular space above the bentonite seal grouted to land surface with a Type I Portland cement/bentonite slurry.

The following procedure will be used for shallow well installation. Once the augers have been advanced to the finished depth and the auger plug removed, the screen and riser pipe will be steam cleaned, assembled, and lowered down the hollow-stem and the augers not raised more than about 2.5 ft. Well gravel (clean silica sand backfill) will be added, as needed, and its level sounded. This procedure will be repeated until the sand pack extends a minimum of 2 ft above the top of the screen. The augers will then be raised approximately 5 ft above the top of the sand and a 5-ft layer of bentonite pellets will be added, and allowed to hydrate, to form a seal over the sand pack. A 1-in. tremie pipe will be lowered down the annulus between the PVC casing and augers to about 5 ft above the bentonite seal, and grout will be tremied into the annulus until grout is observed at ground surface. The grout will be composed by weight of 10 parts Portland Cement to one-half part bentonite, with a maximum 10 gals of water per 94-lb bag of cement. Simultaneously, the tremie pipe and augers will be slowly withdrawn, and additional grout added until it extends to a level which will allow surface completion.

Surface completion of the monitoring wells will be coordinated with the Base Point of Contact (POC) to determine whether they are to be completed flush with or projected above the ground surface. Depending on the concern in the area, well surface completion will be as follows:

1. If well stick-up is of concern in an area, the well will be completed flush with the land surface by cutting the casing 2-3 in. below land surface and installing a protective locking lid consisting of a cast-iron valve box assembly. The lid assembly will be centered in a 3-ft diameter concrete pad sloping away from the valve box to ensure that free drainage is maintained within the valve box. A screw-type casing to prevent infiltration of surface water and 1 ft clearance between the casing top and the bottom of the valve box will be provided.

2. If an above-ground surface completion is used, the PVC well casing will be extended 2.5 ft above land surface and will be fitted with a loose-fitting casing cap. The PVC casing will be shielded with a steel guard pipe (sleeve) which is placed over the casing and cap and seated in a 2-ft x 2-ft x 4-in. concrete surface pad which slopes away from the well sleeve. A lockable cap or lid will be installed on the guard pipe. A maximum of four traffic ballards, consisting of 3-in. diameter cement-filled steel guard posts, will be installed radially from each wellhead, recessed approximately 2-ft into the ground, and set in concrete. Both the flush and above-ground well assemblies will be provided with corrosion-resistant locks which have either identical keys or are keyed for opening with one master key.

2.3.3 Deep Monitoring Well Installation

A total of 9 deep wells will be installed into the lower portion of the Clinton Street-Ballpark Valley aquifer and screened at a depth interval coincident with that of the plant's production well.

Based on the available information, it is anticipated that the deep wells will be completed to an average depth of approximately 95 ft below ground surface and will contain 20 ft of screen.

The deep wells will be installed with a truck-mounted drill rig using 10-in. OD, 6-1/4-in. ID hollow-stem augers. Borehole drilling, soil sampling, and data collection will be conducted as previously detailed for shallow monitoring well installation. However, split-spoon sampling will be performed at 5-ft intervals beginning from the bottom depth of the shallow monitoring wells to the completion depth using the Standard Penetration Test (ASTMD-1586). If soil samples cannot be obtained in the coarser material anticipated in the deeper zones using a standard 2-in. split-spoon, a large diameter (3-in.) split-spoon will be driven to obtain soil samples. The sampler dimensions, hammer weight, length of hammer drop, and blow counts will be recorded on the boring log by the supervisory geologist.

Deep monitoring well installation will also be accomplished through in-place, hollow-stem augers. Each well will be constructed of Schedule 40, threaded (glue not allowed), flush-joint, 4-in. diameter PVC, and will contain 20 ft of bottom-plugged, 4-in. diameter, machine-slotted PVC screen with a slot size of 0.01 in. Clean silica sand backfill, suitable for the formation and screen slot size, will be placed around the screen and up to the bottom of the confining layer. A 5-ft bentonite seal will be placed immediately above the silica sand, and the annular space above the bentonite seal grouted with a Portland Cement/bentonite slurry to 5 ft below the top of the confining layer. A 5-ft layer of bentonite will then be placed immediately above the cement/bentonite slurry to seal the upper water zone from the lower water-bearing zone. Immediately above the bentonite seal, the formation comprising the saturated interval of the shallow water-bearing zone will be allowed to collapse around the PVC riser. Clean silica sand, if necessary, will be added to supplement backfilling around the PVC casing until it extends to 2 ft above the prevailing water table surface. A 2-ft bentonite seal will then be applied and the annular space above the bentonite seal grouted to land surface with a cement/bentonite slurry. This procedure is necessary to prevent grout contamination of the shallow water-bearing zone in the proximity of the shallow well screens.

Surface completion of the monitoring wells will be coordinated with the Base POC to determine whether they are to be completed flush with or projected above the ground surface as was previously described for shallow well installation.

2.3.4 Well Development

All ground-water monitoring wells will be developed as part of the well installation process. Development will be performed in order to create a good hydraulic connection between the well and the aquifer in which it is screened. This is important for obtaining reliable ground-water data and representative ground-water samples. Well development is achieved by removing fine grained geologic materials away from the well screen. Each well will be developed as soon as practical after completion by surging and bailing to remove the heavy sediments, then surging and pumping with a centrifugal or submersible pump.

Development will begin at the bottom of the well, working up to the top of the screen and then back down to the bottom in increments of approximately 2-3 ft. Development will consist of surging and pumping each interval until the discharged water is turbid free to the unaided eye and up to 5 casing volumes plus 5 times the amount of water introduced during borehole drilling (if any) have been removed from the well. If a well should pump dry before the 5 casing volumes have been removed, the well will be allowed to recharge for a short period of time and then pumped dry again. This process will be repeated for a maximum of 1 hour.

Part of the well development process will consist of washing the well cap and the interior of the PVC well riser using the water being purged from the well. The result of this operation will be a well casing free of extraneous materials (grout, bentonite, sand, etc.). This washing will be conducted during the development process, and not after.

The submersible pump or pump intake line will be raised slowly from the bottom until it breaks suction. This will ensure that no water that has been affected by the drilling will be left in the well. The water level and field measurements of pH, temperature, and specific conductance will be obtained before, during, and after development using electrometric devices (USEPA 600/4-79-020). A new, fresh length of flexible polyethylene pipe will be used for each well developed, to prevent potential cross-contamination of the wells. All water removed from the well during development which is suspected to be contaminated will be containerized. Containers will be 55-gal drums approved by the NYSDOT for the transportation of hazardous materials. Containers will be placed on wooden pallets and left onsite at a temporary staging area designated by GE officials for subsequent hazardous constituency characterization.

2.3.5 Decontamination

Before drilling the first well, between drilling of wells, and after drilling the final well (in each phase), all drilling, measuring, and sampling equipment (augers, rods, split spoons, etc.) that have contacted potentially contaminated soils or water will be decontaminated. These procedures are necessary to prevent cross-contamination of wells.

All equipment to be decontaminated will be laid out on blocks (above ground) and steam-cleaned with water from the approved potable water source. A decontamination area will be constructed for this purpose. Immediately prior to installation, the PVC well pipe, screen, and protective steel casing will be steam-cleaned. All pumps, pipes, hoses, and other equipment that cannot be internally scrubbed will be flushed with clean water. Decontamination fluids and other associated wastes will be collected in drums and stored in a temporary storage area for subsequent hazardous constituency characterization. It will be the responsibility of the supervisory geologist to ensure that complete equipment decontamination is carried out.

2.3.6 Well Site Restoration

At each boring/monitoring well location, polyethylene sheeting will be laid out and drilled through to help confine the borehole cuttings and keep the drilling area clean. Following well installation, uncontaminated cuttings will be spread over the general area in the vicinity of the borehole or transported to more suitable areas for disposal as determined and designated by GE officials. Borehole cuttings exhibiting potentially hazardous characteristics (e.g., unusual color, odor, organic vapor readings, etc.) will be containerized in NYSDOT approved 55-gal drums and moved to a temporary staging area designated by GE officials. Each well site will be cleaned and restored to near pre-existing conditions.

2.3.7 Well Abandonment

An existing shallow monitoring well (GE exploratory boring No. 5), located west of the manufacturing building, was observed to have an improper surface seal during the site visit (July 1988) and will be abandoned during the well installation phase of the field program. The well is completed flush to the ground surface in a paved parking lot. According to a plant official, the well was struck by a snow plow during snow removal operations (Schneider 1988). The protective steel tank box, cement cover, and PVC are cracked, allowing surface water runoff to enter the well. As such, it provides a conduit for the direct migration of surface runoff (and potential contaminants) into the underlying aquifer.

The well will be abandoned by grouting in accordance with New York State requirements. The grout will be composed of 10 parts cement to 1/2 part bentonite by weight with a minimum of 10 gal of approved water per 94-lb bag of cement. The grout will be pumped through a tremie pipe (discharge placed at the bottom of a well) until undiluted grout is observed at the top of the well, forming a continuous grout column from the bottom of the well to ground surface. After 24 hours, the well will be checked for grout settlement, and additional grout will be added if needed. If possible, the steel tank box will be removed. The parking lot surface will then be patched with Sakrete black-topping.

2.4 SAMPLING

The purpose of data collection, sample collection, and laboratory analysis is to determine whether any contaminants generated from installation activities are entering the environment. The field investigation is used to determine the source, extent, and migration of any identified contaminants, and the magnitude of contamination relative to ARARs and any naturally occurring or background concentration for specific compounds. In order to provide a comprehensive baseline characterization for the facility as a whole, all new and existing wells, surface water, and sediment from Choconut Creek will be sampled and analyzed for the 126 parameter priority pollutants (as established by 40 CFR 136 "Guidelines Establishing Test Procedures for Analysis of Pollutants Under the Clean Water Act"). Figure 2-1 illustrates the location of all the sampling points for the Stage 2 investigation effort and the field/sample numbering system that will be implemented. Table 2-1 summarizes the number and type of samples which will be collected during various phases of field activity performance. All sampling will be conducted by experienced personnel under the direct supervision of the project geologist. All sampling will be accomplished under a rigorous chain-of-custody protocol and will strictly comply with the sampling techniques contained in Standard Methods for Examination of Water and Wastewater, 16th Edition (1985); ASTM Section 11, Water and Environmental Technology; Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition (USEPA 1986); Methods for Chemical Analysis of Water and Wastes, USEPA Manual 600/4-79-020 (1983); and the Handbook for Sampling and Sample Preservation of Water and Wastewater, USEPA Document 600/4-82-029 (1982).

2.4.1 Soil Sampling

Any soil exhibiting potentially hazardous characteristics (e.g., unusual coloration, odor, organic vapor readings, etc.) during borehole drilling will be collected for priority pollutant analysis. Samples will be obtained with a decontaminated split-spoon sampler, placed in an appropriate container for the analyte to be tested, labeled, packaged, placed in a cooler and chilled to 4 C, and shipped to EA Laboratories for chemical analysis.

2.4.2 Ground-Water Sampling

A total of 19 wells, which will consist of 9 newly installed deep wells, 6 newly installed shallow wells, 3 existing shallow wells, and 1 existing deep production well, will be sampled. Sampling will be performed at least two weeks after well development to allow the aquifer to return to equilibrium.

Prior to going into the field, the ground-water sampling field team leader will gather all available information such as the total depth, water level, and type of casing material for each well. This will aid in determining the bailer size to be used when sampling. The diameter of the well and the water level measurement is also used to calculate the minimum purge water volume to be evacuated from the well prior to sampling. Information on pumping rates, latest dynamic and pumping water levels, pump intake depths, and the length of time the pump has been on will also be gathered for the production well.

To ensure that a representative sample of the aquifer is obtained, 3-5 times the calculated volume of standing water in the well will be purged from each well prior to sample acquisition. In the event of low yielding wells, the well will be purged to dryness and allowed to recover prior to sample acquisition. A round of static water level measurements will be obtained with an electronic water level indicator (QED) both prior to and after purging to ensure recovery before sampling.

Monitoring well purging will be accomplished with a centrifugal or submersible pump equipped with a 1/2- to 1-in. diameter flexible polyethylene pipe suction line. A new, unused length of pipe will be used for each well to prevent cross-contamination of wells. The pipe will be stored in large plastic bags, until ready for use, and will be handled with new, clean surgical gloves for each well. Additionally, the pipe will not be allowed to become contaminated by touching the ground. The suction pipe will be lowered to the bottom of the well and the pump started. After the required volume of water has been nearly evacuated from the well, the suction line is raised in intervals to the water surface and allowed to pump for a short time at each stop. The suction line is then removed from the water and is allowed to purge itself and the discharge hose. The suction line or pump is then removed from the well and the volume purged recorded. Purged well water suspected to be contaminated will be collected and containerized in NYSDOT-approved drums and stored onsite for subsequent hazardous constituency characterization.

Upon completion of the purging operation, ground-water samples will be obtained from each monitoring well using dedicated bottom-filling teflon bailers (a separate bailer for each well). Tap samples will be obtained by directly filling appropriate sample containers at a discharge line at the wellhead of the plant's production well. Prior to arrival at the site, each bailer will be decontaminated in the laboratory, wrapped in aluminum foil, and placed in sealed plastic bags. The decontamination procedure will consist of washing them with hot water and Alkanox soap followed by a hot water rinse, methanol rinses, and air drying. Prior to sample acquisition at a selected monitoring well, the sampler will be rinsed with distilled water. A distilled water rinse sample from each bailer will be obtained for 126-parameter priority pollutant analysis. The sampling effort will also include a trip blank to further validate data generated.

At each monitoring well, the bailer will be lowered into the well with new (unused) polypropylene twine. A new pair of disposable surgical gloves will be used to handle the bailer at each well. The bailer will be lowered into each well slowly to minimize the potential for agitation and aeration of the water sample. Samples will be placed into a sampling container containing an appropriate preservative for the parameter to be analyzed. Samples which will be analyzed for metals will be field-filtered through 0.45-micron filter paper. Measurements of pH and conductivity will also be obtained in the field. All samples will be kept on ice to maintain 4 C or below immediately after sampling. The samples will be packaged and shipped via overnight carrier (e.g., Federal Express) to the laboratory for immediate chemical analysis.

2.4.3 Surface Water/Sediment Sampling

In order to obtain baseline quantitative data for assessing whether past activities at AFP 59 may have impacted Choconut Creek and the degree to which Choconut Creek may be impacting 9 round-water quality at AFP 59, a surface water and sediment sample will be obtained from three locations along Choconut Creek for priority pollutant analysis (Figure 2-1).

The sampling approach for Choconut Creek includes an upstream (of AFP 59) sampling station for establishing background water quality, a downstream sampling station for assessing net water quality changes, and a midstream sampling station between the two outfalls from AFP 59. Data obtained from the midstream sampling station can be used to assess water quality changes up-and downstream of each outfall, and provide a mechanism for assessing potential source areas within AFP 59. Should rainy weather conditions occur at the time of sampling and result in outfall discharge, an effluent sample will be collected from each of the outfalls. Samples will be collected by directly filling appropriate sampling containers for the parameters to be tested.

An attempt will be made to obtain surface water and sediment samples from Choconut Creek using grab sampling techniques. In this method, samples are obtained by wading into the Creek and directly filling sampling containers. Sampling will be initiated at the downstream station, and upstream (background) sampling will be performed last. This procedure is necessary to avoid any water quality changes which may occur as a result of wading activities. Should the depth of standing water and composition of underlying sediments prohibit wading, a nalgene scoop with a 10-ft extension handle (or similar device) will be used to collect samples. The collected sample will then be transferred directly to an appropriate container for laboratory shipment and analysis. Field measurements of temperature, pH, and specific conductance will also be obtained at each location and recorded in the field logbook. All sampling equipment will be decontaminated prior to sample acquisition at each location. Each sampling location will be permanently marked, surveyed, and recorded on a project map.

2.4.4 Waste Materials Sampling

All waste materials generated during the field effort which are suspected to be hazardous (based on color, odor, organic vapor readings, etc.) will be containerized in drums which have been approved by the NYSDOT for the transportation of hazardous materials. Waste materials to be containerized will include soil boring/well drilling cuttings, decontamination rinse waters, and discharge water from well development and purging (prior to sampling). Drums will be placed on wooden pallets and placed in a staging area designated by AFP 59 (GE) officials. AFP 59 will be responsible for the ultimate disposal of containerized wastes.

After field sampling activities have been completed, one composite waste liquid and one composite waste solid (soil) sample will be obtained from the contents of the drummed materials from each cluster well location and containerized decontamination rinse waters for volatile organic compounds, base/neutral and acid extractable organic compounds, EP Toxicity metals (solids), and total metals (liquids) analysis to determine if the wastes must be disposed of as hazardous waste. Composite sampling will be performed by obtaining an equivalent volume of grab sample from each of the drums.

2.4.5 Field QA/QC Sampling

During the sampling effort, quality control samples will be collected based on the number and type of sampling being conducted. At a minimum, the following quality control samples will be collected:

- One field blank prior to initiating sampling on a given day. This sample consists of pouring reagent water into the sample containers and carrying these samples while collecting media samples in the field. The sample is then analyzed for the spectrum of parameters tested for on that given day. Field blanks are utilized to evaluate the field sampling procedure.

- One bailer wash from each bailer. This sample consists of reagent water poured through the bailer and into the sample containers immediately prior to sample collection. Bailer washes are utilized during ground-water sampling to verify the effectiveness of the decontamination procedure.
- One randomly collected duplicate sample for every 10 samples of each medium submitted for analysis. These examples are collected at the same time and in the same manner as the normal laboratory sample. The results of the duplicate analysis are used to evaluate the reproducibility of laboratory results.

The Field Operations Supervisor will ensure all sampling is performed in strict accordance with the Work Plan and QAPP.

2.5 AQUIFER TESTING

EA currently proposes to perform short-term (1- to 2-hour) pumping tests at each of the monitoring well pairs installed, and a long-term (at least 72-hour) pumping test at the AFP 59 Production Well No. 1. The purpose of the aquifer testing program proposed is to obtain data for use in assessing the hydraulic characteristics of the shallow and deep water-bearing zones of the Clinton Street-Ballpark Valley aquifer beneath AFP 59, the extent of their interconnection, and the extent to which Choconut Creek may be recharging the underlying aquifer, such that an overall evaluation of potential ground-water flow and contamination transport can be made.

Revision of the proposed specifications for aquifer testing may be necessary and will be determined: (1) after EA's reconnaissance of AFP 59 Production Well No. 1 and its current condition, and review of the pumping records, and (2) after completion of the planned shallow and deep test borings/monitoring wells which will aid in understanding the site- specific hydrogeology.

The short-term continuous discharge testing of each of the monitoring well pairs will include a 1- to 2- hour pumping test of each well and observing/recording the water levels in both wells of each pair during pumping and recovery portions of the test. Water level recording will be performed using in situ Hermit data loggers and transducers (or similar equipment). Such testing would provide data for use in evaluation of the aquifer characteristics of the shallow and deep portions of the unconsolidated sediment, and the hydraulic connection between the two water-bearing zones.

The long-term continuous discharge testing of AFP 59 Production Well No. 1 is proposed to be performed in two stages. The first stage would be performed after the aquifer water level recovers (stabilizes) fully under non-pumping conditions and at a continuous discharge rate of approximately 350 gpm until stabilization of the cone-of-depression (water level drawdown) is observed for at least 6 hours in all pairs of onsite monitoring wells. Upon achieving stabilization of the cone-of-depression, the discharge rate would be increased to a maximum rate (currently anticipated to be about 600 gpm) that will draw the water level in the production well down to the base of the clay layer which reportedly overlies the lower aquifer zone at a depth of 65 ft below grade. Again, the pumping will be continued until stabilization of the cone-of-depression is observed for at least 6 hours in all pairs of onsite monitoring wells. The pump will then be stopped, and the water level recovery will be monitored in all onsite wells. The depth to water will be monitored and recorded in all wells using in situ Hermit data loggers and transducers (or similar equipment). Additionally, a staff/stream gauge would be established near the shore of Choconut Creek for monitoring of the surface water level before and during the pumping test. During the test, three samples of the discharged ground water from the production well and each well of two of the well clusters along Choconut Creek (SW, DW-2 and SW, DW-8; Figure 2-1) will be collected: (1) approximately 2 hours after the pump is started, (2) just before the end of the 350 gpm continuous discharge phase, and (3) just before the end of the 600 gpm continuous discharge phase, for total metals and volatile organic compound analysis (contaminants presently detected in ground water at AFP 59). Measurement of temperature, pH, and specific conductance will also be obtained. It is noted that the analytical program may be revised and targeted based upon preliminary analytical data for the aforementioned wells and surface water samples from Choconut Creek. These data will be used to assess whether contaminants may be migrating from Choconut Creek and impacting ground-water quality at AFP 59. Ground-water modeling will be performed as part of this effort.

The ground-water modeling will consist of a lumped parameter transient, ground-water flow/contaminant transport model for AFP 59. The model will address, at a minimum, the following:

- A multi-aquifer system with leaky interconnections between aquifers.
- Contaminant transport by convection and nydrodynamic dispersion.
- Aquifer recharge/discharge properties.
- Surface water/ground-water interaction.
- Aquifer heterogeneities.
- Multiple boundary conditions.

Consideration will be given to application of commercially available models (e.g., "PLASM" and "RAMDOM WALK"). However, depending on the complexity of the hydrogeologic and geochemical setting, and on the quantity and quality of existing data, construction of a customized model may be required. In any case, the following subtasks will be performed:

- Identify model objectives.
- Compile and interpret available data.

- Select appropriate existing model, or identify requirements of and development code for a customized model.
- Prepare data for model input.
- Perform sensitivity analyses, compile additional data, and recalibrate as necessary.
- Simulate historical conditions and calibrate model.
- Rerurn the computer model using existing conditions and calibrate model as necessary.
- Perform predictive simulations.

As part of the predictive simulations, it may be necessary to evaluate aquifer response to one or more pumping scenarios. This evaluation may require successive iterations with the flow model, or formal coupling of the model with a mathematical optimization algorithm. The feasibility of the latter will be investigated during flow model construction, and will be primarily dependent on the linearity of the hydrogeological systems. The need to approximate non-linear aspects will clearly be identified, and all such approximations will be qualified with error estimates.

Documentation/reporting requirements will include not only results of the predictive simulations, but also tabulated existing data, data input matrices, calibration efforts and results, and a narrative discussion of sensitivity analyses and error terms.

2.6 FIELD EQUIPMENT

2.6.1 Field Parmaeters

Conductivity, temperature, alkalinity (ASTM 403), and pH will be measured when each surface water or ground-water sample is collected. A conventional pH meter with a gel-filled electrode, or equivalent, will be used for field pH determinations. A combination conductivity-temperature meter, or equivalent measurement devices, will be used for the remaining field parameter measurements.

All instruments will be calibrated daily to ensure accuracy. All probes will be thoroughly rinsed with distilled water prior to and following measurements.

Regardless of the sample collection method (grab, bailer, or pump), a representative water sample will be placed in a nalgene transfer bottle, used solely for field parameter determinations, unless it is possible to make measurements directly at the well discharge point. Measurements will be made as follows:

- The transfer bottle will be rinsed with sample water prior to filling.

- Probes will be immediately submerged in the transfer bottle and measurements will be taken accordingly.

- All field measurements will be recorded in a field notebook along with the sample location, the time and date of measurement, and the sampler's name.

- After parameters are obtained, the transfer bottle and the probe(s) will be decontaminated by rinsing with distilled water. If the transfer bottle cannot be cleaned, a new bottle will be used.

2.6.2 Water Level Surveys

An electronic water level indicator (QED or equivalent) will be used to take water level measurements during the field program. The water level indicator will have marks on the sounder line at regular intervals (0.01 ft).

Each water level indicator will be accompanied by a calibration logbook which will show the time and date of last calibration (before entering the field); the point of calibration (either the center of a mark on the sounding line or along the extreme of the first mark near the probe); who did the calibration; and how it was accomplished. A calibration check will be made in the field by taking a water level measurement with the sounder and checking measurement with a steel tape. The difference between the two measurements should be less than 0.1 ft per 100 ft of depth to water.

Electronic (or pneumatic) pressure transducers and data loggers will be used during pumping tests for continuous monitoring of water levels. Transducers will not be used for "spot" water level measurements unless all other methods fail to generate verifiable data.

The operation, calibration, maintenance, and storage of the Hermit data-loggers and transducers proposed for this project wil be in accordance with the manufacturer's specifications. They will only be placed down the well when the pump is turned off and only within a protective air line or pipe if the pump is to be operated. The exact depth to the sensing tip of the transducer must be known, and the water level at time of placement must be measureed. All electronic and atmospheric conditions which may affect the transducer's reading will be recorded.

During aquifer tests or pump tests in which transducers are being used, the water level will be routinely checked with a tape or sounder to ensure the accuracy of the transducer. The power supply to the data logger and transducer will also be checked routinely.

2.6.3 Well Discharge Measurements

During aquifer tests and ground-water quality sampling events, field measurements will be made to determine the flow rate of the water discharging from the well. This will be accomplished by different methods that will be selected on the discharge rate of the well, as described below.

2.6.3.1 Wells with Small Discharges

Discharges from a well with a low discharge rate will be directed into a 5- to 14-gal container. A stopwatch will be started as soon as the discharge begins. The stopwatch will be turned off when the container is full. This will give the time in minutes and seconds that it took to discharge the known volume of water from the well. The rate of discharge will be converted to gallons per minute. The time this measurement was taken will also be recorded.

2.6.3.2 Wells with Large Discharges

Well discharge measurements for wells discharging at large rates can be accomplished by a number of different methods:

- Orifice plate
- In-line flow meter
- Cox flow meter
- Open channel flow meter
- Parshall or equivalent flume.

The following items will be considered before selecting any of the above discharge measuring methods:

- Well completion details and pump setting specifications.
- Pump type, rating, power source, and type of discharge outlet.
- Determination of the length of time the well has been discharging.
- The status of adjacent active wells (those within a 1/2-mi radius).
- Estimates, records, or field measurements of pump discharge, time of pump or time since last pumping for the adjacent active wells.
- Method to be used for estimating discharge.

Once this information is established, one of the above discharge measurement methods will be employed. At the time of measurement, atmospheric conditions, equipment, or well head conditions which may ultimately affect the discharge measurements will be recorded along with the discharge data.

Below are brief descriptions of each discharge measurement method which may be used.

Office Plate (Circular Orifice Weir)

This technique will require custom design of equipment and piezometer tube for each specific well. The diameter of the orifice must be less than 0.8 of the total diameter of the discharge line where the plate is placed. The piezometer tube must be clear of obstructions and free of air bubbles.

The orifice plate will be used only at wells where it can be adapted and when other techniques will not produce verifiable data. At least two readings will be made using this method, until a ±10 percent difference or less is obtained.

In-Line Flowmeter

If the well is equipped with an operable in-line flowmeter, it will be used to measure well discharge. The meter reading will be compared to a discharge measurement from one of the other acceptable methods to measure accuracy of the measurement. The type and manufacturer of the meter will be known prior to operating and reading the meter. At least two readings will be made, until a ±10 percent difference or less is obtained.

Cox Flowmeter

In most situations, the Cox flowmeter will be used for discharge measurements. It is portable, easily adapted, and accurate to within +5 percent of the actual value. The Cox flowmeter will be used on wells discharging to either open or closed systems and will be used on wells with discharge pipe diameters from 2 to 20 in. (depending on model). If a tap and plug have not already been drilled into the discharge pipe, then one will be drilled at least 8 pipe diameters down from the pump at a 45-degree angle from the horizontal. The manufacturer's specifications and operating procedures will be followed in installing, operating, and reading the flowmeter.

At any well that the Cox flowmeter will be used, it is necessary that the discharge pipe be full of water. If the pipe cannot be constructed to cause a full pipe, then an alternative flow measurment method is required. The component fitting so the flowmeter and discharge pipe adaptation must also be free of air. At each well where the Cox flow-meter will be used, at least two readings will be made, until a ±10 percent difference or less is obtained.

Open Channel Flowmeters

Open channel flowmeters or current meters, such as the type-AA Price and Pygmy meter, will be used when there are no techniques available to measure discharge directly off the pump and discharge pipe at the well. These meters will be used to measure surface water flow across ditches or open sewer lines, depending on where the well discharges. If the flow in the open channel is due to the well discharge only, then the current meter will be used at a point downgradient but near the well, in an area free of turbulence within that channel. If the well discharges to an open channel with flow originating upgradient of the well, then two measuring points are required: one upgradient of the well discharge and one downgradient. The difference between these two measurments will be assumed to be the well discharge value, with no leakage within the channel. The channel flow will be measured according to the manufacturer's specifications and operating procedures of the specific current meter. The limits of velocities measureable by the meter must be known and never exceeded. Cross-section and depth profiles of channel velocity will be generated so as to accurately define the discharge within ±10 percent of the actual value. The same cross-section and depth profile will be used each time a discharge is to be measured. If possible, this method will be checked with another of the methods described herein to ensure its accuracy.

2.6.4 Equipment Calibration

Proper maintenance, calibration, and operation of each instrument will be the responsibility of the field technician and the lead equipment engineer assigned to the project. All instruments and equipment used during the studies will be maintained, calibrated, and operated according to the manufacturer's guidelines and recommendations. At a minimum, all instruments will be inspected and calibrated upon receipt from a vendor or from another office. When in the field, a photocopy of the manufacturer's operation and calibration recommendations will accompany the instrument. In the event that the instrument is not supplied with a manufacturer's recommendations for calibration and calibration frequencies, the following guidelines will apply:

- All equipment will be calibrated prior to a field program. This includes instruments used to measure water quality parameters and water levels, well discharge instruments, and air monitoring devices.
- Air monitoring devices, temperature, pH, and conductivity meters will be recalibrated daily and after maintenance and repair.
- Steel tapes used for measuring well depth will be calibrated twice a year to check for kinks, stretching, or work markings.
- Instruments for which calibration cannot be checked easily will be either tested against another instrument of a similar type, or will be returned to the manufacturer for appropriate calibration.

2.6.5 Decontamination Procedures

All equipment which comes in contact with potentially contaminated soil or water, including OVA, soil and water sampling, water-level measuring, and sample preparation equipment, will be cleaned prior to and after each use on this project. Decontamination will consist of a laboratory-grade detergent wash, followed by drinking quality water, pesticide-grade methanol, and pesticide-grade hexane rinses. Sufficient time will be allowed for the solvent to evaporate and the equipment to dry completely before reuse. Sampling equipment used to collect samples for organics analysis will not be allowed to come in contact with any type of plastics (e.g., plast storage bags). Solvents and reagent water used to decontaminate sampling equipment will be stored and dispensed from glass or teflon bottles. The use of plastic squeeze or squirt bottles will be expressly prohibited. Analytical data or manufacturer's certification which verifies the quality of the Type II Reagent Water will be furnised to USAFOEHL.

2.7 SURVEYING

In order to determine the direction of ground-water flow, and to assess whether a hydraulic gradient exists from Choconut Creek to the underlying aquifer, the horizontal coordinates and elevations of each newly installed monitoring well and each surface water and sediment sampling location will be surveyed by a New York State registered licensed surveyor. In addition, the four existing wells (three shallow monitoring wells and the production well) will be surveyed to provide a uniform database for the survey. Benchmarks shall be established from, and traceable to, a U.S. Coast and Geodetic Survey (USCGS) or U.S. Geological Survey (USGS) survey marker. This will be a third order survey. Vertical elevations and horizontal locations will be measured to an accuracy of 0.01 ft and 1 ft, respectively. Surveying of the wells will be to the top of the PVC riser casing which will be notched where the elevations are established. (The notch provides a reference point for all water level measurements.) All survey positions will be recorded on a base map of AFP 59. All benchmark locations will be clearly identified on the base map.

2.8 SITE MANAGEMENT

EA will be responsible for ensuring the safe and proper conduct of employees and subcontractors in performing this work. All personnel under EA supervision will adhere to the policies and procedures as they relate to access to AFP 59, security, safety, and health procedures.

A field office will be established onsite, and lines of communications established with responsible base personnel.

Decontamination procedures will be conducted to ensure that potential contamination remains onsite. General cleanup of equipment and vehicles will be conducted consistent with accepted facility practices and in close coordination with the Base POC. The objective of site cleanup is to leave the area of investigation essentially as it was originally, except for the physical addition of monitoring wells and guard posts. Site cleanup requires close coordination with base personnel to ensure that cleanup operations are in accordance with the overall management of base operations.

APPENDIX A

MANUAL OF STANDARD OPERATING PROCEDURES FOR GEOTECHNICAL SERVICES

EA Manual GtS-001

MANUAL OF STANDARD OPERATING PROCEDURES FOR GEOTECHNICAL SERVICES

EA ENGINEERING,
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15 Loveton Circle
Sparks, Maryland 21152

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MANUAL OF STANDARD OPERATING PROCEDURES
FOR GEOTECHNICAL SERVICES

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This copy, EA Manual GtS-001 No. ________, is issued by

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CORPORATE POLICY

It is the policy of EA Engineering, Science, and Technology, Inc. to conduct its work on behalf of its clients in accordance with those applicable standards and procedures that ensure the highest possible quality of performance. The procedures presented in this manual provide the written guidance and related information for performance of geotechnical investigations as specified in each project study plan.

The policy of the corporation is to adopt and implement procedures that assure quality of project data. The assurance of quality performance this manual affords through standardized procedures and requirements is available to all our clients and is considered an integral part of client projects incorporated in the client-approved Project Plans. All EA employees are expected to adhere to the applicable procedures adopted for their projects.

Loren D Jensen

Loren D. Jensen, Ph.D.
President

6 December 1985

MANUAL OF STANDARD OPERATING PROCEDURES FOR GEOTECHNICAL SERVICES

Protocol	Title	Revision	Date Approved
GtS-101	Standard Format for the Completion of Boring Logs	0	6 DEC 85
GtS-201	Standard Operating Procedure for the Installation of Ground-Water Monitoring Wells	0	6 DEC 85
GtS-202	Standard Operating Procedure for Aquifer Tests of Monitoring Wells	0	3 NOV 87
GtS-401	Standard Operating Procedure for Ground-Water Sampling and Sample Handling	0	9 DEC 85

STANDARD FORMAT
FOR THE
COMPLETION OF BORING LOGS

Approved:

David Cantor
Chief Engineer

6 DECEMBER 1985
Date

CAHoulik Jr
Program Director

12-06-85
Date

Protocol GtS-101
EA Engineering, Science,
and Technology, Inc.

CONTENTS

1. INTRODUCTION

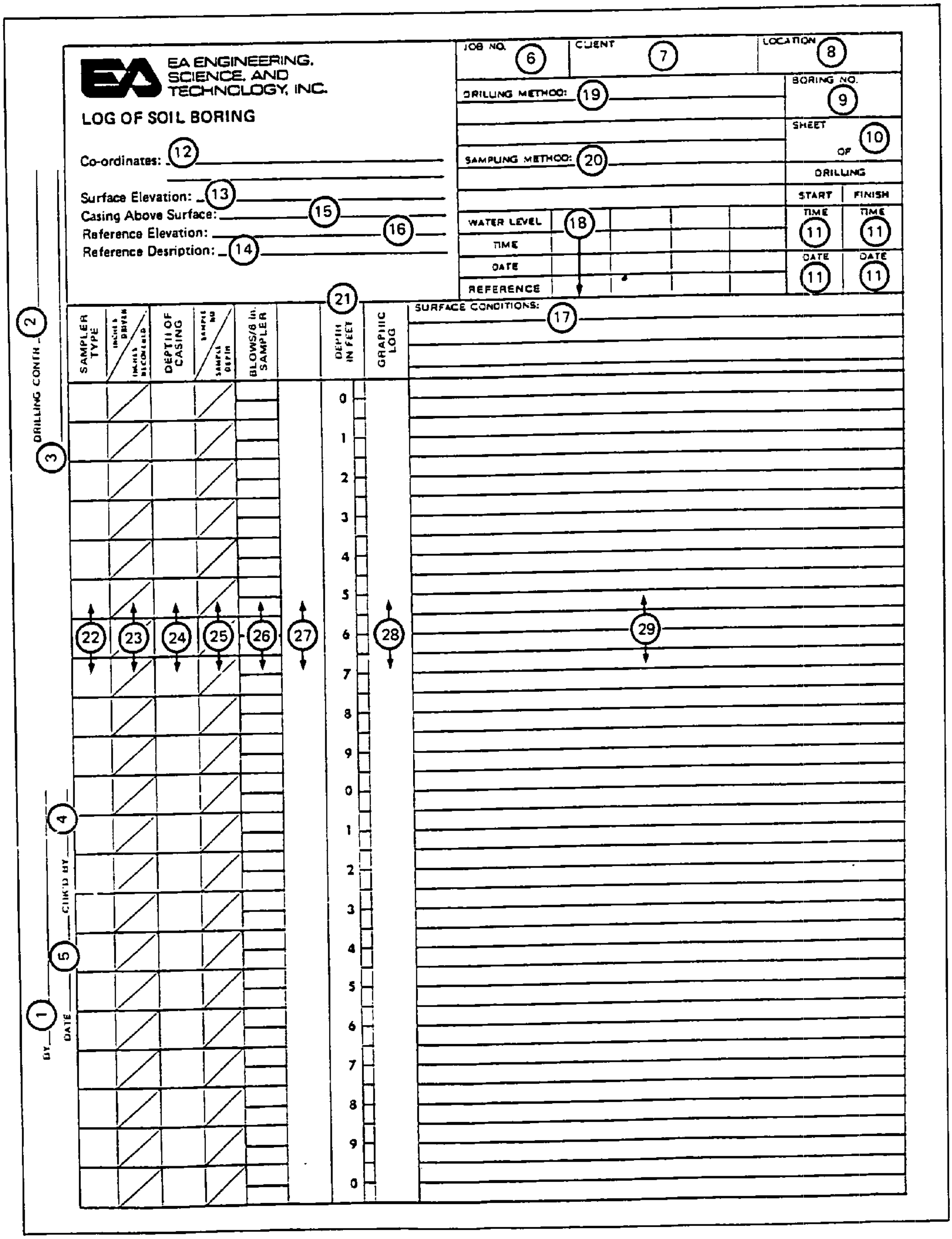
This protocol describes EA Engineering, Science, and Technology's Standard Format for the completion of logs of subsurface borings. Adherence to this format is necessary to ensure completeness of the log and to facilitate the comparison and correlation of logs completed by different personnel.

On a project-specific basis, the Standard Operating Procedure (SOP) for supervision of drilling operations is comprised of this Standard Format, EA's SOP for Installation of Ground-Water Monitoring Wells (GTS-201), and the Project Plan. Typically, the Project Plan includes three documents: (1) Safety and Health Plan, (2) Field Sampling Plan and/or Drilling Plan, and (3) Quality Assurance/Quality Control Project Management Plan.

Project-specific plans will supplement and may modify this Standard Format. Generally, elements of a Project Plan which modify and supersede the Standard Format are identified as such in the Project Plan. A pre-mobilization conference is generally held to ensure that all personnel understand the project objectives and protocols. During the pre-mobilization conference the Project Manager and/or Principal Investigators will review the project plans and discuss their impact or lack thereof on EA's SOPs. Prior to the pre-mobilization conference, the field geologist/ engineer must develop a thorough understanding of all project-specific plans, as well as EA's SOPs, for the planned field activities. This should ensure that any potential conflicts can be resolved before initiating work.

An EA geologist/engineer shall be present at each operating drill rig and responsible for the logging of samples, monitoring of drilling operations, recording of water losses/gains and ground-water data, preparing the boring logs and well diagrams, and recording well installation procedures of that rig. Each geologist/engineer shall be responsible for only one operating rig. Each geologist/engineer shall have onsite, as a minimum: (1) his own copy of the Drilling Plan and the approved Safety and Health Plan, (2) a 10X hand lens, (3) a weighted (with steel or iron) tape(s) long enough to measure the deepest well within the contract, heavy enough to reach that depth, and small enough to readily fit within the annulus between the well and drill casing, and (4) a water level measuring device, preferably electrical. See also Appendix A, B, and C.

Figures 1 and 2 illustrate the standard forms for Soil Boring and Core Boring logs and provide the key for the descriptions that follow. Example completed logs are also provided (Figures 3 and 4). Logs shall be recorded directly on the standard forms in the field without transcribing from a field book or other documents. This procedure reduces offsite work hours for the field geologist/engineer, reduces the potential for errors of manual copying, and allows the completed document to be field-reviewed closer to the time of drilling. This requirement shall in no way be construed as an excuse for sloppiness. EA's clients invest thousands of dollars in a drilling program. An incomplete or illegible Log of Boring is of no value.



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

LOG OF SOIL BORING

Co-ordinates: ⑫

Surface Elevation: ⑬

Casing Above Surface: ⑮

Reference Elevation: ⑯

Reference Desription: ⑭

JOB NO. ⑥

CLIENT ⑦

LOCATION ⑧

DRILLING METHOD: ⑲

BORING NO. ⑨

SHEET ⑩ OF

SAMPLING METHOD: ⑳

DRILLING	
START	FINISH
TIME ⑪	TIME ⑪
DATE ⑪	DATE ⑪

WATER LEVEL	⑱			
TIME				
DATE				
REFERENCE				

SURFACE CONDITIONS: ⑰

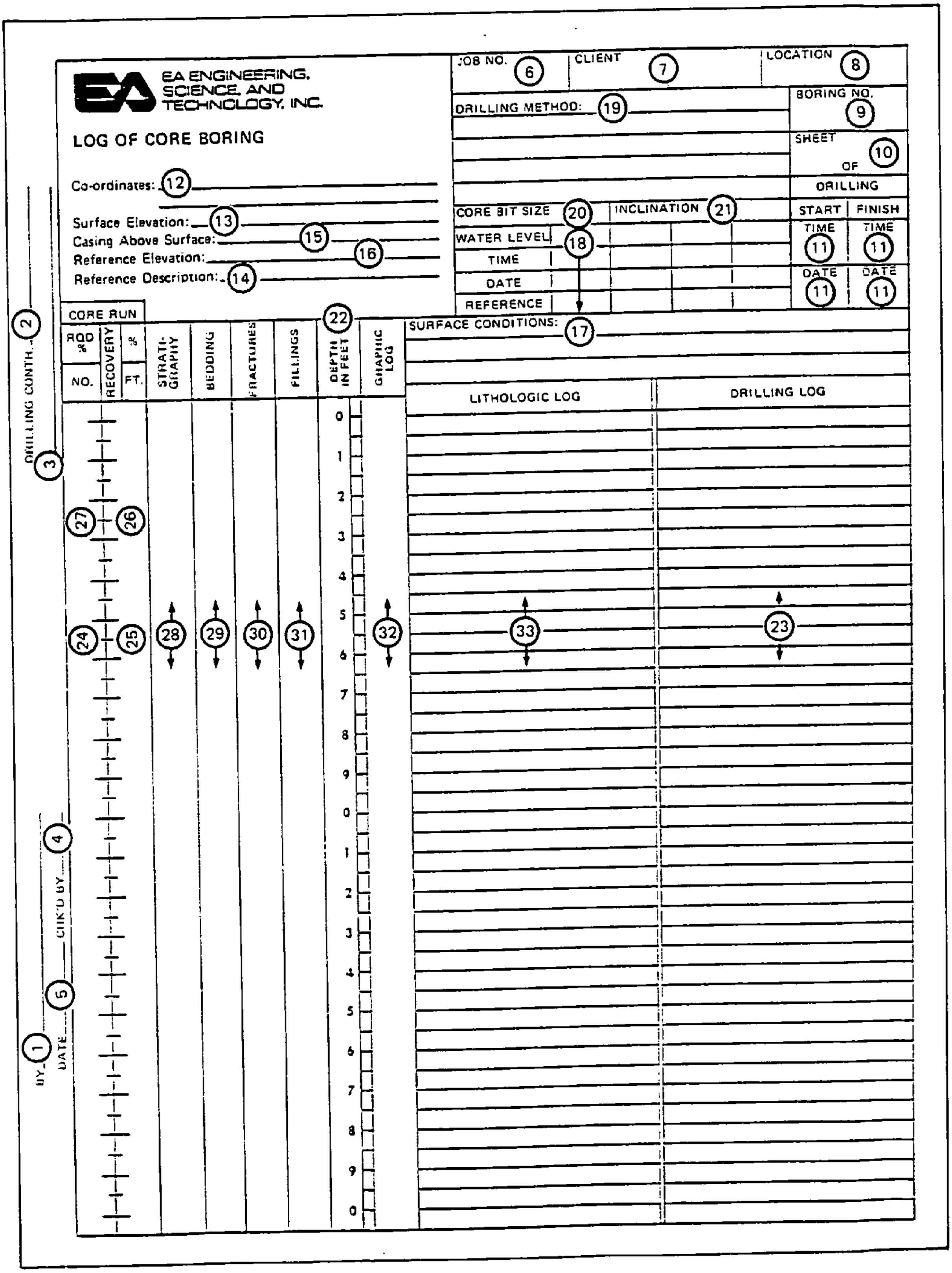
SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	DEPTH OF CASING	SAMPLE NO / SAMPLE DEPTH	BLOWS/6 in. SAMPLER		DEPTH IN FEET ㉑	GRAPHIC LOG	
㉒	㉓	㉔	㉕	㉖	㉗	0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0	㉘	㉙

DRILLING CONTR. ② ③

CHK'D BY ④ ⑤

BY ① DATE

Figure 1. Standard format for log of soil boring.



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

LOG OF CORE BORING

JOB NO. ⑥
CLIENT ⑦
LOCATION ⑧
BORING NO. ⑨
SHEET ⑩ OF
DRILLING METHOD: ⑲
Co-ordinates: ⑫
Surface Elevation: ⑬
Casing Above Surface: ⑮
Reference Elevation: ⑯
Reference Description: ⑭
CORE BIT SIZE ⑳
INCLINATION ㉑
WATER LEVEL ⑱
TIME
DATE
REFERENCE

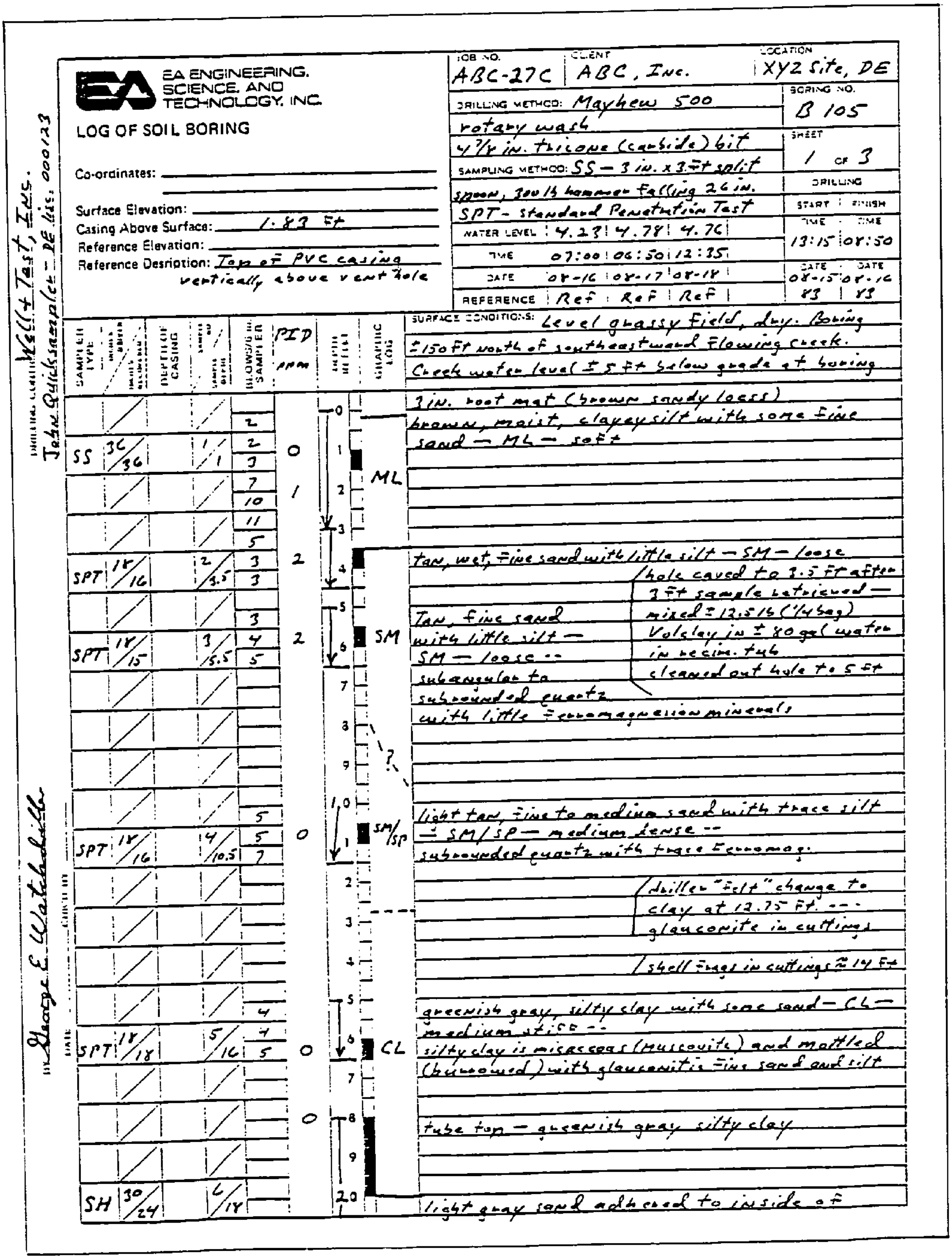
DRILLING	
START	FINISH
TIME ⑪	TIME ⑪
DATE ⑪	DATE ⑪

SURFACE CONDITIONS: ⑰

DRILLING CONTR. ② ③
BY ① DATE ⑤ CHK'D BY ④

CORE RUN								DEPTH IN FEET ㉒	GRAPHIC LOG	LITHOLOGIC LOG	DRILLING LOG
RQD %	RECOVERY	%	STRATIGRAPHY	BEDDING	FRACTURES	FILLINGS					
NO.		FT.									
㉗ ㉔		㉖ ㉕	㉘	㉙	㉚	㉛	0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0	㉜	㉝	㉓

Figure 2. Standard format for log of core boring.



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

LOG OF SOIL BORING

Co-ordinates:
Surface Elevation:
Casing Above Surface: 1.83 ft
Reference Elevation:
Reference Desription: Top of PVC casing vertically above vent hole

JOB NO. ABC-27C
CLIENT ABC, Inc.
LOCATION XYZ Site, DE
BORING NO. B 105
DRILLING METHOD: Mayhew 500 rotary wash 4 7/8 in. tricone (carbide) bit
SHEET 1 OF 3
SAMPLING METHOD: SS — 3 in. x 3 ft split spoon, 300 lb hammer falling 24 in.
SPT - Standard Penetration Test

WATER LEVEL	4.23	4.78	4.76	
TIME	07:00	06:50	12:35	
DATE	08-16	08-17	08-18	
REFERENCE	Ref	Ref	Ref	

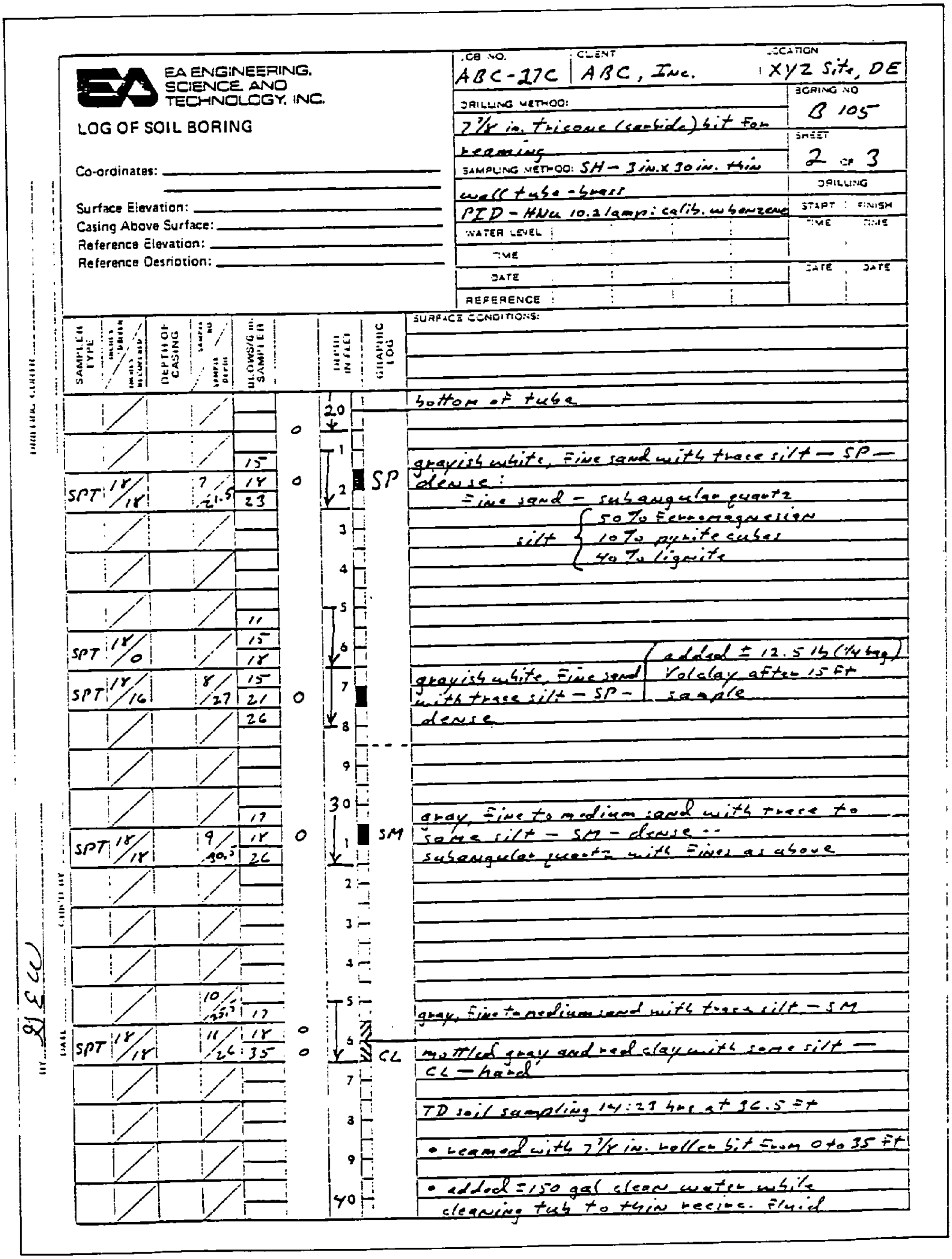
DRILLING	
START	FINISH
TIME 13:15	TIME 08:50
DATE 08-15-83	DATE 08-16-83

SURFACE CONDITIONS: Level grassy field, dry. Boring ± 150 ft north of southeastward flowing creek. Creek water level ± 5 ft below grade at boring

SAMPLER TYPE	[illegible]	DEPTH OF CASING	[illegible]	BLOWS/6 IN. ON SAMPLER	PID ppm	DEPTH IN FEET	GRAPHIC LOG	
								3 in. root mat (brown sandy loess)
				2		0		brown, moist, clayey silt with some fine
SS	36/36		1/1	2 3	0	1		sand — ML — soft
				7 10	1	2	ML	
				11 5		3		
SPT	18/16		2/3.5	3 3	2	4		tan, wet, fine sand with little silt — SM — loose hole caved to 3.5 ft after 3 ft sample retrieved —
				3		5		Tan, fine sand / mixed ± 12.5 lb (1/4 bag)
SPT	18/15		3/5.5	4 5	2	6	SM	with little silt — / Volclay in ± 80 gal water SM — loose -- / in recirc. tub
						7		subangular to / cleaned out hole to 5 ft subrounded quartz
						8		with little ferromagnesian minerals
						9	?	
				5		1,0		light tan, fine to medium sand with trace silt
SPT	18/16		4/10.5	5 7	0	1	SM/SP	± SM/SP — medium dense -- subrounded quartz with trace ferromag.
						2		driller "felt" change to
						3		clay at 12.75 ft. --- glauconite in cuttings
						4		shell frags in cuttings ≈ 14 ft
				4		5		greenish gray, silty clay with some sand — CL — medium stiff --
SPT	18/18		5/16	4 5	0	6	CL	silty clay is micaceous (muscovite) and mottled (burrowed) with glauconitic fine sand and silt
						7		
					0	8		tube top — greenish gray silty clay
						9		
SH	30/24		6/18			20		light gray sand adhered to inside of

Well + Test, Inc.
John Quicksampler – DE Lic. 000123
George E Watchdille

Figure 3. Example log of soil boring/monitor well.



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

LOG OF SOIL BORING

JOB NO.	ABC-27C
CLIENT	ABC, Inc.
LOCATION	XYZ Site, DE
BORING NO	B 105
SHEET	2 of 3
DRILLING METHOD:	7 7/8 in. tricone (carbide) bit for reaming
SAMPLING METHOD:	SH — 3 in. x 30 in. thin wall tube - brass PID — HNu 10.2 lamp; calib. w benzene
WATER LEVEL	
TIME	
DATE	
REFERENCE	
DRILLING START TIME / DATE	
DRILLING FINISH TIME / DATE	

Co-ordinates: ______________

Surface Elevation: ______________

Casing Above Surface: ______________

Reference Elevation: ______________

Reference Desription: ______________

DRILLING CONTR. ______________

BY ______ DATE ______ CHECKED BY ______

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	DEPTH OF CASING	SAMPLE NO. / SAMPLE DEPTH	BLOWS/6 in. ON SAMPLER		DEPTH IN FEET	GRAPHIC LOG	SURFACE CONDITIONS:
						20		bottom of tube
					0			
				15		1		grayish white, fine sand with trace silt — SP —
SPT	18/18		7/21.5	18	0	2	SP	dense:
				23				fine sand — subangular quartz
						3		silt { 50% ferromagnesian 10% pyrite cubes 40% lignite
						4		
				11		5		
SPT	18/0			15		6		added ± 12.5 lb (1/4 bag) Volclay after 15 ft sample
				18				
SPT	18/16		8/27	15		7		grayish white, fine sand with trace silt — SP — dense
				21	0			
				26		8		
						9		
				17		30		gray, fine to medium sand with trace to some silt — SM — dense -- subangular quartz with fines as above
SPT	18/18		9/30.5	18	0	1	SM	
				26				
						2		
						3		
						4		
			10/35.5	17		5		gray, fine to medium sand with trace silt — SM
SPT	18/18		11/26	18	0	6	CL	mottled gray and red clay with some silt — CL — hard
				35	0			
						7		TD soil sampling 14:23 hrs at 36.5 ft
						8		• reamed with 7 7/8 in. roller bit from 0 to 35 ft
						9		• added ±150 gal clean water while cleaning tub to thin recirc. fluid
						40		

Figure 3. (Cont.)

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

LOG OF SOIL BORING

Co-ordinates:
Surface Elevation:
Casing Above Surface:
Reference Elevation:
Reference Desriotion:

JOB NO. ABC-27C	CLIENT ABC, Inc.	LOCATION XYZ Site, DE
DRILLING METHOD:		BORING NO. B 105
SAMPLING METHOD:		SHEET 3 OF 3
WATER LEVEL		DRILLING START / FINISH
TIME		TIME / TIME
DATE		DATE / DATE
REFERENCE		

SURFACE CONDITIONS:

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	DEPTH OF CASING	SAMPLE NO / SAMPLE DEPTH	BLOWS/6 in. SAMPLER	DEPTH IN FEET	GRAPHIC LOG
					0	
					1	
					2	
					3	
					4	
					5	
					6	
					7	
					8	
					9	
					0	
					1	
					2	
					3	
					4	
					5	
					6	
					7	
					8	
					9	
					0	

- back filled with Morie #2 sand to 34 Ft
- 4 in. ID, sched. 40, Flush joint, threaded PVC well installed with 0.010 in. slotted screen from 34 to 24 Ft
- Morie #2 sand tremied into annulus from ~~2~~ 34 to 20 Ft
- bentonite pellets placed from 20 to 12 Ft
- cement-bentonite grout (used 2 bags Portland type I and ½ bag Volclay) placed from 12 Ft to surface and
- set 5 Ft length of 6 in. steel casing 3 Ft into casing seal
- locked steel cap and left well site at 17:50 hrs 08/15/83

08/16/83
07:00 hrs - started developing with air lift surge
07:50 - water clear after surging
08:30 - stopped developing
dug out 18 in. radius around 6 in. casing to 6 in depth and poured collar of cement-bentonite grout
08:50 - moved to B 106

Figure 3. (Cont.)

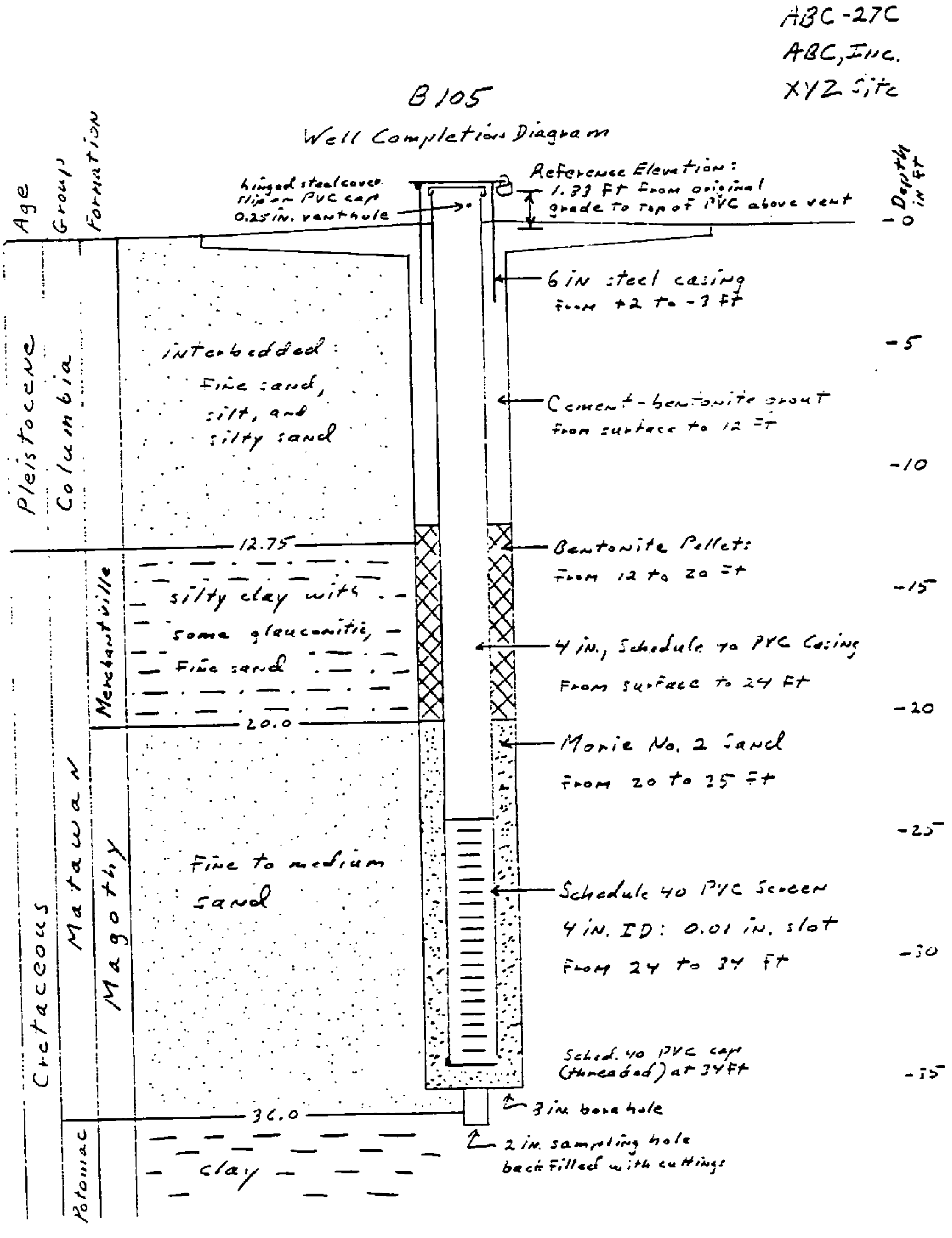
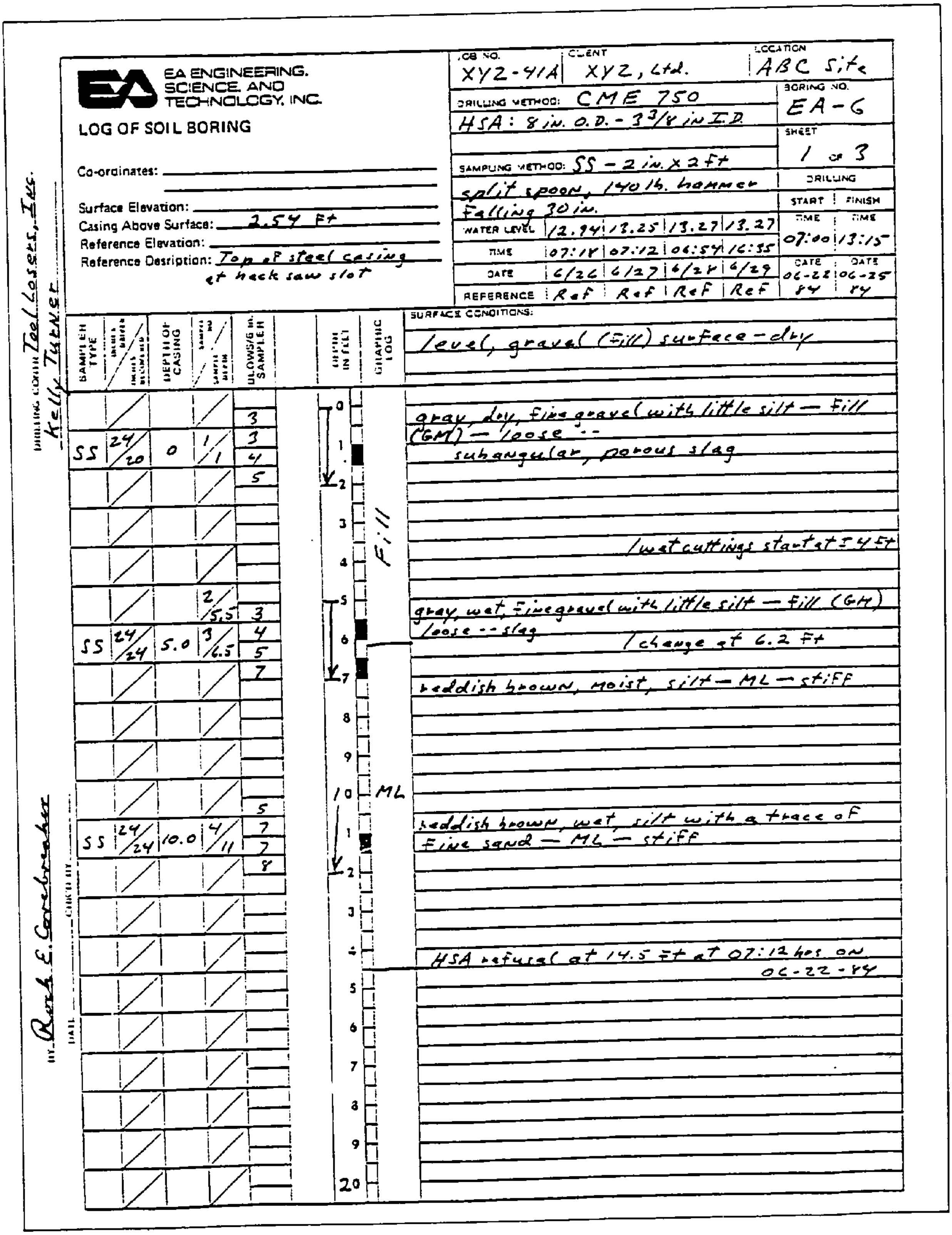


Figure 3. (Cont.)



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

LOG OF SOIL BORING

Co-ordinates:
Surface Elevation:
Casing Above Surface: 2.54 Ft
Reference Elevation:
Reference Desription: Top of steel casing at hack saw slot

JOB NO. XYZ-41A	CLIENT XYZ, Ltd.		LOCATION ABC Site
DRILLING METHOD: CME 750 HSA: 8 in. O.D. - 3 3/8 in I.D.			BORING NO. EA-6
SAMPLING METHOD: SS - 2 in. x 2 ft split spoon, 140 lb. hammer falling 30 in.			SHEET 1 of 3

					DRILLING	
					START	FINISH
WATER LEVEL	12.94	13.25	13.27	13.27	TIME 07:00	TIME 13:15
TIME	07:18	07:12	06:54	16:35		
DATE	6/26	6/27	6/28	6/29	DATE 06-22-84	DATE 06-25-84
REFERENCE	Ref	Ref	Ref	Ref		

SURFACE CONDITIONS: level, gravel (Fill) surface - dry

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	DEPTH OF CASING	SAMPLE NO. / SAMPLE DEPTH	BLOWS/6 in. SAMPLER	DEPTH IN FEET	GRAPHIC LOG	
				3	0		gray, dry, fine gravel with little silt — fill (GM) — loose --
SS	24/20	0	1/1	3 4	1		subangular, porous slag
				5	2		
					3	Fill	
					4		/wet cuttings start at = 4 Ft
			2/5.5	3	5		gray, wet, fine gravel with little silt — fill (GM) loose -- slag
SS	24/24	5.0	3/6.5	4 5	6		/change at 6.2 Ft
				7	7		reddish brown, moist, silt — ML — stiff
					8		
					9		
				5	10	ML	reddish brown, wet, silt with a trace of fine sand — ML — stiff
SS	24/24	10.0	4/11	7 7	1		
				8	2		
					3		
					4		HSA refusal at 14.5 Ft at 07:12 hrs on 06-22-84
					5		
					6		
					7		
					8		
					9		
					20		

DRILLING CONTR. Tool Losers, Inc.
Kelly Turner
BY Rock E. Corebreaker
DATE
CHECKED BY

Figure 4. Example log of soil-rock boring/monitor well.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

LOG OF CORE BORING

JOB NO.	XYZ-41A
CLIENT	XYZ, Ltd.
LOCATION	ABC Site
DRILLING METHOD:	CME 750 10 ft, double tube, core barrel GSA Rock-Color Chart
BORING NO.	EA-6
SHEET	2 OF 3
CORE BIT SIZE	NX
INCLINATION	
DRILLING START TIME / DATE	
DRILLING FINISH TIME / DATE	

Co-ordinates:
Surface Elevation:
Casing Above Surface:
Reference Elevation:
Reference Description:

WATER LEVEL				
TIME				
DATE				
REFERENCE				

SURFACE CONDITIONS:

DRILLING CONTR.
BY REC DATE CHK'D BY

CORE RUN (NO.)	RQD % / RECOVERY % / FT.	BEDDING	FILLINGS	DEPTH IN FEET	GRAPHIC LOG
				10	
				1	
				2	ML
				3	
				4	
Run #1	RQD 89% Rec. 5.32 ft/97%	12	silt + Fe stain	5	
				6	
				7	
				8	
				9	
				20	
Run #2	RQD 86% Rec. 10.2 ft (0.2 ft grout) / 100%		calcite	1	
				2	
				3	
				4	
			Fe stain	5	
				6	
				7	
				8	
			Fe stain slks.	9	
				30	

LITHOLOGIC LOG

LIMESTONE - dolomitic;
fine-grained, dark gray
(N3); bedding 0.4-0.6 ft
thick, planes limonite stained;
rock-hard, weathering
very slight
prim. & sec. K low -
fine-grained, hard,
very slightly weathered,
no fractures

dip-slip slickensides
on bedding planes and
sub-parallel fractures

DRILLING LOG

Run #1 through HSA
14.5 ft at 08:10 hrs
Hole took ± 50 gal water
before return circulation at
16 ft - cuttings gray L.S.
Drilling smooth at constant
rate (avg. 4.5 min/ft) to
20 ft at 08:22 hrs
Drove 10 in steel casing to 8 ft
Pulled HSA, hole open to 10 ft
Cleared hole and reamed
rock to 20 ft by rotary
wash with 7 7/8 in.
carbide tricone bit.
Set 6 5/8 in. OD/6 in. ID steel
casing to 20 ft. Mixed 5 bags
cement and 30 gal water +
pumped through 1 in tremie
pipe. Could not get tremie
past 15 ft. Filled annulus
to surface. Sounded ± 3 in.
grout inside 6 in. casing.
Pulled 10 in. casing, added
grout and built grout collar
1 ft radius outside 6" casing by 6"
Left site 15:30 hrs 06-22-84
Return 07:00 hrs 06-25-84
Run #2 through 6 in. casing
19.8 ft at 07:18 hrs
Drilling smooth at
constant rate to 30 ft
at 08:08 hrs
(avg 5 min/ft)

Figure 4. (Cont.)

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

LOG OF CORE BORING

JOB NO.	XYZ-41A
CLIENT	XYZ, Ltd.
LOCATION	ABC Site
BORING NO.	EA-6
SHEET	3 OF 3

Co-ordinates:
Surface Elevation:
Casing Above Surface:
Reference Elevation:
Reference Description:

DRILLING METHOD:

CORE BIT SIZE | INCLINATION

WATER LEVEL			
TIME			
DATE			
REFERENCE			

DRILLING	
START TIME	FINISH TIME
DATE	DATE

SURFACE CONDITIONS:

DRILLING CONTR.
BY REC
DATE
CHK'D BY

CORE RUN NO.	RQD % / RECOVERY % FT.	STRATIGRAPHY	BEDDING	FRACTURES	FILLINGS	DEPTH IN FEET	LITHOLOGIC LOG	DRILLING LOG
Run #3	RQD 74% Rec. 9.7 ft / 97%					30		Run #3
					Fe. stain slks			30 ft at 08:15 hrs
			12			1		Hole taking 3-5 gpm below 31 ft
								Drill chatter and lost circ.
						2		at 33 ft — added ±250 gal
							Shear zone at 33 to 35 ft	water during run — return
					Fe. stain slks	3	Near horizontal attitude	circ. at 33.5 ft
							and dip-slip slickensides	Drilling rate ±3 min/ft from
						4	indicate thrust fault	33 to 35 ft — chatter
							High secondary K in shear	stoped at 35 ft
						5	zone	Drilling rate ±4 min/ft
								From 35 to 40 ft
			8		Fe. stain	6	Lithology, bedding thick-	
							ness and rock quality	
						7	below shear zone is	
							same as above	
					Fe. stain	8	Bedding dips 12° above	
							shear and 8° below shear	
						9		
								TD coring at 40 ft at
						40		08:56 hrs 06-25-84
								Reamed NX hole with 5 5/8 in.
						1		carbide tricone by rotary
								wash bit at:
						2		20 ft at 09:20 hrs
								30 ft at 10:40 hrs
						3		40 ft at 11:50 hrs
								Continued washing through bit
						4		while cleaning recirc. tub
								added ±100 gal water
						5		waste ±60-70 gal
								est 2.5-3 ft³ cuttings
						6		recirc. water clear at
								12:40 hrs (lunch till 13:15)
						7		Moved rig to EA-7 at
								13:15 hrs 06-25-84
						8		
						9	06-27-84 — Well developed by air lift	
							surge (150 cfm) 16:00 to 17:00 hrs	
						0	hole open to 40 ft	

Figure 4. (Cont.)

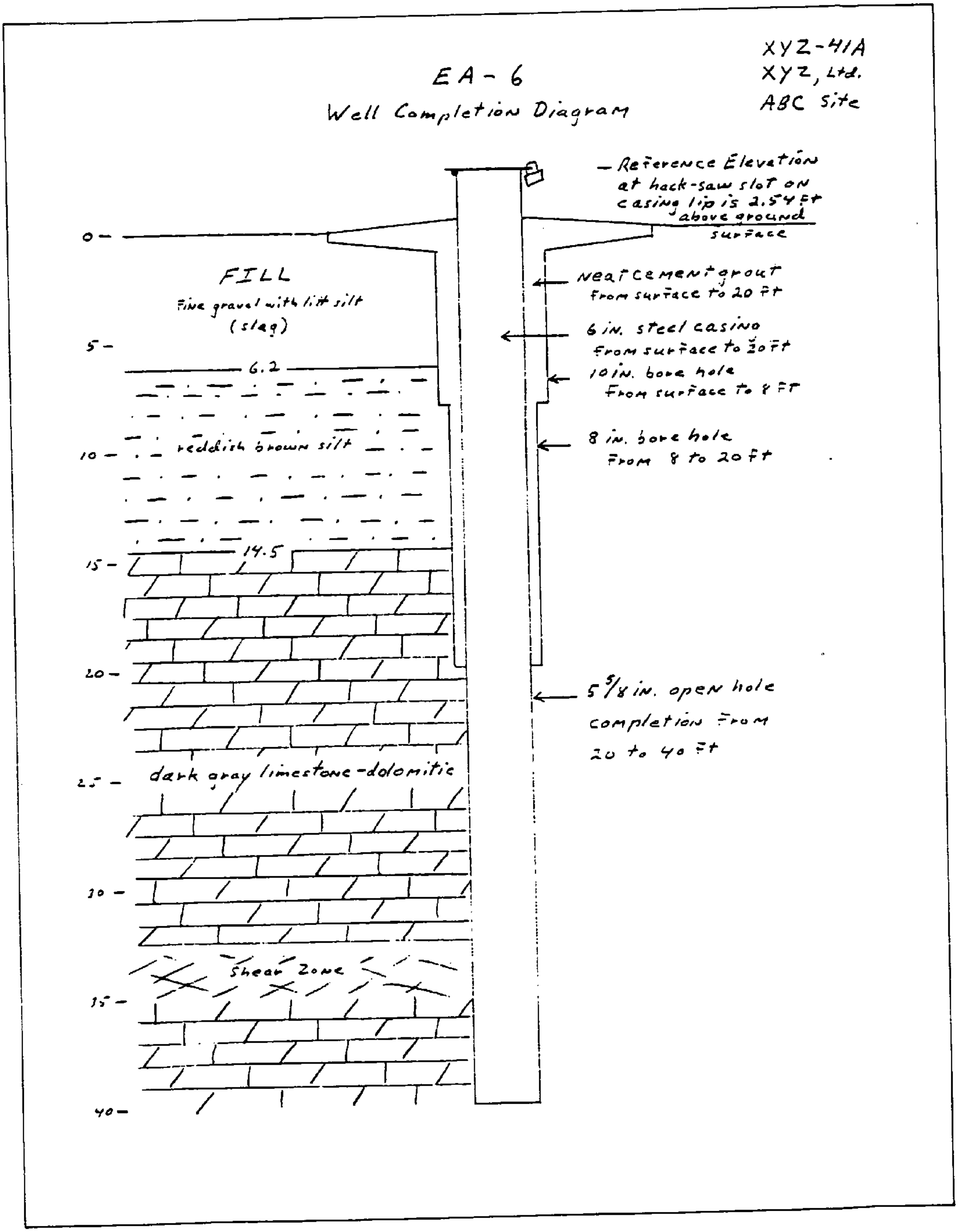


Figure 4. (Cont.)

2. LOG OF SOIL BORING

A Log of Soil Boring is completed for all test borings and borings advanced through soil for purposes of installing a well or piezometer. A Soil Boring Log is completed for the overburden portion of a boring advanced through soil and into bedrock. If rock core is obtained, a Core Boring Log is completed as appropriate (Section 4). In the event that no core of bedrock is obtained, the Log of Soil Boring form may be used to log drill cuttings from the bedrock portion of the boring. Refer to Figure 1 for the location of the following items. All items except Nos. 4, 5, 12, 13, and 16 as discussed below, are completed in the field by the geologist/engineer responsible for the boring.

1. The field geologist/engineer completing the log shall sign his full name on the first page of the log for each boring in a clear and legible fashion. Initials will suffice on succeeding pages of the log. The signature/initials are placed upon completion of each page of the log as certification of the accuracy and completeness of the log by the field geologist/engineer. In the event there is a personnel change prior to completion of the boring, the personnel involved, the date, and time (24-hour clock) of change shall be documented in the descriptive portion (29) of the log at the depth where the change occurred.

2. The full name (legal, business name) of the drilling company shall be placed on the first page of the log for each boring. Any change shall be documented as per item 1.

3. The full name of the driller shall be placed on the first page of the log for each boring. In states which require a licensed driller for the type of work in progress, the driller's license number shall also be placed on line 3 of the first page of the log for each boring. Any change shall be documented as per item 1.

4. Each boring log shall be checked for completeness and edited as appropriate by a qualified geologist or engineer to be assigned by the project manager or the Director of Geotechnical Services. Editing shall be completed prior to preparation of final boring logs in report format (cf. Project Plan). Editing of sample descriptions and soil classifications shall be performed as appropriate for all samples for which laboratory, physical testing (e.g., grain-size distribution by sieve and hydrometer) has been performed. Sample descriptions and soil classification shall also be checked by visual examination of jar samples. Typically, a minumum of 25 percent of the jar samples are checked by the editor (cf. Project Plan).

The editor shall initial line 4 of each edited page of the log he edits.

5. The editor shall indicate the date each page was edited on line 5 of the edited page.

6. EA's alpha-numeric job code shall be indicated on each page of each boring log.

7. The client's name shall be indicated on each page of each boring log.

8. The site name or other geographic designation of the drilling site as appropriate shall be indicated on each page of each boring log.

9. The boring number as per the Project Plan shall be indicated on each page of each boring log.

10. The page number and total number of pages for the log shall be indicated on each page of each boring log.

11. The time (24-hour clock) and date drilling operations begin and end, including grouting or completion of well installation, shall be indicated on the first page of each boring log. The time and date of completion of soil sampling activities shall be documented in the descriptive portion of the log at the depth of penetration of the last sample or sample attempt. For borings completed in more than 1 day, the time and date drilling operations stop and resume shall be indicated in the descriptive portion of the log at the appropriate depth.

12. Coordinates of latitude and longitude shall be indicated on the first page of the log for each surveyed boring. Surveyed information is generally added by the editor in the office. When surveyed by EA during the same mobilization, this information may be added in the field. If so, the editor shall confirm that all QA/QC for the survey data have been met. The use of a site datum shall be indicated on the log. If a site grid is utilized, the site grid coordinates shall be indicated on the field log and identified as such.

13. The elevation of the ground surface at the bore hole shall be indicated on the first page of each boring log. Surveyed information is added or checked by the editor as per item 12.

14. A reference point for determination of elevation and water levels shall be established as per the Project Plan for each monitoring well. The field geologist/engineer shall ensure that the reference point is permanently marked in a clearly visable fashion (cf. Project Plan). The reference point and its marking shall be described on the first page of each boring log (e.g., "top of PVC casing next to hack saw slot"). Unless otherwise stipulated in the Project Plan, the reference point shall be established on the well riser casing rather than the protective casing.

15. The field geologist/engineer shall determine the difference in elevation between the reference point (14) and the ground surface at the bore hole (13), and record this information on the first page of the boring log. Casing "stick up" is recorded as a positive number. For "man hole" type completions, where the reference point is below grade, a negative number is recorded and the type of surface completion described.

16. The elevation (± 0.01 ft) of the reference point shall be indicated on the first page of each boring log. Survey information is generally added or confirmed as per item 12 by the editor. The use of a datum other than mean sea level shall be indicated.

17. Surface conditions at the bore hole site shall be described on the first page of the log and continued on succeeding pages as necessary (e.g., "level, asphalt pavement-dry" or "grassy slope [± 3 percent], ground soft and wet"). Significant nearby features (outcrops, surface water bodies, etc.) should be noted.

18. The depth to water (± 0.01 ft) shall be determined and recorded as feasible during drilling and as per the Project Plan after well completion. The time (24-hour clock) and date for each determination shall be noted on the log. The point from which the depth was measured--either "surf" for ground surface (13), or "ref" for the established reference point (14)--shall also be indicated for each depth to water recorded.

19. The drilling equipment and methodology shall be summarized on the first page of each boring log (and continued on succeeding pages as necessary). Record the rig manufacturer and model. Note such information as rod size, bit type and size, internal and external diameter of hollow stem augers, pump type or compressor size, etc.

20. The method(s) for obtaining soil samples shall be identified on the first page of each boring log (and continued on succeeding pages as necessary). The citation of ASTM designations on this portion of the log constitutes the field geologist/engineer's certification that the ASTM standard was met.

21. All information in the descriptive portion of the log is placed with reference to the depth scale which is divided into 0.5-ft increments. The field geologist/engineer shall indicate "tens" units on the depth in feet scale as apprporiate. The sampler drive interval shall be indicated on the left side of the column as shown on Figure 4. The vertical location of samples (25) shall be indicated by shading on the scale as shown on Figure 4.

22. For each soil sampling attempt the type of sampler shall be indicated at the appropriate depth. The most commonly used samplers are:

    <u>SPT</u>--Standard Penetration Test (ASTM D-1586-84) samples are obtained in soil by driving a split spoon sampler of 2-in. outside diameter/one and three-eights-in. inside diameter and a length of split barrel of 18 or 24 in. The sampler is driven into undisturbed soil by a 140-lb drop hammer free-falling 30 in. The number of "blows" (hammer drops) required to effect each successive 6 in. of penetration are recorded on the log (26). The sampler is advanced until one of the following occurs:

    1. a total of 50 blows have been applied during any one of the first, second, or third 6-in. increment,
    2. a cumulative total of 100 blows have been applied,
    3. there is no observed advance of the sampler during the application of 10 successive blows of the hammer, or
    4. the sampler is advanced a total of 18 in. without the limiting blow counts, as described above, occurring.

SS--When Standard Penetration Test data (blow counts) are not required the above described split spoon sampler may be driven 24 in. rather than 18 in. Larger diameter and/or length split spoon samplers may be used. Heavier hammer weights and different drop lengths may be used with larger split spoons. All of which must be in accordance with the Project Plan. Sampler dimension, hammer weight and length of hammer drop shall be described under item 20. Blow counts are also recorded on the log (26).

SH--Cohesive and plastic soils may be sampled with the Shelby Tube sampler which utilizes a brass or steel, thin wall tube of 3-in. outer diameter and 30 in length (typical). Tube dimensions shall be recorded in item 20. The sampler is pushed into undisturbed soil by one continuous drive using a hydraulic piston.

DEN--The Denison Core Barrel Sampler may be used to sample stiff and hard clay, non-cohesive soil or soft, weathered rock. Sawtooth, carbide or diamond coring bits may be utilized (cf. Project Plan). Sampling tube dimensions shall be recorded in item 20. The Denison sampler is advanced by rotary and continuous drive using a hydraulic piston.

OST--The Osterberg Piston Sampler advances a thin wall sampling tube with a down-hole hydraulic piston. Tube dimensions shall be recorded in item 20. The sampler is lowered into a drilled and cleaned-out hole. Reaction to pushing is accomplished by clamping drill rod to either casing or drill rig. Water pressure, applied through rod, pushes piston and its attached thin-walled sampling tube out of sampler's pressure cylinder and into soil. A fixed piston, at bottom of sampler, is connected to sampler head by a hollow piston rod. A vent hole in piston rod relieves air pressure through piston rod and ball check in sampler head. When full stroke of piston is reached, water pressure is also relieved through vent hole, piston rod and ball check. Sampler is then turned 1-1/2 revolutions to shear off bottom of sample. A friction clutch holds sampling tube to sampler.

23. The total number of inches the sampler is advanced (actual penetration) into undisturbed soil and the total number of inches of actual sample recovered shall be recorded for each sampling attempt.

24. The total depth (± 0.1 ft) of penetration of casing or hollow stem auger at the time of the sampling attempt shall be recorded for each sampling attempt. Casing depth shall be no greater than the shallowest portion of the attempted sample interval.

25. Samples which are retained in jars and/or tubes (or other appropriate containers as per the Project Plan) shall be numbered sequentially down the bore hole. Unsuccessful sampling attempts shall not be numbered. Individual samples from one sampler drive shall be numbered individually. The sample number and depth (± 0.5 ft) of the top of that portion of the sample which is retained shall be recorded for each sample. The vertical location of the containerized sample shall be indicated by shading on the depth scale (21).

Each sample container shall be labeled. The label shall be permanently marked (e.g. Sharpie) and shall identify the following:

<u>Client</u>:	as per item 7
<u>Project</u>:	as per item 6
<u>Location</u>:	as per item 8
<u>Station</u>:	Boring No. as per item 9, Sample No. and sample depth as per item 25
<u>Collected by</u>:	name of field geologist/engineer
<u>Date</u>:	of sample collection

Chain-of-custody requirements may also apply as per the Project Plan. Containerization and handling of soil samples scheduled for chemical analysis is defined in the Project Plan.

26. The number of hammer blows required to advance a split spoon sampler shall be recorded for each 0.5-ft advance for each sampling attempt. The number of blows and the number of inches penetrated for an incompleted 0.5-ft interval shall be recorded (e.g., 75/3 in.). The letter "P" shall indicate that the sampler was advanced by the weight of the drill stem or the weight of the drill stem and hammer without driving. For the Standard Penetration Test (and only for the Standard Penetration Test), when less than 18 in. (but greater than 12 in.) are penetrated by a total (maximum allowable) of 100 blows, the number of

blows for the last 12 in. of penetration (N) shall also be recorded (e.g., N = 63).

27\. A number of field determinations of properties of soil samples may be made in the field as per the Project Plan. These include but are not limited to:

- pocket penetrometer readings
- screening for organic vapors with a photoionozation detector (PID) or flame-ionization detector (FID)
- pH
- specific conductance

Protocols are established in the Project Plan. The protocol shall be identified in item 20 and the data recorded in column 27 with reference to the depth scale (21).

28\. The depth of each significant lithologic change shall be drawn to scale (± 0.1 ft) on the graphic log. Lithology shall be designated by the appropriate Unified Soil Classification System symbol. Changes observed in samples shall be indicated with a solid line. Changes inferred on the basis of cuttings or action of the drill rig shall be indicated with a dashed line on the graphic log and described in the narrative log (29). Gradational changes shall be indicated by a dashed, diagonal line extending over the depth of the gradational interval.

29\. Each soil sample recovered shall be fully described on the log. The descriptions of intact samples shall include in sequence the following:

<u>Color</u>--e.g., "gray" or "reddish brown." Some project plans may specify the use of the Munsell Soil Color Chart or the Geological Society of America Rock Color Chart. If so, the chart shall be identified in item 20 and both narrative and numerical descriptions of color shall be recorded in the log.

<u>Moisture Content</u>--"dry," "moist," or "wet." Below the water table, moisture content is noted only for samples less than completely saturated.

<u>Unified Soil Classification</u>--e.g., "sandy clay." Appendix D summarizes the Unified Soil Classification System. Additional guidance is provided in Tables 1 and 2.

ASTM designations D-2487 and D-2488 define standard engineering practice.

Secondary Components--e.g., "with some silt." Descriptive terms for relative proportions of secondary components are provided in Table 1.

Unified Soil Classificatin Symbol--e.g., "CL." Refer to Appendix D.

Density (noncohesive soil)--e.g., "medium dense." Refer to Table 1.

Consistency (cohesive soil)--e.g., "stiff." Refer to Table 1.

Between sampling attempts wash samples, drill or auger cuttings shall be described as to color and grain size, along with a description of drill action and water losses/gains for the corresponding depth.

The brand name and amount (lb) of any bentonite used for each boring, the reason for use and start (by depth) of this use shall be recorded.

A narrative description of all special problems and their resolutions shall be recorded on the boring log, e.g., hole caving, "running sands," recurring problems at a particular depth, excessive grout takes, unrecovered tools, casing or screens, etc.

A narrative description of the grouting of the bore hole or the installation of the monitoring well shall be recorded on the boring log (below the depth of completion and/or on succeeding pages). For monitoring wells, the following shall be recorded:

- Depths of screened interval, screen composition, diameter and slot size
- Composition and diameter of riser casing
- Depths of screen pack placement, size gradation of screen pack or commercial designation thereof (e.g., Morie No. 2)
- Depths of bentonite seal placement
- Composition and depths of placement of casing seal
- Description of protective casing
- Composition and placement of surficial grout

A Well Completion Diagram shall also be completed as described in Section 3. However, since the Well Completion Diagram may not be prepared in the field, the above information shall be recorded on the Log of Boring at the time of well completion.

TABLE 1 FIELD CLASSIFICATION OF SOIL SAMPLES

Particle Size Identification

Boulders	12-in. diameter or more	
Cobbles	3-12-in. diameter	
Gravel	Coarse	3/4-3 in.
	Fine	1/4-3/4 in.
Sand	Coarse	2.0-4.75 mm (dia. of pencil lead)
	Medium	0.425-2.0 mm (dia. of broom straw)
	Fine	0.074-0.425 mm (dia. of human hair)
Silt		0.005-0.074 mm (cannot see particles)

Moisture Content

Descriptive Term	Criteria
Dry	Absence of moisture, dusty, dry to touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Relative Proportions

Descriptive Term	Percent
Trace	1-10
Little	11-20
Some	21-35
And	36-50

NONCOHESIVE SOILS

(Silt, Sand, Gravel, and Combinations)

Density

Descriptive Term	$N^{(a)}$
Very Loose	5 blows/ft or less
Loose	6-10 blows/ft
Medium Dense	11-30 blows/ft
Dense	31-50 blows/ft
Very Dense	51 blows/ft or more

COHESIVE SOILS

(Clay, Slit, and Combinations)

Consistency

Descriptive Term	$N^{(a)}$
Very Soft	3 blows/ft or less
Soft	4-5 blows/ft
Medium Stiff	6-10 blows/ft
Stiff	11-15 blows/ft
Very Stiff	16-30 blows/ft
Hard	31 blows/ft or more

Plasticity

Degree of Plasticity	Plasticity Index
None to slight	0-4
Slight	5-7
Medium	8-22
High to Very High	over 22

(a) Standard Penetration Test -- Driving a 2-in. O.D., 1-3/8-in. I.D., split barrel sampler a distance of 1 ft into undisturbed soil with a 140-lb. hammer free falling a distance of 30 in. The sampler is driven 6 in. to seat into undisturbed soil; then the test is performed. The number of hammer blows for seating the spoon and making the test are recorded for each 6 in. of penetration on the drill log (e.g., 6/8/9). The standard penetration test result (N) is obtained by adding the last two figures (i.e., 8 + 9 = 17 blows/ft) (ASTM D-1586-84).

TABLE 2 COMPARISON OF GRAIN SIZE SCALES FOR SOILS

in.	UNIFIED	AASHO	AGU	WENTWORTH	mm.
	boulders	coarse gravel or stone		boulder gravel	4026
			very large boulders		2048
			large boulders		1024
			medium boulders		512
12			small boulders		256
6	large cobbles		large cobbles	cobble gravel	128
3	small cobbles		small cobbles		64
	coarse gravel		very coarse gravel	pebble gravel	32
1 3/4		medium gravel or stone	coarse gravel		16
3/8	fine gravel		medium gravel		8
mm. 4.76	No. 4*	fine gravel or stone	fine gravel		4
	coarse sand		very fine gravel	granule gravel	2
2.00	No.10*				
1.00	medium sand	coarse sand	very coarse sand	very coarse sand	1
			coarse sand	coarse sand	1/2
0.42	No.40*				
0.25	fine sand	fine sand	medium sand	medium sand	1/4
0.125			fine sand	fine sand	1/8
			very fine sand	very fine sand	1/16
0.074	No.200*				
	silt or clay	silt	coarse silt	silt	1/32
			medium silt		1/64
			fine silt		1/128
		.005 mm.	very fine silt		1/256
		clay	coarse clay size	clay	1/512
			medium clay size		1/1024
		colloids	fine clay size		1/2048
			very fine clay size		

*U.S. Standard Sieve Number

3. WELL COMPLETION DIAGRAM

A Well Completion Diagram is prepared as part of the Log of Boring for all borings completed as a test, monitoring, observation, recovery, or production well.

The Well Completion Diagram shall be drawn on 10 to the inch graph paper. The well shall be centered on the page as shown on Figures 3 and 4. The well, borehole, and surficial completion shall be drawn at a horizontal scale of 0.1 in. equals 1.0 in. The vertical scale of the drawing shall be 1.0 in. equals 5.0 ft. Larger vertical scales (1.0 in. = 10 ft or 1.0 in. = 20 ft) shall be used to the extent necessary to illustrate the well on one page.

A summary lithologic log shall be drawn to vertical scale to the left of the well. This log shall be of a sufficient level of detail to illustrate the lithology and depths of contacts of the major hydrogeologic units. If formal stratigraphic nomenclature is known with certainty, this may be illustrated to the left of the lithology.

The elements of well completion shall be labelled and identified as to dimensions and composition to the right of the well. This shall include:

- Diameter(s) and depth(s) of boring
- Depths of screened interval, screen composition, diameter, and slot size
- Composition and diameter of riser casing
- Depths of screen pack placement, size gradation of screen pack, or commercial designation thereof
- Depths of bentonite seal placement
- Composition and depths of placement of casing seal
- Composition and placement of surficial grout
- Description of protective casing
- Definition of reference elevation and "stick up"

4. LOG OF CORE BORING

A Log of Core Boring is completed for all borings from which rock core is obtained. If soil sampling is performed in the overburden portion of the boring, a Soil Boring Log is completed as appropriate (Section 2). In the event that no soil samples are obtained, the Log of Core Boring form may be used to log drill cuttings from the overburden portion of the boring. Refer to Figure 2 for the location of the following items. The specification for Items 1 through 19 for the Log of Core Boring are identical to those for the Log of Soil Boring as described in Section 2.

20. The core bit size shall be indicated on the first sheet of each Log of Core Boring.

21. The inclination of any core boring performed in other than a vertical borehole shall be indicated as the number of degrees of inclination with respect to the surface (i.e., horizontal = 0 degrees and vertical = 90 degrees) on the first sheet of each Log of Core Boring.

22. All information in the log is placed in reference to the depth scale which is divided into 0.5-ft increments. The field geologist/engineer shall indicate "tens" units on the depth-in-feet scale as appropriate.

23. The field geologist/engineer shall record all drilling activities in chronological sequence and with respect to the depth scale. Personnel and equipment changes and shift start and stop times are documented in this item with notation of time (24-hr clock) and date of occurrence at the depth of the boring at the time of occurrence.

    Start and stop time (24-hr clock) for each core run shall be recorded. Interruptions in coring shall be documented by time of occurrence and description of the problem and its resolution. Coring rate and depths of changes in coring rate shall be recorded.

    The depths of intervals of nonrecovered core shall be identified and an evaluation of the reason for loss recorded.

    Casing record, cementing or grouting needs, changes in core bit size, changes in color of circulating water/ drilling fluid shall be recorded. Quantitative estimates of fluid losses and gains and the interval over which they occur shall be indicated. These estimates shall take into consideration losses due to spillage and intentional wasting (e.g., recirculation tank cleaning). The brand name and amount (lb) of any bentonite used, the reason for use, and start (by depth) of this use shall be recorded.

A narrative description of all special problems and their resolutions shall be recorded on the boring log, e.g., hole caving, recurring problems at a particular depth, excessive grout takes, unrecovered tools, etc.

A narrative description of the grouting of the bore hole or the completion of the monitoring well shall be recorded on the boring log (below the depth of completion). See also Section 3.

24. Core runs shall be numbered consecutively down the hole as performed and indicated on the log with horizontal lines at the appropriate depth and the core run number recorded in the lower left quadrant of the indicated core run.

25. Total core recovery (Appendix E) shall be determined in feet (± 0.1 ft) and recorded in the lower right quadrant.

26. Total core recovery as a percent of the length of core run shall be determined for each core run and recorded in the upper right quadrant.

27. The Rock Quality Designation (RQD) as a percent of the length of core run shall be determined for each core run and recorded in the upper left quadrant. The rock quality determination is performed as described in Appendix F.

28. The standard name of the rock units intersected shall be indicated in this column. Formation or member name or other geologic unit names shall be used when the stratigraphy is known. Otherwise, informal units (e.g., Unit A) may be used on a project-specific basis (cf. Project Plan).

29. The angle of bedding, foliation, schistosity, etc. shall be recorded as the dip angle as measured from the perpendicular to the core axis (i.e., in vertical core holes a bedding plane parallel to the axis of the core has a dip of 90 degrees)

30. The angle of fracture, joint, fault, or seam surfaces shall be measured from the perpendicular to the core axis and graphically illustrated to scale.

31. The dominant type of coatings or fillings (or lack thereof) found in each of the fractures or seams shall be recorded. Slickensides shall be identified as dip-slip or strike-slip; or the rake in degrees recorded.

32. Standard rock symbols (Appendix G) shall be used in the graphic log. The graphic log shall do no more than illustrate the major variations in lithology; minor changes shall be documented in the written lithologic log (33).

33. Rock core shall be visually described for the following parameters:

Lithology--The rock name shall be emphasized by capitalizing the name and putting it first. The modifying terms should follow in a logical sequence (e.g., GRANITE--fine-grained, biotite, hornblende; LIMESTONE--argillaceous).

Grain Size and Texture--The grain size of clastic sedimentary rocks shall be described according to the Wentworth scale (Table 2). The degree of cementation shall be described. Crystalline rocks are described as glassy (vitreous luster) or dense (low luster) when crystals are too small to see with a 10X hand lens. Observable crystals are classified as follows:

<1 mm	fine-grained
1 mm - 1 cm	medium-grained
1 cm - 3 cm	coarse-grained
>3 cm	very coarse-grained

For metamorphic rock, texture is identified by the rock name. Standard geologic textural terms shall be used (Appendix H).

Color--The color of clean, wet core shall be described. Some project plans may specify the use of the Geological Society of America Rock Color Chart. If so, both narrative and numerical descriptions of color shall be recorded on the log.

Bedding/Foliation/Banding--Planar Fabric of the rock shall be described in standard geologic terms. Thickness of beds or banding shall be recorded as a measurement. A representative value or range shall be recorded.

Hardness--See Appendix I.

Degree of Weathering--See Appendix J.

Solution or Void Conditions--The nature and size of cavities; the presence or absence of and composition of infillings shall be recorded.

Permeability--An evaluation of primary and secondary permeability (low, moderate, high) shall be recorded with a brief description of the rationale for the estimates.

5. HANDLING AND STORAGE OF CORE

Core shall be placed in core boxes with the top and bottom of each run clearly labeled. Core is always placed so it can be "read" like a book, top at upper left; bottom at lower right. For the standard hinged core box, the hinged side is designated the "upper side" of the box. Any breaks that are made to fit the core into the boxes shall be clearly marked and identified as such.

Wooden spacers showing the footage at the beginning and end of each run shall be placed in the boxes. Spacers should also be used to fill in zones of no core recovery. In addition, boxes should be clearly marked on each outside end to identify the job number, the boring number, the numerical position of the box (e.g., 2 of 7), and the footage interval within the box (Figure 5).

When it is necessary to split cores for detailed examination, the cores should be handled carefully and put back into the box in the same position they were prior to splitting. Before splitting core the geologist should know the nature of any testing which is anticipated, because some tests can only be run on unsplit core (e.g., RQD logging can only be done before the core is split).

Core should be stored and secured in a dry location out of the weather. Ideally, core boxes should be stored on shelves or racks to make their handling easier, especially if extensive later inspection or testing is required. As a general rule, all cores should be retained at least one year beyond the completion of a project. Cost overruns, and claims for "changed conditions" are common. The cores may be important for rechecking the conditions that the contractor faced at the time he prepared his bid compared with those which were encountered during the construction.

Examination Record

Frequently, cores are examined or otherwise handled by several people and samples of rock may be removed by various people for various reasons. It is advisable (cf. Project Plan), therefore, to have tacked inside of each core box an examination record which contains the boring number, foot interval in box, the signatures of the examiners, the dates of the examinations, and a description and interval of any rock which was removed. Any core removed for testing should be replaced with wooden blocks, clearly labeled with footage and reason for removing.

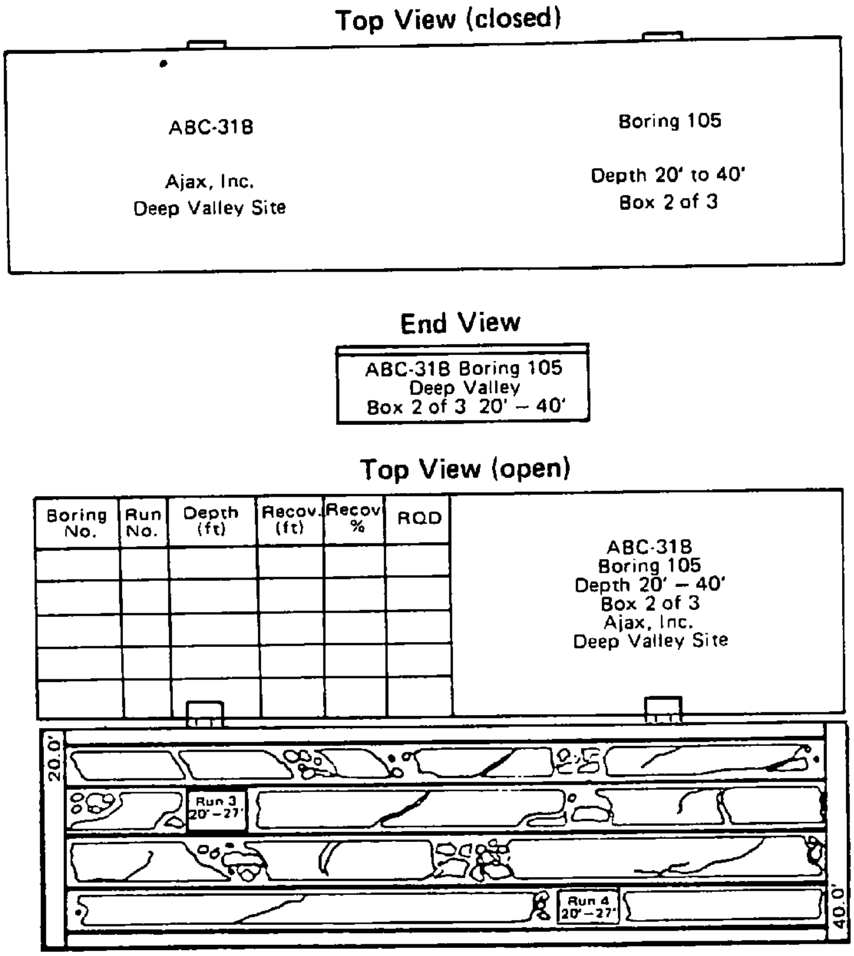


Figure 5. Labeling of core box.

APPENDIX A:

EQUIPMENT WHICH MAY BE REQUIRED FOR CORE LOGGING

Pencil

Log of Core Boring Forms

Notebook

Hand lens

Geologist's pick

Knife

Needle

Magnet

Core splitter

Ruler (graduated in tenths of a foot)

Steel tape (graduated in tenths of a foot)

A blue-white light, 100 watts or more

10% HCl solution

Rock dyes (to facilitate distinction between rock types)

Color chart

Rock classification charts

Bucket of water and paint brush (to wet core to highlight rock features)

Tape recorder

Camera

Clinometer/protractor

Waterproof marking pen (for core boxes)

Assisting muscle power (to move core boxes)

APPENDIX C:

CHECKLIST FOR DRILLING LOG

The drilling log portion of the Log of Core Boring should include the following items:

- Date and depth of hole at start and end of working day or shift
- Depth of start and finish of each core run
- Depth and size of any casing at start and end of each core run
- Core diameter and changes in core size
- Type and condition of bit
- Start and stop time of each core run
- Time and description of interruptions in coring
- Depths of changes in coring rate
- Gain or loss of water, mud, or air flush; type of cuttings
- Standing water level at start and end of each working period
- Information as to location and possible cause of core losses
- Location of samples
- Details of delays and breakdowns
- Details of *in situ* tests and instrumentation installed
- Backfilling and grouting

Note: This list excludes any special items which may be required for contractual record purposes or for special engineering tests (cf. Project Plan).

APPENDIX B:

ACTIVITIES OF THE FIELD GEOLOGIST/ENGINEER DURING DRILLING

1. Complete the Log of Boring as per the Standard Format and Project Plan.

2. Maintain a diary of all site activities.

3. Record the make, license number, and state of issuance of the vehicle(s) used by EA and subcontractors.

4. Note the weather or any special external conditions which influence the drilling.

5. Maintain a daily record of drilling cost information as per the Project Plan.

6. Check the driller's daily cost records to verify their accuracy.

7. Record the Drilling Log (Appendix C) as the core is drilled and describe any subsurface situation encountered during drilling which could relate to the engineering character of the subsurface.

8. Note date and time of all activities associated with the drilling.

9. Be responsible for the conduct of any tests (such as permeability) which are run during the drilling.

10. Make certain that the drillers follow required procedures, both for drilling and well installation (cf. Project Plan).

Note: Additional information may be needed, depending on the type of contract the drilling is done under and project needs as defined in the Project Plan.

APPENDIX D:

UNIFIED SOIL CLASSIFICATION SYSTEM

FIELD CLASSIFICATION											SYMBOL
COARSE GRAINED SOILS	More than half of material (by weight) is of individual grains visible to the naked eye.	No. 200 sieve size is about the smallest particle visible to the naked eye.	GRAVEL AND GRAVELLY SOILS	More than half of Coarse Fraction (by weight) is larger than ¼ in. size	For visual classification the ¼ in. size may be used as equivalent to the No. 4 sieve size.	CLEAN GRAVELS Will not leave a dirt stain on a wet palm.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.				GW
							Predominantly one size or a range of sizes with some intermediate sizes missing.				GP
						DIRTY GRAVELS Will leave a dirt stain on a wet palm.	Nonplastic fines or fines with low plasticity (for identification of fines see characteristics of ML below)				GM
							Plastic fines (for identification of fines see characteristics of CL below).				GC
			SAND AND SANDY SOILS	More than half of Coarse Fraction (by weight) is smaller than ¼ in. size.		CLEAN SANDS Will not leave a dirt stain on a wet palm.	Wide range in grain size and substantial amounts of all intermediate paticle sizes.				SW
							Predominantly one size or a range of sizes with some intermediate sizes missing.				SP
						DIRTY SANDS Will leave a dirt stain on a wet palm.	Nonplastic fines or fines with low plasticity (for identification of fines see characteristics of ML below).				SM
							Plastic fines (for identification of fines see characteristics of CL below).				SC
					ODOR	DRY CRUSHING STRENGTH	DILATANCY (SHAKE) REACTION	TOUGHNESS	RIBBON (NEAR THE P.L.)	SHINE (NEAR THE P.L.)	
FINE GRAINED SOILS	More than half of material (by weight) is of individual grains not visible to the naked eye.		SILTS AND CLAYS (Low Plastic)	See Identification Procedures.		Slight	Rapid	Low to None	None	Dull	ML
						High	Medium to None	Medium	Weak	Slight to Shiny	CL
					Pronounced	Medium	Slow to None	Low	None	Dull to Slight	OL
			SILTS AND CLAYS (Highly Plastic)			Medium	Very Slow to None	Medium	Weak	Slight	MH
						Very High	None	High	Strong	Shiny	CH
					Pronounced	High	None	Low to Medium	Weak	Dull to Slight	OH
HIGHLY ORGANIC SOILS							Readiliy identified by color, odor, spongy feel and frequently by fibrous texture.				Pt

Appendix D: Unified Soil Classification, Field Identification.

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended; simply remove by hand the coarse particles that interfere with the tests.

Dry Strength (Crushing Characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dry specimen. Fine sand feels gritty, whereas a typical silt has the smooth feel of flour.

Calcium carbonate or iron oxides may cause higher dry strength in dried material. If acid causes a fizzing reaction, calcium carbonate is present.

Dilatancy (Reaction to Shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction, whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Toughness (Consistency Near Plastic Limit)

After removing particles larger than No. 40 sieve size, a specimen of soil about one-half inch cube in size is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms, into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation, the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Nonplastic soils cannot be rolled into a thread at any moisture content.

The toughness increases with the Plasticity Index.

TABLE D-1 CRITERIA FOR DESCRIBING DRY STRENGTH

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling.
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure.
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very high	The dry specimen cannot be broken between the thumb and a hard surface.

TABLE D-2 CRITERIA FOR DESCRIBING DILATANCY

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

TABLE D-3 CRITERIA FOR DESCRIBING TOUGHNESS

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

TABLE D-4 CRITERIA FOR DESCRIBING PLASTICITY

Description	Criteria
Nonplastic	A 1/8-in. (3-mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

TABLE D-5 IDENTIFICATION OF INORGANIC FINE-GRAINED SOILS FROM MANUAL TESTS

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

APPENDIX E:

CLASSIFICATION OF MATERIAL IN CORE BARRELS

During the drilling process, the bit cuttings are removed by fluid circulation. The sample which passes up into the core barrel may be classified into five categories:

1. solid core greater than 4 in. (10 cm) in length;
2. solid core less than 4 in. (10 cm) in length;
3. fragmental material not recovered as core;
4. additional material which may have been lost from the previous core run. This may be the core stump left when the barrel was pulled, material dropped from the core barrel during its withdrawal from the hole, or cuttings which have settled when circulation of drilling fluid was stopped.

In addition, core may have been lost by:

5. erosion of soft or friable material, resulting in a reduction in diameter or length of the core, or both. This eroded material may be entirely removed by the drilling fluid.

   The material which is placed in the core box consists of items 1, 2, 3, and 4 above and (omitting 5 from the subsequent discussion) is strictly defined as the total core recovery. If no material falls into class 5, then the total core recovery is 100 percent, in that there is no loss of sample. The material, which is recovered as solid core pieces at full diameters (1 and 2 above), is strictly defined as the solid core recovery. It must be stressed that total and solid core recoveries are only equivalent when no fragmental material is recovered. This arises either when the rock is solid or loss of sample is represented wholly by material carried away by the drilling fluid. It should be noted that core recovery is expressed as a percentage of the total run length.

APPENDIX F:

ROCK QUALITY DESIGNATION

The Rock Quality Designation (RQD) method of determining rock quality is as follows:

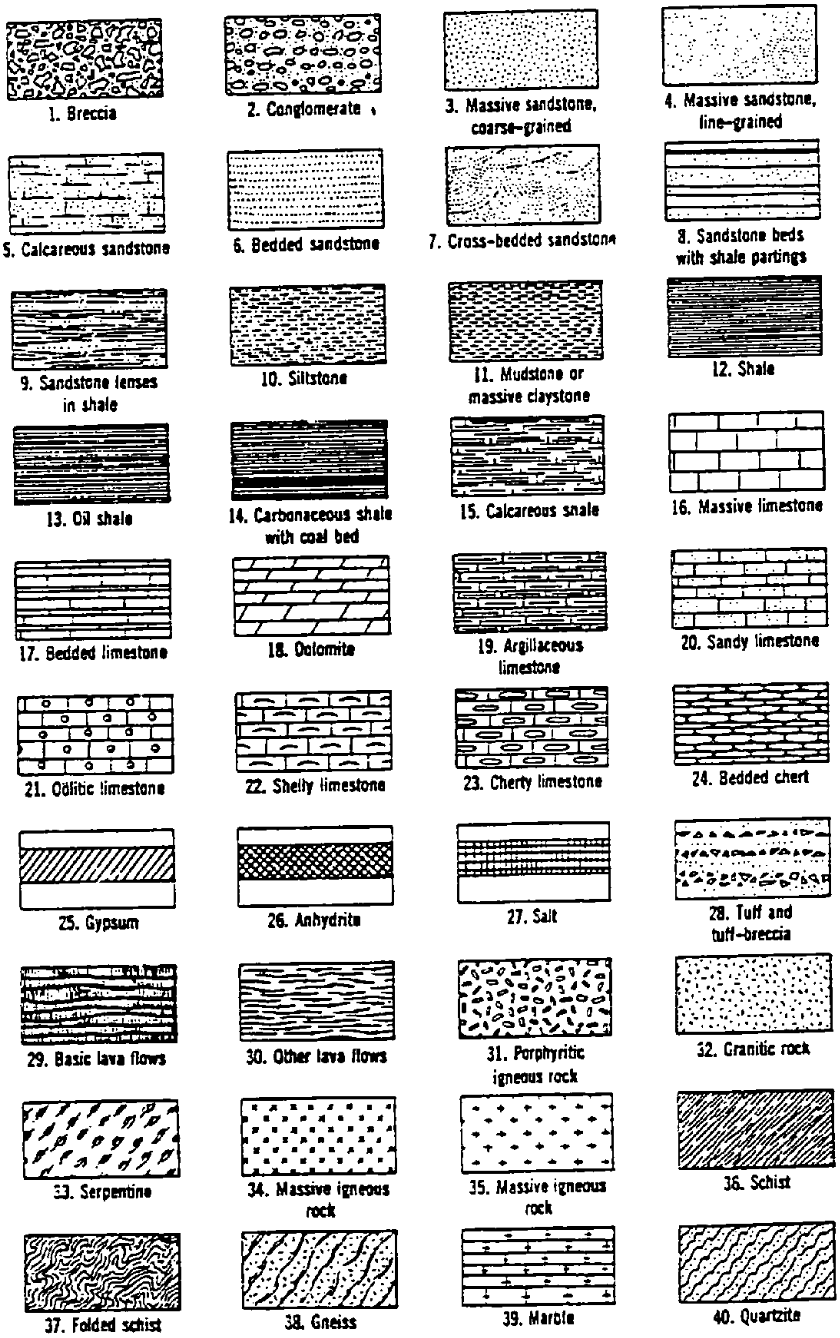
Sum up the total length of core recovered in each run, but count only those pieces of core which are 4 in. (10 cm) in length or longer and which are hard and sound. The sum is then represented as a percentage over the length of the run. If the core is broken by handling or by the drilling process, the fresh broken pieces are fitted together and counted as one piece provided that they form the requisite length of 4 in. (10 cm).

Relation of RQD and Rock Quality

RQD (%)	Description of Rock Quality
0 - 25	Very poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

Note: RQD can only be used on NX core or larger. The RQD should always be shown on the core log as a percentage. The diagnostic description is intended primarily for evaluating problems with tunnels or excavations in rock.

APPENDIX G
STANDARD ROCK SYMBOLS



1. Breccia
2. Conglomerate
3. Massive sandstone, coarse-grained
4. Massive sandstone, fine-grained
5. Calcareous sandstone
6. Bedded sandstone
7. Cross-bedded sandstone
8. Sandstone beds with shale partings
9. Sandstone lenses in shale
10. Siltstone
11. Mudstone or massive claystone
12. Shale
13. Oil shale
14. Carbonaceous shale with coal bed
15. Calcareous shale
16. Massive limestone
17. Bedded limestone
18. Dolomite
19. Argillaceous limestone
20. Sandy limestone
21. Oölitic limestone
22. Shelly limestone
23. Cherty limestone
24. Bedded chert
25. Gypsum
26. Anhydrite
27. Salt
28. Tuff and tuff-breccia
29. Basic lava flows
30. Other lava flows
31. Porphyritic igneous rock
32. Granitic rock
33. Serpentine
34. Massive igneous rock
35. Massive igneous rock
36. Schist
37. Folded schist
38. Gneiss
39. Marble
40. Quartzite

Lithologic symbols for cross sections and columnar sections (after Compton, 1965).

APPENDIX H:

DESCRIPTIVE CLASSIFICATION OF METAMORPHIC ROCKS(a)

In this system for naming metamorphic rocks, the main rock name is based on the texture of the rock, and the principal or more significant minerals are added as modifying nouns, as in SCHIST-biotite, quartz or HORNFELS-andalusite, cordierite. The names are meant to be applied on a descriptive basis; a schistose rock, for example, should not be called a hornfels just because it is found in a contact aureole.

TEXTURES

Schistose--grains platy or elongate and oriented parallel or subparallel. Foliated (lepidoblastic) if fabric is planar, lineated (nematoblastic) if linear.

Granoblastic--grains approximately equidimensional; platy and linear grains oriented randomly or so subordinate that foliation is not developed.

Hornfelsic--grains irregular and interincluded but generally mircoscopic; recognized in field by unusual toughness, ring to hammer blow, and hackly fracture at all angles. Under hand lens, freshly broken surfaces show a sugary coating that will not rub off (formed by rending of interlocking grains).

Semischistose (gneissic)--platy or linear grains subparallel but so subordinate or so unevenly distributed that rock has only a crude foliation; especially common in metamorphosed granular rocks, such as sandstones and igneous rocks.

Cataclastic--clastic textures resulting from breaking and grinding with little if any recrystallization; characterized by angular, lensoid, or rounded fragments (porphyroclasts) in a fine-grained and commonly streaked or layered groundmass. Mortar structure applied to nonoriented arrangements, and phacoidal, flaser, and augen structure apply to lenticular arrangements.

(a) Modified after AGI Data Sheet 22.1 (1982).

ROCK NAMES

Schistose Rocks

Schist--grains can be seen without using a microscope.

Phyllite--all (or almost all) grains of groundmass are microscopic, but cleavage surfaces have sheen caused by reflections from platy or linear minerals; commonly corrugated.

Slate--grains are microscopic; very cleavable; surfaces dull; tougher than shale and cleavage commonly oblique to bedding.

Phyllonite--appearance like phyllite but formed by cataclasis (see mylonite) and recrystallization commonly of coarser-grained rocks, as indicated by relict rock slices, slip folds, and porphyroclasts.

GRANOBLASTIC ROCKS

Granulite or Granofels--granoblastic rocks, irrespective of mineral composition; because granulite can connote special compositions and conditions or origin, granofels may be preferred.

Quartzite, Marble, and Amphibolite--compositional names that generally connote granoblastic texture; exceptions should be modified for clarity, as schistose quartzite or plagioclase hornblende schist.

Tactite (skarn)--heterogeneous calc-silicate granulites and related metasomatic rocks of typically uneven grain.

HORNFELSIC ROCKS

All called hornfels, or, if relict features are clear, hornfelsic may be used with the original rock name (as hornfelsic andesite).

SEMISCHISTOSE (GNEISSIC) ROCKS

Semischist--fine-grained (typically less than 1/4 mm) so that individual platy or lineate grains are indistinct; relict features often common.

Gneiss--generally coarser than 1/2 mm with small aggregates of platy of lineate grains forming separate lenses, blades, or streaks in otherwise granoblastic rock. Platy or lineate structures may be distributed evenly through the rock or may be concentrated locally so that some layers or lenses are granoblastic or schistose (banded gneiss).

CATACLASTIC ROCKS

Where original nature of rock is still apparent, rock name can be modified by suitable adjectives (as cataclastic granite, flaser gabbro, phacoidal rhyolite).

Mylonite--crushing so thorough that rock is largely aphantic and commonly dark-colored; may be layered and crudely foliated but not schistose like phyllonite; porphyroclasts commonly rounded or lenticular.

Ultramylonite, Pseudotachylyte--Aphanitic to nearly vitreous-appearing dark rock commonly injected as dikes into adjoining rocks.

RELICT AND SPECIAL TEXTURES AND STRUCTURES

If texture of low-grade metamorphic rocks are dominantly relict, rock names may be modified (as massive metabasalt, semisschistose meta-andesite). If hydrothermal alteration has produced prominent new minerals, names such as chloritized diorite and sericitized granite can be used.

Strongly metasomatized rocks with coarse or unusual textures may require special names such as greisen, quartz-schorl rock, and corundum-mica rock.

Migmatite--a composite rock composed of igneous-appearing and/or metamorphic materials that are generally distinguishable megascopically.

APPENDIX I:

HARDNESS

Hardness (for engineering description of rock--not to be confused with Moh´s scale for minerals).

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist´s pick
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to 1/4 in. deep can be excavated by hard blow of point of a geologist´s pick. Hand specimens can be detached by moderate blow
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1 in. maximum size by hard blows of the point of a geologist´s pick
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1 in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail

APPENDIX J:

WEATHERING/DECOMPOSITION

The following weathering classification has been presented by the American Society of Civil Engineers (1976).

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks, occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and the majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick. Rock goes "clunk" when struck.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.

Complete	Rock reduced to "soil." Rock "fabric" not discernible or discernible only in small scattered locations. Quartz may be present as dikes or stringers.

STANDARD OPERATING PROCEDURE
FOR THE
INSTALLATION OF GROUND-WATER MONITORING WELLS

Approved:

Chief Engineer — Date: 6 DECEMBER 1985

Program Director — Date: 12-06-85

Protocol GtS-201
EA Engineering, Science,
and Technology, Inc.

CONTENTS

1. INTRODUCTION

The Standard Operating Procedure (SOP) for supervision of drilling operations includes this protocol, EA's Standard Format for Completion of Boring Logs (GTS-101), and the Project Plan. Typically, the Project Plan includes three documents: (1) Safety and Health Plan, (2) Field Sampling Plan and/or Drilling Plan, and (3) Quality Assurance/Quality Control Project Management Plan.

Details of well design and well construction materials and procedures are specified in the Project Plan on a project-specific basis. This approach is necessary, not only to address varying client needs and regulatory requirements which vary by state, but also to ensure that the design and materials are suitable to site conditions and the analytical parameters of interest. This SOP provides minimum requirements and is intended to serve only as a support document to the Project Plan.

2. WELL CONSTRUCTION

Figures 1 and 2 illustrate the significant aspects of typical monitoring wells. EA's basic requirements with regard to these aspects are discussed below.

2.1 WELL SCREENS, CASINGS, AND FITTINGS

All well screens shall be commercially fabricated, slotted or continuously wound, and have an inside diameter equal to or greater than the well casing. For PVC screens, their schedule/thickness shall be the same as that of the well casing. No fitting (coupling) shall restrict the inside diameter of the joined casing and/or screen. PVC solvent welded fittings shall not be used when project concerns include organic compounds. All screens, casings, and fittings shall be new. Dimensions and quantities shall be confirmed by direct measurement and counting by the EA geologist/engineer upon mobilization of the materials to the site.

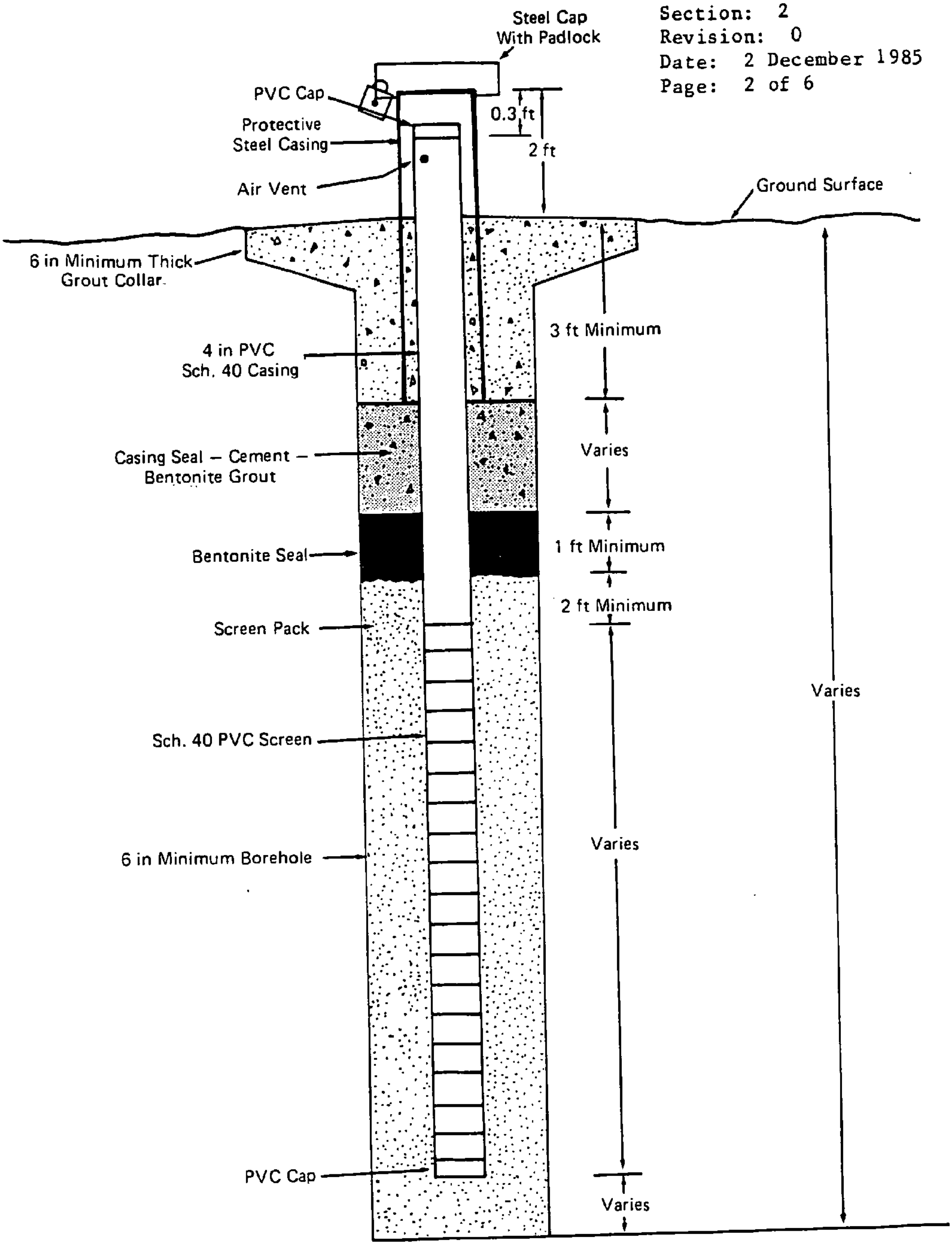
All well screens and well casings shall be free of foreign matter (e.g., adhesive tape, labels, soil, grease, etc.) and washed with approved water or steam-cleaned (cf. Project Plan) prior to use. Cleaned screens and casings shall be stored in plastic sheeting or kept on racks prior to installation. This cleaning and storage operation is particularly important because future water samples from the well may be analyzed for trace constituents to a detection limit of one (1) part per billion (ppb) or less.

Well screens shall be placed no more than 3 ft above the bottom of the drilled borehole. All screen bottoms shall be securely fitted with a cap or plug of the same composition as the screen. This cap/plug shall be within 0.5 ft of the open portion of the screen. Silt traps shall not be used.

A small hole (1/8-1/4 in.) shall be drilled through the riser pipe approximately 3-6 in. below the top of the well to allow for constant pressure equalization within the well. Such a hole should not be drilled through the well cap because extraneous material could be inadvertently introduced through the hole. The hole must obviously be drilled in the side of the well casing prior to placement of any protective casing. This hole is particularly important for wells with a water level which extends above the top of the screen.

2.2 SCREEN PACK

Granular backfill shall be chemically and texturally clean (as seen through a 10x hand lens), inert, siliceous, and of appropriate grain size (c.f. Project Plan) for the screen slot size and the host environment.



Not to scale.

Figure 1. Typical installation detail for screened monitor well.

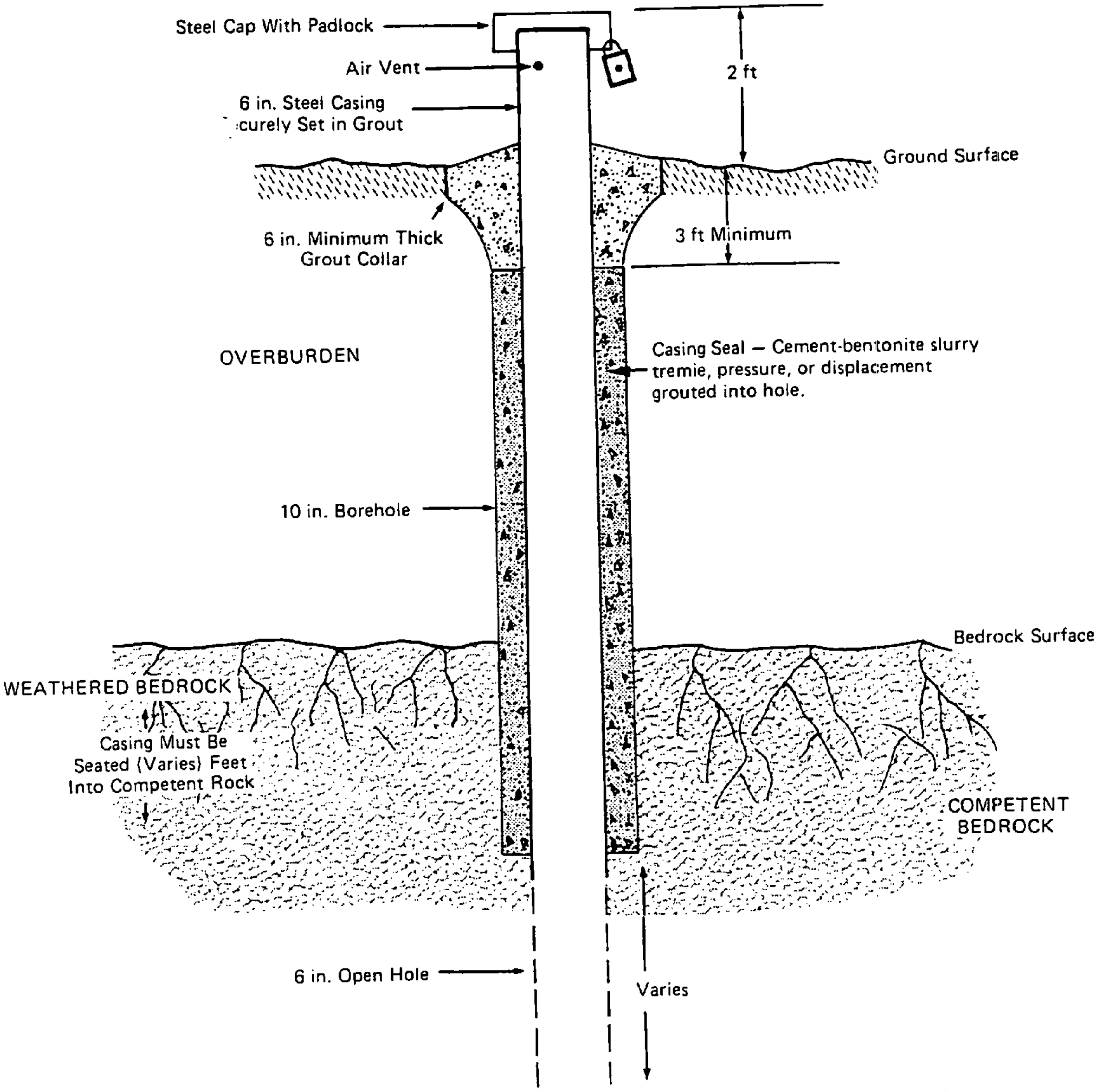


Figure 2. Typical installation detail for rock monitor well.

Prior to installing the screen, a bedding of screen pack (minimum of 0.5 feet) shall be placed in the bottom of the hole. Next, the well screen and riser casing shall be installed and the screen pack shall be placed via a tremie pipe around the screen and casing to a depth of 2 ft above the top of the well screen. The depth to the top of the screen pack should be sounded frequently. At this point, in wells installed through casing or hollow stem augers without drilling mud, it is desirable to pump, bail, or air surge the well to induce settlement of the screen pack. The depth to the top of the screen pack shall then be sounded and additional screen pack added until the depth complies with the Project Plan. In no case should the screen pack be placed higher than 4 ft below ground surface to allow space for placement of the bentonite seal and protective casing with cement or cement-bentonite grout.

2.3 BENTONITE SEAL

Bentonite seals shall be composed of commercially available pellets. Pellet seals shall be a minimum of 1-ft thick as measured immediately after placement, without allowance for swelling. In no case should the bentonite seal be placed higher than 3 ft below ground surface to allow space for placement of protective casing with cement or cement-bentonite grout.

In screened wells designed to monitor bedrock, the bentonite seal shall be located at least 3 ft below the top of firm bedrock, as may be determined by drilling refusal. "Firm bedrock" refers to that portion of solid or relatively solid, moderately to unweathered bedrock where the frequency of loose and fractured rock is markedly less than in the overlying, highly weathered bedrock. The interval between the top of the bentonite seal and the top of the highly weathered bedrock shall be filled with grout.

2.4 CASING SEAL

Acceptable casing seal materials include:

- Benseal, when prepared in accordance with the manufacturer's specifications.
- Neat cement grout, consisting of cement (portland cement, any of types I to V) and not more than 6 gal of clean water per 94-lb bag of cement.
- Cement-bentonite grout, composed by weight of 10 parts cement (portland cement, any of types I to V) to 1/2 part bentonite with a maximum of 10 gal of approved water per 94-lb bag of cement. Bentonite shall be added after the required amount of cement is mixed with water.

Neither additives nor borehole cuttings shall be mixed with the casing seal. All casing seal materials shall be combined in an above-ground rigid container and mixed onsite to produce a thick, lump-free mixture.

The casing seal shall be placed from within a tremie pipe, initially located just over the top of the bentonite seal. The casing seal shall be pumped through this pipe to the bottom of the open annulus until a continuous, undiluted column of casing seal is formed from the bentonite seal to ground surface. When Benseal is used as the casing seal, it shall be placed to no higher than 3 ft below ground surface to allow for placement of protective casing with cement or cement-bentonite grout.

2.5 PROTECTIVE CASING

Protective casing shall be installed around each screened monitor well within 24 hours of casing seal placement in that well. The steel riser casing for rock monitor wells may also serve as protective casing, as shown in Figure 2, as long as items 4-7 below are met. Rock monitor wells with PVC riser casing shall have steel protective casing.

All protective casing shall be washed with clean water or steam-cleaned (c.f. Project Plan) prior to placement, free of extraneous openings, devoid of any asphaltic, bituminous, encrusting, and/or coating materials (except the black paint or primer applied by the manufacturer).

Minimum elements of protection design include:

1. A 5-ft minimum length of new, black iron/steel pipe extending about 2 ft above ground surface and set in grout.
2. The diameter of the protective casing shall be 2 in. larger than the diameter of the well riser casing.
3. No more than 0.3-ft difference in elevation between the top of the protective casing and the top of the well riser casing.
4. A hinged cover or loose-fitting telescoping cap to keep precipitation and runoff out of the casing.
5. All protective casing covers/caps secured to the casing by means of a padlock from the date of protective casing installation.
6. All padlocks at a given site (project area) opened by the same key.

7. A grout collar sloped away from the well at the ground surface. The outer edge (minimum 0.5-ft thick) of the collar shall be vertical to inhibit frost heave. Acceptable grout collar materials are neat cement grout and cement-bentonite grout as specified for casing seal (Section 2.4).

3. WELL DEVELOPMENT

The development of monitoring wells shall be performed as soon as practical after well installation to remove drilling fluid (if used) and to minimize turbidity (silt, clay, and fine sand). However, well development must be delayed approximately 5 days after well installation if Revert drilling fluid additive is used, to allow time for the Revert to biodegrade. Well development serves two main purposes: first, and foremost, to remove silt and clay so turbidity-free samples of ground water can be obtained for chemical analysis; and second, turbidity-free water is necessary to minimize clogging and scoring of submersible pump impellers during future pumping tests and/or purging. Well development is accomplished by actively agitating the water column in a well, forcing water back and forth through the well screen to release silt, clay, and fine sand from the screen and screen pack. This material is then removed from the well by pumping.

Development may be accomplished by air lift surge or with a pump and may be supplemented with a bottom filling bailer (for sediment removal) and surge block. A bottom filling bailer may be used in lieu of a pump in 2-in. wells or wells with extremely low yield. Part of well development shall be the washing of the entire well cap and the interior of the well casing above the water table using only water from that well. The result of this operation shall be a well casing free of extraneous materials (grout, bentonite, and sand etc.) inside the riser, well cap, and blank casing between the top of the well casing and the water table. This washing shall be conducted before and/or during development--not after development.

No dispersing agents, acids, disinfectants, or other additives shall be used during development or at any other time introduced to the well.

When drilling fluids (bentonite) are used in the boring, well development shall be completed at least 14 consecutive days before initiating well sampling.

Development shall continue until each of the following is met:

a. The well water is clear to the unaided eye.

b. The sediment thickness remaining within the well is less than 5 percent of the screen length.

The following sections provide guidelines for well development by surging with compressed air, pumping with a centrifugal pump and manual development.

3.1 DEVELOPMENT BY SURGING WITH COMPRESSED AIR

This method will work in wells no matter what the depth to water. However, it can be frustrating for wells with very low yields. Generally, a 100-150 cubic foot per minute (CFM) air compressor will be quite sufficient for development of monitoring wells. In order to perform well development by this method, there must be at least 20 percent submergence of the air discharge line. For example, if a monitoring well is set to a depth of 100 ft below grade, there must be at least a 20-ft column of water in the well and preferably more, assuming that the water level will be drawndown during development. Such drawdown of the water level will create a lower percent of submergence than was calculated using the static water level.

It is imperative that the compressed air discharge line of the air compressor include a functioning oil/air separator filter. The effectiveness of such a filter should be checked before and after each well is developed. Such a check can be performed by placing a clean white cloth over the air discharge, opening the discharge valve fully, and then checking the cloth for oil staining. If staining is observed, the problem must be corrected before performing development.

Under no circumstances shall the high pressure hose(s), supplied with an air compressor, be placed within a well. Such hoses are sheathed with synthetic rubber and have probably laid on the ground at many previous job sites, and thus absorbed a variety of contaminants. New, fresh lengths of flexible polyethylene pipe should be used as the air discharge line for each well developed. Such pipe is relatively inexpensive and can be attached to the air compressor using a Chicago fitting and an insert fitting. Be sure all connections are securely attached. The polyethylene pipe should be stored in large plastic bags, until used, to mitigate contamination. Additionally, the pipe must be handled with new, clean gloves for each well, and must not be allowed to touch the ground.

Compressed air discharging at about 100 PSI can be dangerous and must be handled carefully. Make sure all connections are tightly secured. Bring the pressure up slowly so as to not blow the polyethylene pipe out of the well. To aid in keeping the pipe in the well, a length of 3/4-in. diameter steel pipe can be attached to the end of the polyethylene pipe (be careful not to pierce the bottom of the well). Alternatively, if the well is of large enough diameter, the end of the polyethylene pipe can be fitted with a metal deflector or a short length of steel pipe bent into a J-shape. Both of these attachments will discharge the compressed air directly upward through the water column, and thus keep the polyethylene pipe from being blown out of the well. It is important that these attachments be decontaminated (cf. Project Plan) before use in each well.

Development should begin at the bottom of a well, working up to the top of the screen and then back down to the bottom in increments of 5 ft or less and as many times as necessary. Development should consist of alternating surging and continuous air lift at each interval until the discharged water appears to be clear.

3.2 DEVELOPMENT BY CENTRIFUGAL PUMP

This method can be used only if the depth to water is less than 20 ft below ground surface, and can be effective for wells of very low yield. Because operation of a centrifugal pump depends upon suction, all fittings on the intake side of the pump must be air tight.

A good and inexpensive choice for the suction line into the well is 1/2- to 3/4-in. diameter flexible, polyethylene pipe. A new, unused length should be used for each well. The pipe should be stored in large plastic bags, until ready for use, and should be handled with new clean gloves for each well. Additionally, the pipe must not be allowed to become contaminated by touching the ground. The end of the pipe which will be placed into the well should be cut off at an angle to minimize the potential of becoming quickly plugged with silt at the bottom of the well. Additionally, this end of the pipe should be fitted with one or more large steel washers which are large enough to fit over the polyethylene pipe but small enough to fit into the well. If the washers are reused, they must be decontaminated (cf. Project Plan) before use in each well. The washer(s) should be held in place a few inches from the end of the polyethylene pipe by two hose clamps tightened by a screwdriver. The washer(s) will act as a plunger (surge block) when raised and lowered in the screen interval. Such surging will force ground water back and forth through the well screen and aid in loosening and removing silt, clay, and fine sand from the screen pack. Simultaneously, pumping of the centrifugal pump will remove the turbid water. Well development should begin at the bottom of the well, working up to the top of the screen and back down surging and pumping at intervals of 5 ft or less, as many times as necessary, until the discharged water appears to be clear.

3.3 MANUAL DEVELOPMENT

This method is used as a last resort, when the water level is too deep for a centrifugal (suction) pump, and there is less than 20 percent submergence so air lift with compressed air cannot be used. This method can be effective in low yielding wells, but is slow and requires considerable elbow grease.

This method consists of flexible polyethylene pipe, a washer for surging (Section 3.2), and a foot valve placed on the end of the pipe which will be placed in the well. The foot valve keeps water from flowing back out of the pipe once it has entered. By quickly raising and lowering the pipe about 1-2 ft, water is forced into and up the pipe until it finally discharges at ground surface from the other end of the pipe. As for the previously described well development methods, new flexible pipe must be used in each well. The pipe must be carefully handled so it is not contaminated. Any reused attachments (washers, foot valves, etc.) must be decontaminated per the Project Plan before use in each well. Finally, development should begin from the bottom of the well, working up to the top of the screen and back down as often as necessary to obtain discharged water that is visibly clear (if possible).

4. DECONTAMINATION

Much of the ground-water work in which EA is involved requires contaminant assessment at the ug/L or lower level. It is therefore essential that every effort be made to avoid cross-contamination. This can best be done by ensuring that no equipment coated with or containing contaminants from one well be introduced into another well. The criticality of this issue results from the fact that as little as one drop of contaminant has the potential to contaminate a well to the mg/L level and possibly to render the well unsuited for future monitoring.

On the other hand, if the project is, for example, a siting study in undeveloped territory, steam cleaning the drilling equipment between borings or using new suction line for each well during development may be inappropriate from a cost-benefit standpoint. It may be appropriate, however, to have the drill rig steam cleaned prior to entering the site. The level of effort for decontamination is a site and project-specific issue to be resolved individually for each project. The vehicle for resolving this issue is the Project Plan. The Project Plan must specify the protocols for decontamination and the rationale for selection of the protocols specified.

EA's basic requirements at contaminated sites are discussed herein. The drill rig and all down-hole tools and equipment shall be steam cleaned prior to entering and prior to leaving the site or at the site's designated cleaning area prior to performing work at the site and prior to leaving the site. Down-hole tools and equipment (at a minimum) shall be steam cleaned between borings. Soil samplers shall be steam cleaned between samples.

All well screens, casings, fittings, and caps shall be steam cleaned prior to installation.

Reusable down-hole equipment for developing wells including water level sounding devices shall be steam cleaned or washed with methanol and rinsed with clean water prior to use at each well.

STANDARD OPERATING PROCEDURE
FOR
AQUIFER TESTS OF MONITORING WELLS

Approved:

Chief Engineer — Date 11-03-87

Program Director — Date 11-03-87

Protocol GtS-202
EA Engineering, Science,
and Technology, Inc.

CONTENTS

1. INTRODUCTION

This protocol defines EA procedures for evaluating aquifer characteristics through testing of wells which were designed primarily for water level and/or water quality monitoring. The field procedures and methods for data reduction described herein generally provide estimates adequate for purposes of environmental assessment. Evaluation of test/production wells for purposes of water supply or recovery of contaminated ground water is outside the scope of this protocol. Procedures for these evaluations are addressed in Driscoll (1986) and Lohman (1979).

Aquifer tests are performed in monitoring wells to estimate the transmissivity and permeability of unconsolidated aquifers, and the transmissivity and effective permeability of rock formations. Evaluation of these parameters is important in estimating the rates of ground-water movement. The results of short-term, in-well aquifer tests should not be over interpreted. The values obtained refer strictly to the conditions immediately around the well which have invariably been altered to some extent by the drilling procedures. Although the transmissivity and permeability values obtained by these methods should be considered approximate, field procedures must be performed with care to provide optimal data.

1. INTRODUCTION

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2. IN-WELL PUMPING TEST

A frequently used aquifer test is the short term, in-well pumping test which is comprised of: 1) a continuous discharge, pumped (drawdown) phase until stabilization of the water level drawdown is achieved, and 2) a recovery phase. For such a test, pumping and water level measurements occur in the same well. During a pumping test, a discharge (pumping) rate is selected such that it is compatible with the estimated amount of ground water produced from the well during development. In other words, do not pump a well at 10 to 15 gallons per minute (gpm) when it produced only about two gpm during well development, or the well will quickly be pumped dry. However, if the aquifer reacts quickly (rapid drawdown) over a wide range of pumping rates, then accurate water level measurements obtained during the first minute of the pump test are very important. (In this type of situation, water level measurements should be obtained and recorded as often as possible).

Accurate depth to water measurements during the drawdown phase are generally obtained and recorded at regular time intervals (Table 2-1) until little or no further drawdown is indicated. The discharge of ground water is then stopped, and timing and water level measurement of the recovery phase is instantly begun. Accurate depth to water measurement is performed and recorded at regular time intervals (Table 2-1) until at least 90 percent recovery to the static (prepumping) water level is achieved.

2.1 EQUIPMENT FOR PUMPING TESTS

2.1.1 Pumps

Short-term pumping tests can be performed with a variety of pump types and monitoring equipment. Selection of the type of pump to be used is dependent upon three major items: 1) depth to water (greater or less than about 20 ft below ground surface), 2) well yield, and 3) well diameter. If the depth to the water is less than about 20 ft below ground surface, then a centrifugal pump or peristaltic (tubing) pump can be used. Both of these pumps depend upon suction to remove water from a well. They are operated at ground surface (not physically in the well) with only a suction line (pipe) lowered into the well. Centrifugal pumps can be operated over a wide range of discharge rates (<100 gpm to >5 gpm), while a peristaltic pump (e.g. Materflex) generally provides a discharge rate of <1 gpm. One advantage of these pumps is that they can pump turbid (silty) water with no problem. A major disadvantage is that they can not pump water from a level (head) greater than about 20 ft; and the deeper the pumped water level becomes, the lower the discharge rate. It is imperative when using centrifugal pumps, to assure that all connections are tight (rubber washers, teflon tape, etc.) so as to minimize leaks between the pump and the well, and thus "maintain suction." An additional disadvantage of peristaltic pumps, is the use of Tygon (plastic) tubing from which phthlates are reportedly leached. The use of Tygon tubing must be approved by the project manager.

If the depth to water is greater than 20 ft below ground surface, then a submersible-type pump must be used to perform a pumping test. Selection of the type of submersible pump is more dependent than centrifugal pumps upon the diameter of the monitoring well. For wells that are $\geq$ 4-in. internal diameter (ID), standard submersible pumps are readily available. Of particular value is a 4-in. nominal diameter submersible pump manufactured by Grundfos which has stainless steel rather than plastic impellers (important if the well is expected to be turbid with silt and/or fine sand).

For wells that are 2-in. ID, the selection is limited to several types of specialty pumps. Discharge rates generally are quite low, ranging from 1/2 gpm to 1-1/2 gpm. There are various types of pumping mechanisms as follows:

1. direct displacement of water by compressed air or gas.
2. squeeze or bladder pump, e.g., ISCO sampling pump.
3. Submerisble pump, e.g., Fultz Back Pack pump.
4. Moyno-type progressive cavity with a rotor and stator, e.g., Keck Sp-84

The first two types of pumps require a regulator and source of compressed air/gas (nitrogen) from an air compressor or compressed-gas cylinder. These pumps do not produce a constant discharge due to their cyclic mode of operation and are, therefore, not recommended for pump tests. The pumping of turbid water can damage the bladder of a "squeeze" pump, and field experience has shown that turbid water rapidly clogs the back pack pump with silt. The fourth type of pump listed (progressive cavity) operates well in clear and turbid water, and requires only a 12-volt vehicle battery as a power source.

2.1.2 Water Level Measurement

During a pumping test it is necessary to obtain accurate and frequent depth to water level measurements at periodic time intervals. Such depth to water measurements can be performed with a variety of equipment, including:

1. Electronic water level indicators which, when the water level is encountered (and the electronic circuit completed), a light goes on and/or an audible alarm sounds. Examples include: the Johnson Division UOP Watermarker, the Soiltest M-Scope, the Q.E.D. water level indicator, etc.

2. Water Level Sensing Device available from Keck Geophysical Instruments, Inc. which directly measures the amount of drawdown or recovery of the water level.

3. Hydraulic data logger (e.g., InSitu SE1000B) which utilizes pressure transducers and can be programed to record either water level or drawdown.

The first type of instruments listed above have depth markers at 0.05 ft intervals (QED instrument) or at 5-foot intervals (other instruments), and only measure the depth to water below a measuring point. It is necessary to have on hand a folding engineer's rule (0.01 ft marking) with which to perform accurate measurements between the interval markers provided.

The Keck Water Level Sensing Device directly measures the amount of drawdown or recovery of the water level. A probe (which is attached by electrical wire to a device at the ground surface) is lowered to the water level and the digital dial "zero-ed". As the water level is drawndown or recovers, the amount is shown to hundredths of a foot on an odometer-like dial.

The SE 1000B is a menu driven, programmable data logger which can store data from several tests for later printout or transfer to a computer. The pressure transducer is set in the well below the anticipated drawdown and the data logger set to reference the static level. For short-term in-well pump tests and slug tests, static level can be set at zero and the instrument programed to record drawdown and recovery directly. Drawdown and recovery are recorded as separate tests and the data for each recorded on the logarithmic time schedule (Table 2-1).

2.1.3 Discharge Rate Measurement

Measurement of the discharge rate is readily performed using a stop watch and a calibrated bucket. The size of the bucket depends upon the general discharge rate, say a 2-1/2 gallon bucket with 1-quart marking and/or a 5-gallon bucket with 1-gallon markings. The discharge rate is readily controlled using two ball valves in series (one as an on/off valve and the other set to the selected discharge rate).

2.2 PERFORMANCE OF A PUMPING TEST

1. First measure and record the static (prior to setting the pump) water level.

2. Set pump and pressure transducer or Keck sensor as appropriate.

3. Start the pump with the on/off ball valve closed.

4. Open the on/off ball valve, and simultaneously start a stopwatch and/or the data logger. Water should be discharged some distance, preferably downgradient, from the well so as to not directly recharge the well. Containment or pretreatment of the discharge may be required at contaminated sites (cf. Project Plan).

5. Obtain and record depth to water, or direct drawdown measurements, at regular time intervals (Table 2-1), on the Field Record of Drawdown Data (Figure 2-1) or in the data logger memory.

6. Obtain and record (Figure 2-1) discharge rate measurements, if possible, at 5 minute intervals for 30 minutes after the pumping test begins, and then at 10 minute intervals. Also, note the

color, turbidity, and odor. Some project plans may also require readings of pH, conductivity or organic vapors (PID or FID) on the discharged water.

7. Continue recording until stabilization of the water level drawdown is achieved. (This will provide data to calculate the specific capacity of the well in gpm/ft of drawdown.)

8. Turn off the on/off ball valve on the discharge line (to minimize backflow into the well), and simultaneously restart the stop watch or the data logger and shut off the pump.

9. Obtain and record depth to water or direct residual drawdown measurements at the time intervals given in Table 2-1. Continue these measurements until at least 90 percent recovery of the static water level is achieved.

10. Remove pump. Decontaminate the pump and any reusable, down-hole equipment as required by the project plan (see also, GtS-201, Section 4).

2.3 DATA REDUCTION

The following method (Driscoll, 1986; Cooper & Jacob, 1946) is applicable to a fully penetrating well in a confined aquifer or a thick, unconfined aquifer that drains rapidly and reasonably completely during the test. Monitoring wells often are not fully penetrating. However, the method may still provide a reasonable estimate for these wells. Good agreement between drawdown and residual drawdown plots (see below) can be taken as an indication that the effects of partial penetration are not significant. Monitoring wells may be placed in aquifers which drain slowly and/or incompletely. The method, idealy, should not be used in clearly non-isotropic and/or low permeability situations. However, it is often necessary to estimate aquifer characteristics in situations where project constraints preclude the installation of a test well and observation wells to provide data for more sophisticated analysis. This method may be used in these circumstances as long as the data, and the conclusions based thereon, are qualified.

Time and drawdown data are plotted on semi-log graph paper. For the pumping phase, time (t) in minutes since the pump was started is plotted on the logarithmic scale on the x-axis and drawdown (s) in ft is plotted on the linear scale on the y-axis. For the recovery phase, residual drawdown (s′) is plotted on the linear scale and the ratio (t/t′) of time since the pump started (t) and time since the pump stopped (t′) is plotted on the logarithmic scale. Except for the early stages of drawdown or recovery, the data on these plots will typically fall on a straight line. The slope (Δs) of this line (Figure 2-2) is expressed as the difference in drawdown, or residual drawdown, (y intercepts of the line) over one log cycle (any two x intercepts of the straight portion of the line separated by one log cycle).

An estimate of transmissivity can be calculated by the following equation:

$$T = 264Q/\Delta s \qquad \text{(Equation 2-1)}$$

where

T = coefficient of transmissivity, in gpd/ft

Q = pumping rate, in gpm

Δs = slope of the time drawdown graph expressed as the change in drawdown between any two times on the log scale whose ratio is 10 (one log cycle).

For a relatively thin unconfined aquifer (i.e., if drawdown during the test exceeds 20% of the saturated thickness of the aquifer at static water level), drawdown data should be corrected to account for decreasing transmissivity due to decreasing saturated thickness as a result of pumping. Jacob (1963) developed the following equation:

$$S_t = S_o - (S_o^2/2H) \qquad \text{(Equation 2-2)}$$

where

S_t = theoretical drawdown

S_o = observed drawdown

H = height of water column (static) above impervious or semi-impervious layer, or estimated aquifer thickness

Theoretical drawdown and theoretical residual drawdown should be plotted on the semi-log graphs to determine ΔS for estimating transmissivity of a relatively thin unconfined aquifer by Equation 2-1.

TABLE 2-1 RECOMMENDED* TIME INTERVALS FOR MEASURING DRAWDOWN IN THE PUMPED WELL DURING A PUMPING TEST

TABLE 2-1A MANUAL RECORDING

Time Since Pumping Started (or Stopped) in Minutes	Time Intervals Between Measurement in Minutes
0 - 10	0.5 - 1
10 - 15	1
15 - 60	5
60 - 300	30
300 - 1440	60
1440 - termination of test	480 (8 hr)

TABLE 2-1B DATA LOGGER LOGARITHMIC SAMPLING SCHEDULE

Elapsed Time	Sample Interval	No. of Points
0-2 sec	0.2 sec	11
2-20 sec	1 sec	18
20-120 sec	5 sec	20
2-10 min	0.5 min	16
10-100 min	2 min	45
100-1000 min	10 min	90
1000-10,000 min (1 wk)	100 min	90
1 wk---	500 min	---

---

*cf. Project Plan

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Field Record of Drawdown Data

Well No. ________ Test No. ________ Job No. ________

Location ________________ Sheet No. ____ of ____

Client ________________

by ________ Date ________ Checked by ________ Date ________

Type of Test ________________

Pumping Equipment ________________

Measuring Equipment ________________

________________ or

Well Data: Check Screened ____ Open Hole ____

Slug Type ________________

Total Depth ________ Length Open to fm ________

Slug Volume ________________

Casing I.D. ________ Screen or Openhole I.D. ________

Boring Diameter of Screened Well ________________

Time Data

Pump on: Date ____ Time ____ (t_0)
Pump off: Date ____ Time ____ (t_0')
Duration of aquifer test: ________
Pumping ________ Recovery ________

Water Level Data

Static water level ________
Measuring point ________
Elevation of measuring point ________

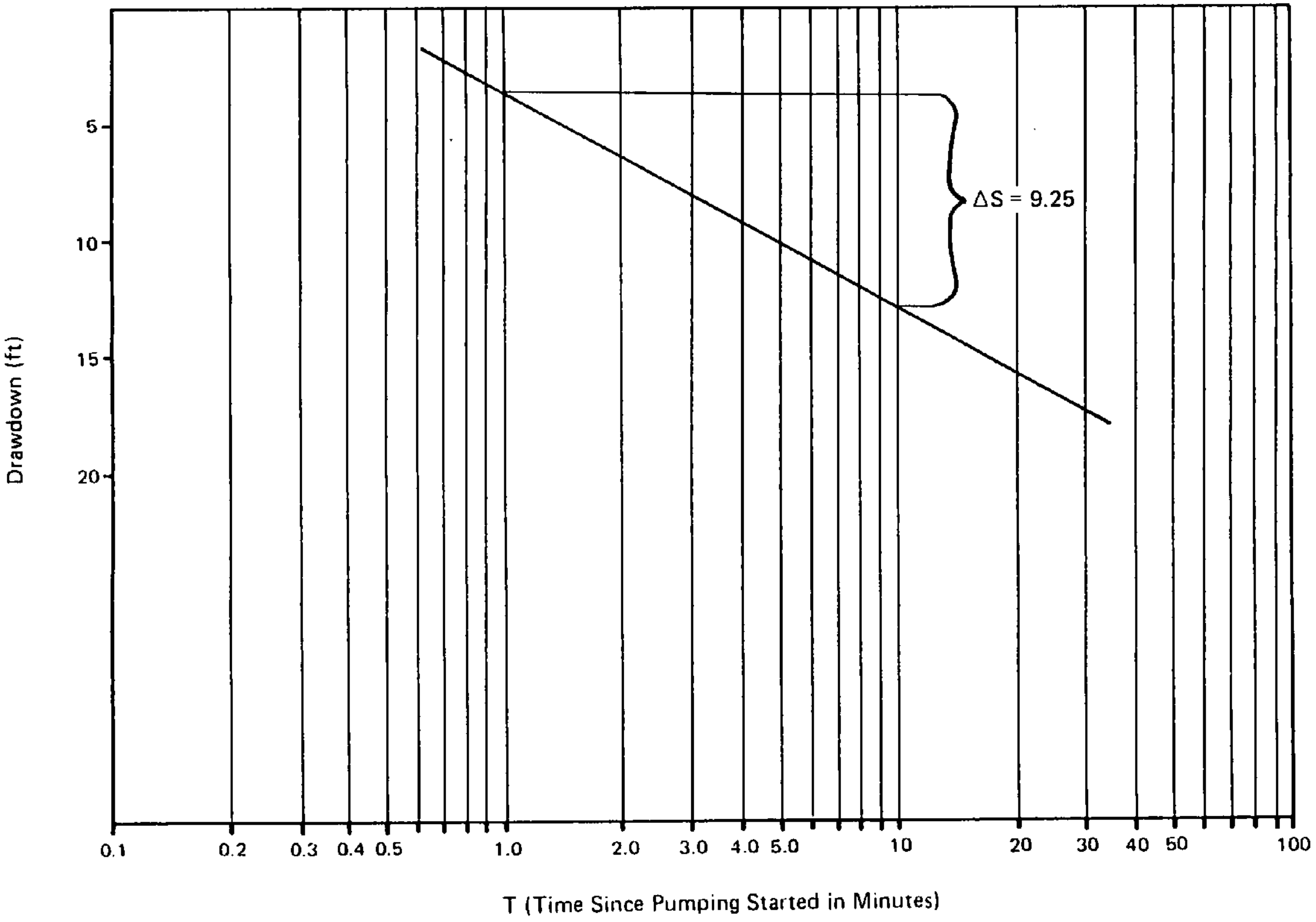
Discharge Data

How Q measured ________
Depth of pump/air line ________
Previous pumping? Yes ____ No ____
Duration ________ End ________

Remarks

Date	Clock Time	Time Since Pump Started t	Time Since Pump Stopped t'	t/t'		Water level measurement	Correction or Conversion	Water Level	Water Level Change s or s'		Rate	Color Turbidity Order	pH Conduct. PID/FID	

Figure 2-1. Field record of drawdown data.



$\Delta S = 9.25$ ft

$Q = 1.5$ gpm

$$T = \frac{264\,Q}{\Delta S}$$

$$T = \frac{264\,(1.5)}{9.25}$$

$T = 42.8$ gpd/ft

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EA-3D Drawdown Data

Pepe Field Boonton, NJ REMEDIAL INVESTIGATION New Jersey Department of Environmental Protection	CALC. BY: JPC CHECKED BY: SAB

Figure 2-2. Pump test, example data curve.

3. SLUG TEST

The slug test method involves the "instantaneous" removal or addition of a slug of known volume to the well and monitoring water level recovery. An initial static water level of the well is taken. A slug of water is quickly removed by a clean bailer or added with a calibrated bucket at which time an elapsed time count begins. Water levels are then repeatedly taken at close elapsed time intervals until the water level in the well has risen to or fallen to not less than 90 percent of the original static level.

Alternatively, a solid slug may be used. A closed-end pipe or rod is inserted into the well and lowered a specified depth below the static water level. A pipe or rod is preferable to a solid cylinder (non-buoyant) lowered by line such that its upper surface is submerged, since the latter results in greater turbulence. However, the latter may be more logisticaly feasible in deeper wells. Solid slugs are preferable to water slugs when static level is deep. Solid slugs also allow for two data sets, one subsequent to slug addition and one subsequent to slug removal, to be recorded per test.

Monitoring wells, unlike production wells, are often constructed in hydrogeologic units of low permeability. In such instances the permeability of the well screen and/or screen pack is likely to be greater than that of the formation. If the screen pack extends above the water table, the head difference resulting from the slug may be dissipated by the screen pack. Slug injection tests, in particular, are inappropriate under these circumstances. The results of water removal tests should be carefully evaluated to ensure data are representative of the formation. The volume of slug to be removed or added is determined based on well diameter, available drawdown, and the yield of the well as estimated during development.

Water is removed from the well with a clean bailer sized to remove a volume of water adequate to achieve sufficient drawdown to be measurable over a time frame sufficient to develop the time versus residual drawdown curve. Some project plans may specify that the bailer be laboratory cleaned. Alternatively, a known volume of water (meeting the above criteria) may be added to the well. The source of water to be added must be approved by the project manager. Some project plans may specify the use of laboratory cleaned bucket or other suitable vessel to transfer the water to the well. Similarly, the project plan must be consulted for specific requirements regarding the composition and cleaning of solid slugs and equipment (e.g., pipe wrenches) used to insert, suspend or remove the slug. Minimum requirements are discussed in Section 4 of GtS-201.

Equipment for water level measurment is described in Section 2.1.2. The hydraulic data logger and the Keck water level sensing device provide for rapid high resolution data, thereby minimizing the slug volume required to develop the time versus head difference curve.

3.1 PERFORMANCE OF A SLUG TEST

1. First measure and record (Figure 2-1) the static (prior to setting the bailer for a water removal test or the solid slug) water level.
2. Remove or add the required slug volume.
3. Obtain and record (Figure 2-1 or data logger) depth to water, or residual drawdown measurements, at the time intervals given in Table 2-1. Continue these measurements until at least 90 percent recovery of the water level is achieved.
4. Repeat for slug removal, if the test is a solid slug test.
5. Decontaminate the bailer or slug and any reusable, down-hole equipment as required by the project plan (see also, GtS-201, Section 4).

3.2 DATA REDUCTION

3.2.1 Unconfined Aquifer

The following method (Bouwer and Rice, 1976) is applicable to fully or partially penetrating wells within a water-table (unconfined) aquifer. An estimate of hydraulic conductivity of an aquifer in the immediate vicinity of the well screen is calculated by the following equation:

$$K = [r_c^2 \ln(r_e/r_w)/2L_e] \; [\ln(h_o/h_t)/t] \qquad \text{(Equation 3-1)}$$

where

K = hydraulic conductivity; this being a dimensionally correct equation, K is expressed in the same units as the length and time parameters (Appendix A).

r_c = internal radius of well casing

r_e = effective radial distance over which the head difference h is dissipated

r_w = radial distance between well center and undisturbed aquifer (r_c plus thickness of screen pack or developed zone outside casing)

L_e = length of perforated, screened, uncased, or otherwise open section of well through which ground water enters

h_o = h at time zero

h_t = h at time t

t = time since h_o

L_w = length of water column in well at static water level

H = height of water column (static) above impervious or semi-impervious layer, or estimated aquifer thickness.

Head difference versus elapsed time (in minutes if feasible) is plotted on semi-log graph paper. Head values (h_t) are scaled along the y-axis (logrithmic axis) and elapsed time (t) scaled along the x-axis (linear axis). A straight line is fitted along the plotted data points. Variations from a straight line may occur at the beginning of the test due to measurement error and/or turbulence resulting from the addition of water. This can be corrected by extending the straight portion of the line. From the resultant curve (Figure 3-1) values of h_t, h_o, and t are obtained to calculate $\ln(h_o/h_t)/t$ where the intercept of the regression line with the y-axis is h_o and h_t is the residual water level at time t.

Because r_e is an unknown, the following equations are used to estimate $\ln(r_e/r_w)$ under one of three conditions: well screen at the bottom of the aquifer, or approximately so (Equation 3-2 when $H \sim L_w$); well screen partially penetrating the aquifer (Equation 3-3 when $H > L_w$); or well screen partially penetrating a relatively deep aquifer with respect to well depth (Equation 3-4 when $H >> L_w$). When H is much larger than L_w, a further increase in H has little effect on the flow system, and, hence, on r_e. Therefore, if $H-L_w$ is so large that $\ln[(H-L_w)/r_w] > 6$, a value of 6 (Equation 3-4) is used instead of $\ln[(H-L_w)/r_w]$.

$$\ln(r_e/r_w) = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{C}{L_e/r_w}\right]^{-1} \quad \text{(Equation 3-2)}$$

$$\ln(r_e/r_w) = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{A + B\ln[(H-L_w)/r_w]}{L_e/r_w}\right]^{-1} \quad \text{(Equation 3-3)}$$

$$\ln(r_e/r_w) = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{A + 6B}{L_e/r_w}\right]^{-1} \quad \text{(Equation 3-4)}$$

In some cases H may be determined by information collected during drilling, but in cases where the bottom of aquifer is not ascertained while drilling, H is estimated using available geologic information. A, B, and C are dimensionless parameters based upon functions of L_e/r_w and incorporated into the empirical equations to solve for $\ln(r_e/r_w)$. Values of A, B, and C are obtained from the curves relating coefficients A, B, and C to L_e/r_w (Figure 3-2).

The resultant values of $\ln(h_o/h_t)/t$ and $\ln(r_e/r_w)$ are then used in Equation 3-1 to estimate the hydraulic conductivity.

3.2.2 Confined Aquifer

The following method (Cooper, et. al., 1967) is applicable to fully penetrating wells in confined aquifers. For partially penetrating wells, transmissivity may be estimated for that thickness of aquifer in which the well is screened or open.

An estimate of transmissivity can be calculated by the following equation:

$$T = (8.64 \times 10^4)(T_t/r_c^2)\ (r_c^2/t)$$

where

T = coefficient of transmissivity, in ft^2/day

r_c = internal radius of well casing, in ft

T_t/r_c^2 = 1.0

t = time, in seconds, since time zero when $T_t/r_c^2 = 1.0$

therefore:

$$T = (8.64 \times 10^4)\ (r_c^2/t) \qquad \text{(Equation 3-5)}$$

For purposes of Equation 3-5, t is determined by curve matching. The type curves are shown on Figure 3-3. Data should be plotted to the same scale as Figure 3-3 on transparent or semi-transparent graph paper or mylar. The ratio h_t/h_o is plotted on the linear scale. The value of h_o is calculated by one of the following equations. For a slug of water or a submerged solid slug:

$$h_o = V/\pi r_c^2 \qquad \text{(Equation 3-6)}$$

where

V = slug volume, in ft^3

For a solid slug of constant diameter extending above h_o:

$$h_o = [D^2][x/(4\pi r_c^2 - D^2)] \qquad \text{(Equation 3-7)}$$

where

D = slug diameter in ft

x = depth of slug penetration below static water level in ft

The logarithmic axis of the data curve is a plot of time (t) since injection or withdrawal of the slug. When the data curve and the appropriate type curve are superposed, the value of t on the data curve corresponding to $T_t/r_c^2 = 1.0$ on the type curve can be read directly for use in Equation 3-5.

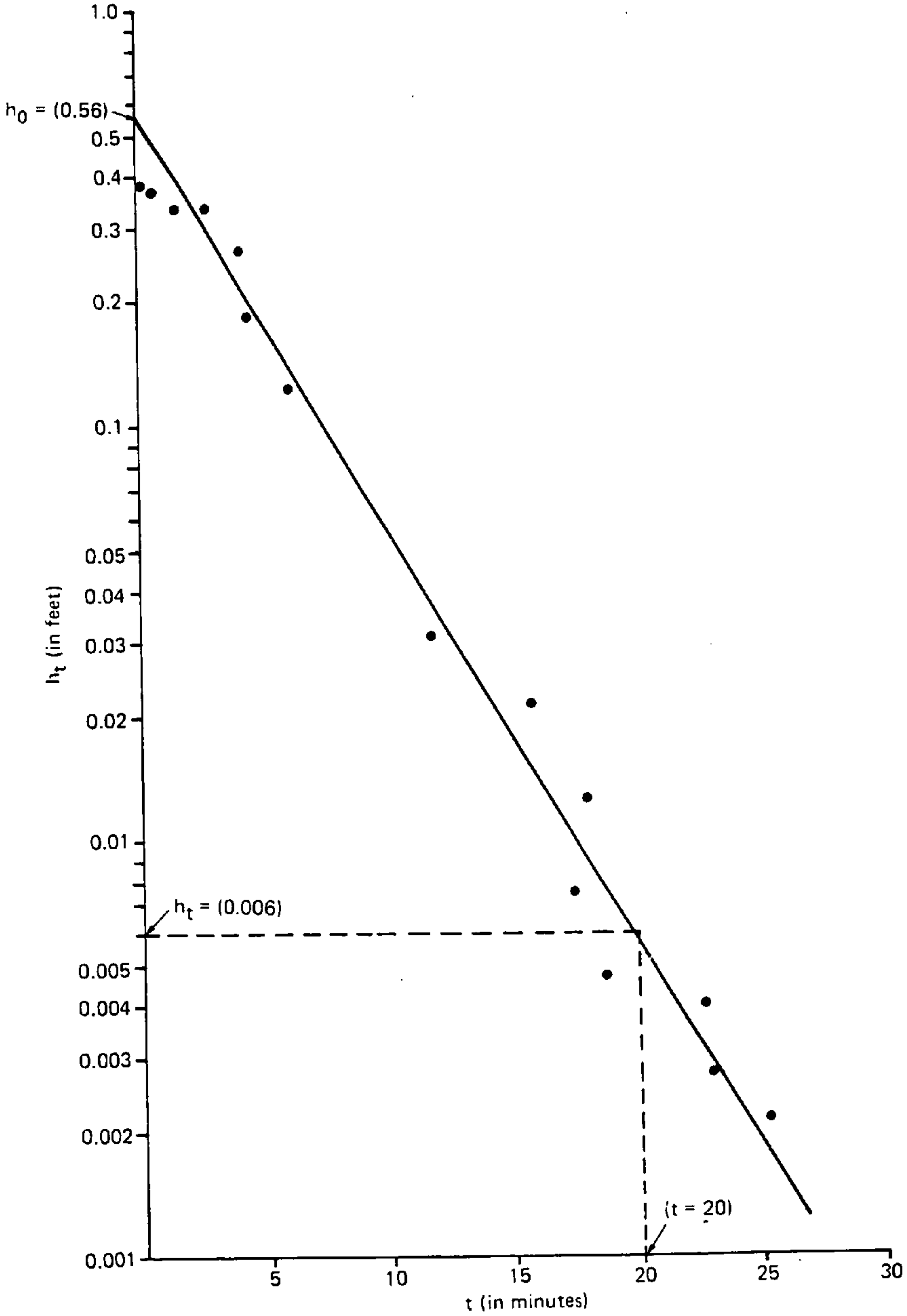

Figure 3-1. Slug test; example data curve.

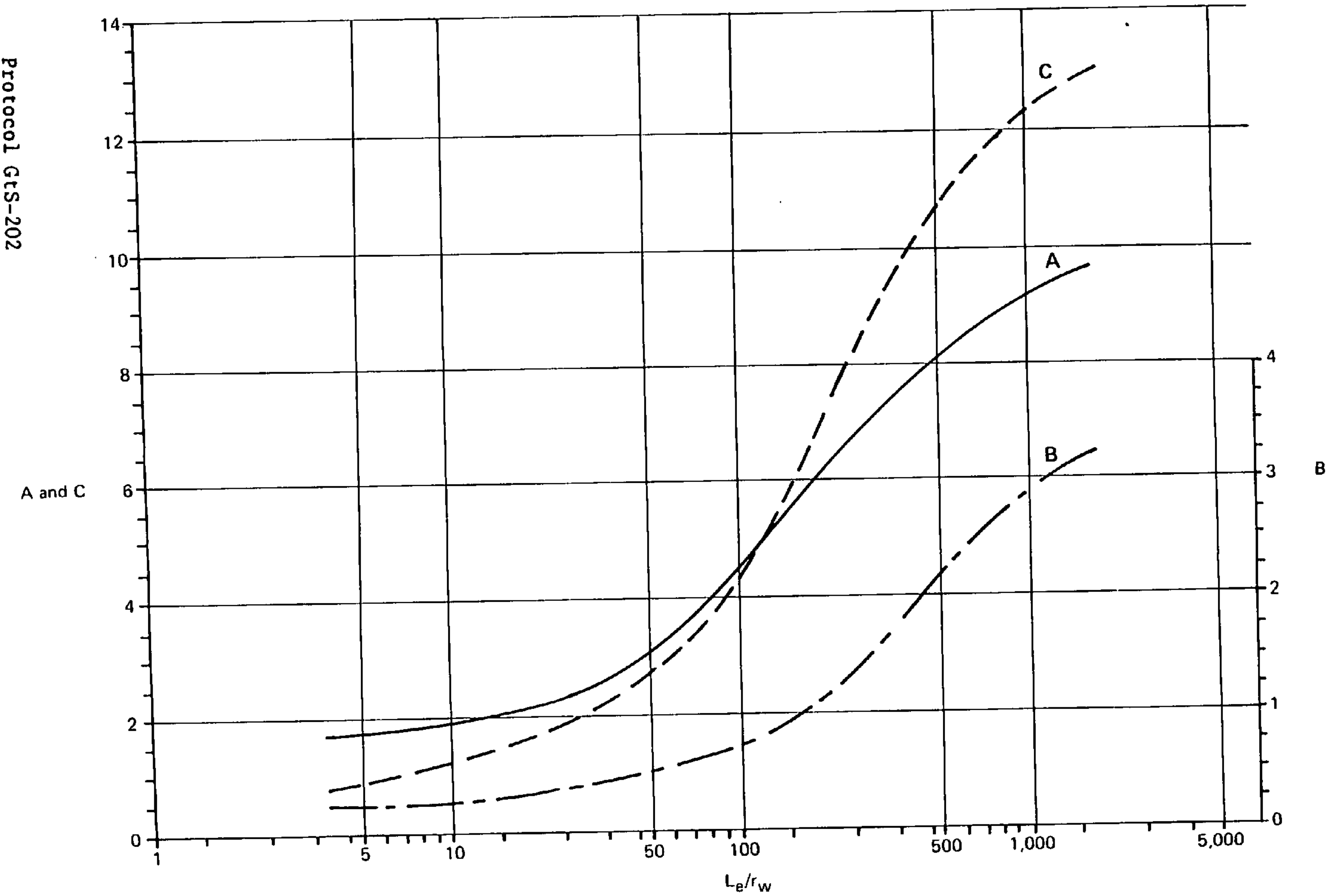

Figure 3-2. Curves relating coefficients A, B, and C to L_e/r_w.
(Source: Bouwer and Rice 1976).

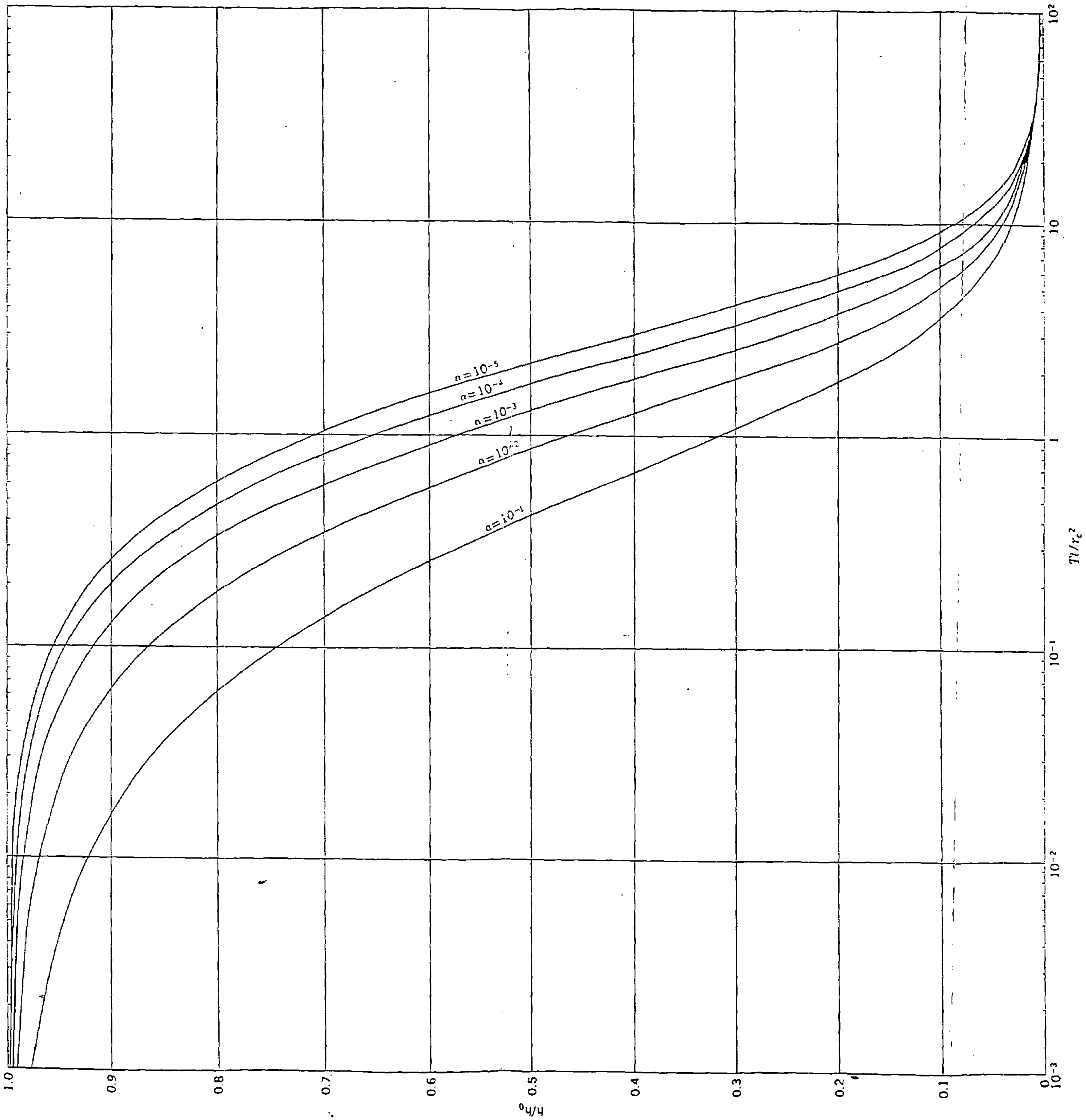

Figure 3-3. Type curves for h/h_0 versus Tt/r_c^2 for five values of α. (Source: Lohman, 1979 after Cooper, Bredehoeft, and Papadopulos 1967)

STANDARD OPERATING PROCEDURE
FOR
GROUND-WATER SAMPLING AND SAMPLE HANDLING

Approved:

Chief Engineer	9 DECEMBER 1985 Date
Program Director	12-09-85 Date

Protocol GtS-401
EA Engineering, Science,
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Appendix A - Permeability Conversion Factors*

	cm per s	ft per Day	ft per Year	Darcy	Meinzer, gallons per day per ft^2
cm per s	1	2.835×10^3	1.0348×10^6	1.033×10^3	2.12×10^4
ft per day	3.53×10^{-4}	1	365	3.64×10^{-1}	7.48
ft per year	9.67×10^{-7}	2.74×10^{-3}	1	9.99×10^{-4}	2.05×10^{-2}
Darcy	9.68×10^{-4}	2.75	1.001×10^3	1	20.50
Meinzer gallons per day per ft^2	4.72×10^{-5}	1.34×10^{-1}	48.8	4.88×10^{-2}	1

---

* Multiply the unit at the left by the number in the column to get the unit at the top of the column. All units are based on a temperature of 60 F or 15.6 C (Source: Johnson, 1981).

CONTENTS

1. INTRODUCTION

Collection and proper handling of ground-water samples forms the foundation of the data generation effort in any ground-water quality assessment. Samples collected must be as representative as possible of the formation from which they have been drawn if the assessment is to be as accurate as possible. Failure to collect and handle samples properly results in generation of erroneous or misleading data and results in a significant waste of resources.

It is the responsibility of the project manager to work with the environmental chemistry and laboratory staff to prepare a sampling plan specific for a given project. The site-specific plan should be viewed as a supplement to the protocol set forth in this document. Thus, the objective of this protocol is to, in a generic sense, detail the procedures to be followed on all EA projects requiring the collection and handling of samples of ground water. In lieu of a project plan the contents of this document shall serve as the protocol to be followed.

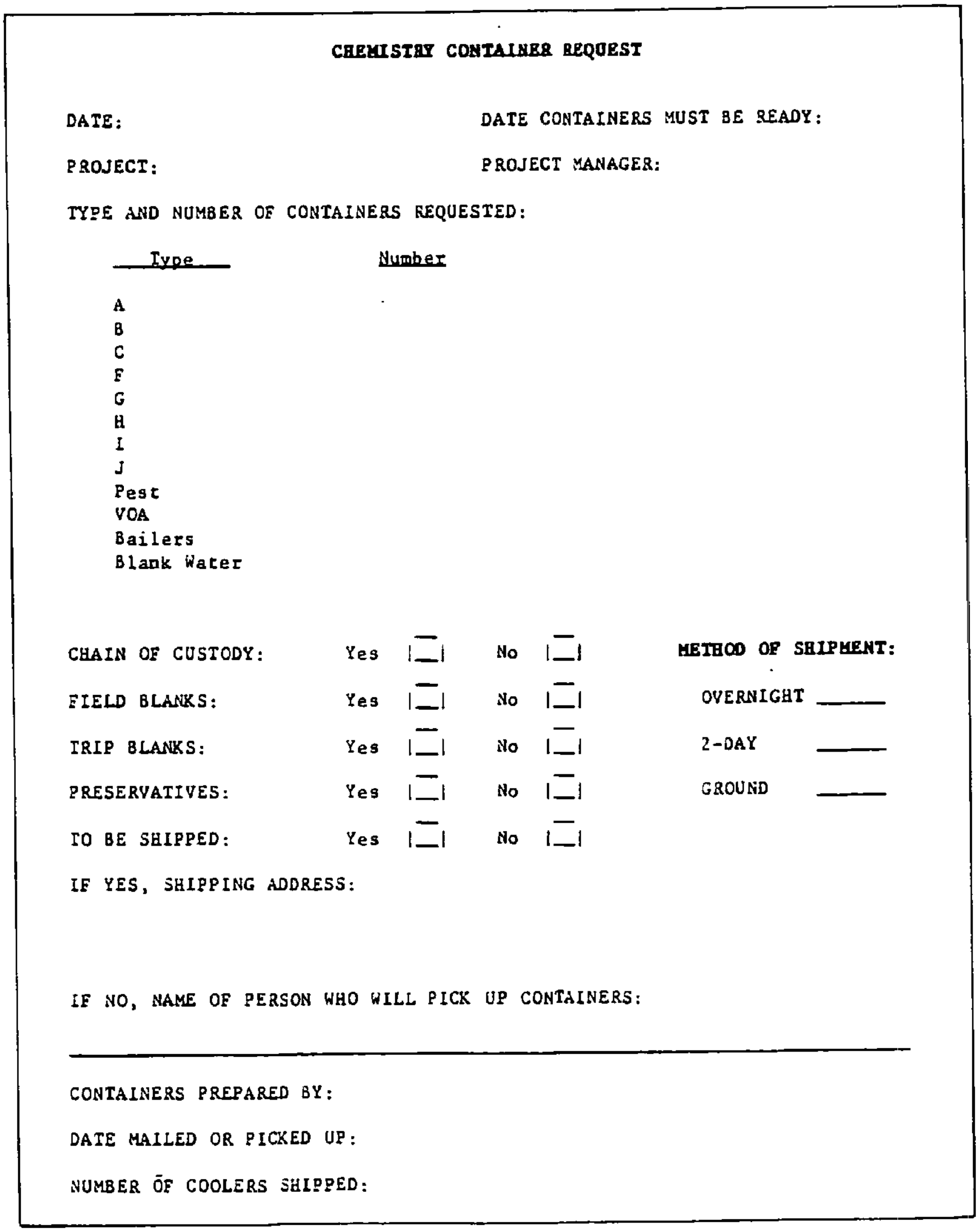
2. APPLICATION

This protocol is applicable. in a generic sense. to all ground-water sampling and sample handling associated with all EA projects. It applies to sample acquisition from wells of all diameters and both contaminated and noncontaminated ground waters. As was mentioned in Section 1. this protocol was designed as a generic approach and is to be rendered site specific when incorporated with a project work plan.

3. MOBILIZATION

3.1 ACQUISITION OF SAMPLE CONTAINERS

It is the responsibility of the project manager to procure the required sample containers and blanks from the laboratory. This is done by notifying the laboratory of the need for containers and by initiating a "Chemistry Container Request" form (Figure 3-1). An aspect of this form is specification of the type and number of sample containers required. This information should also be provided by the project manager based on his knowledge of the parameters required in the analytical program. Specification of the container types required can be made by consulting Table 3-1. Should there be questions regarding container-type selection, they should be directed to the laboratory. Should the project manager need guidance in deciding what container types are required he/she should contact the laboratory sample custodian. When this contact is made, the project manager should be prepared to specify the parameters that are to be determined, the matrix, the number of sampling locations, and the analytical protocol to be followed (i.e., standard, CLP, USATHAMA). This information is important to ensure that adequate container-types that will provide adequate volumes for analysis are provided. The project manager should also specify the types of blanks required. The options available here include trip blanks, field blanks, and wash blanks. The trip blank consists of one set of all containers filled in the laboratory, shipped to the field, returned to the laboratory, and analyzed. The field blank consists of one set of bottles shipped empty, filled with water that has passed through the sampling gear, shipped to the laboratory, and analyzed. The wash blank is the same as the field blank except that the water has passed through gear that has been field cleaned. The sample custodian will then complete a container request for the project manager.



CHEMISTRY CONTAINER REQUEST

DATE: DATE CONTAINERS MUST BE READY:

PROJECT: PROJECT MANAGER:

TYPE AND NUMBER OF CONTAINERS REQUESTED:

Type	Number
A	
B	
C	
F	
G	
H	
I	
J	
Pest	
VOA	
Bailers	
Blank Water	

CHAIN OF CUSTODY: Yes ☐ No ☐

FIELD BLANKS: Yes ☐ No ☐

TRIP BLANKS: Yes ☐ No ☐

PRESERVATIVES: Yes ☐ No ☐

TO BE SHIPPED: Yes ☐ No ☐

METHOD OF SHIPMENT:

OVERNIGHT ______

2-DAY ______

GROUND ______

IF YES, SHIPPING ADDRESS:

IF NO, NAME OF PERSON WHO WILL PICK UP CONTAINERS:

CONTAINERS PREPARED BY:

DATE MAILED OR PICKED UP:

NUMBER OF COOLERS SHIPPED:

Figure 3-1. Chemistry container request.

TABLE 3-1 SAMPLE CONTAINERS AND PRESERVATIVES

Designation	Aqueous Sample Preservatives and Container Materials	Volume
A	No preservative (plastic)	500 ml
B (nutrients)	1 ml H_2SO_4 (plastic)	500 ml
C (metals)	1 ml HNO_3 (plastic)	500 ml
F (phenol)	H_3PO_4 and $CuSO_4$ (glass)	250 ml
G (cyanide)	0.5 ml 10N NaoH (plastic)	125 ml
H (oil & grease)	2 ml H_2SO_4 (glass with teflon liner)	1 liter
J (bact)	Sterile ($Na_2S_2O_3$) (plastic)	500 ml
VOA	$Na_2S_2O_3$ (glass with teflon liner)	40 ml
PEST	No preservative (amber glass)	1 gallon(a)

A	Acidity
A	Alkalinity
A	Bromide
A	Carbonate, total
A	Chloride
A	Chlorine residual
A	Chlorine demand
	Cyanide:
G	total
G	amenable to chlorination
A	Fluoride
A	Hardness (EDTA)
A	Iodide
	Nitrogen:
B	total
B	ammonia
B	organic
A	nitrite
B	nitrate
	Oxygen, dissolved:
A	electromagnetic
A	modified Winkler titration
A	pH
	Phosphorus:
B	total
A	ortho
B	hydrolyzable organic
A	Sulfate
I	Sulfide
A	Sulfite
A	Silica
A	Sediment fractionation
A	Specific gravity
A	Taste
A	Turbidity
A	Chlorophylls:
	a only
A	a, b, and c
C	Aluminum
C	Antimony
C	Arsenic
C	Barium
C	Beryllium
C	Bismuth
A	Boron
C	Cadmium
C	Calcium
	Chromium:
A	hexavalent
C	total
C	Cobalt
C	Copper
C	Iron
C	Lead
C	Lithium
C	Magnesium
C	Maganese
C	Mercury
C	Molybdenum
C	Nickel
C	Potassium
C	Selenium
C	Silver

TABLE 3-1 (Cont.)

A	Calcium carbonate saturation
	Color:
A	apparent
A	true
A	Conductance @ 25 C
A	Odor
A	Oxygen consumption
	Residue:
A	total
A	total volatile
A	total filterable
A	total non-filterable
A	volatile non-filterable
A	settleable, volumetric
A	settleable, gravimetric
	Salinity:
A	argentometric
A	conductometric
A	hydrometric
PEST	Halogenated hydrocarbon pesticides
PEST	PCBs
PEST	Phenoxy acid herbicides
PEST	Organophosphorus pesticides
PEST	Carbamate pesticides
PEST	Triazine class pesticides
PEST	Acid extractable organics
PEST	Base/neutral organics
PEST	Benzidine
VOA	Volatile organics
C	Sodium
C	Tin
C	Titanium
C	Thallium
C	Vanadium
C	Zinc
C	Zirconium
H	Hydrocarbons
	Oxygen demand:
A	biochemical
B	chemical
H	Oil and grease
	Organic carbon:
B	total
A	particulate
F	Phenols
A	Surfactants
J	Standard plate count
	Coliforms, total:
J	multiple tube fermentation
J	membrane filter
	Coliforms, fecal:
J	multiple tube fermentation
J	membrane filter
	Streptococci, fecal:
J	multiple tube fermentation
J	membrane filter

Designation	Soil Sample Preservatives and Container Materials	Volume
Soil	No preservatives, wide-mouth glass	Variable

The laboratory should be given as much advance notice of sampling container needs as possible (at a minimum 48 hours). This is particularly important when containers are to be shipped. Whenever possible, sample requests should be made far enough in advance to minimize shipping costs. The laboratory operating protocol specifies that the cost of sample container shipment will be borne by the laboratory when surface means (i.e., UPS) can be used. When it is necessary to ship containers via air courier, the costs will be passed on to the project. Surface shipping costs are about 25 percent of air assuming the same destination. When the containers have been prepared it is the responsibility of the project manager or his designee to assure that all containers required have been provided **PRIOR TO** going to the field. If the containers received are other than those requested, the sample custodian should be notified so that the problem can be resolved.

3.2 PRE-INITIATION BRIEFING

Prior to initiation of any ground-water sampling activities, it is imperative that the project manager formally brief the field team. At this time the field team leader should be given a copy of the field sampling plan and project health and safety plan. The briefing should lay out in detail all activities to be undertaken and all protocols to be followed. This would also be a good time for the sample container shipment to be checked. The field equipment and supply check list (Attachment A) should also be initiated at this time. The field team should raise any questions they may have and the project manager should answer them. The field team should leave the briefing with a thorough understanding of all aspects of the field activity.

3.3 STAGING

Prior to any field effort. it is necessary to assemble the required equipment and supplies. Because ground-water sampling is a rather involved process that requires a relatively large variety of equipment and supplies. planning is important. Failure to adequately plan often results in aborted sampling efforts as a result of arrival in the field without required equipment. One means by which this situation can be avoided is preparation of check lists (Appendix A). The check lists should be prepared by the project manager and the field team leader. The project manager is responsible for specifying the items required for the field effort. The field team leader should then check the equipment off as it is loaded into the field vehicle. The completed check list should subsequently become part of the project file.

4. PHYSICAL INSPECTION

It is important for personnel sampling ground water to realize that they are the eyes and ears of the project manager and ultimately of the client. Thus the importance of accurate and detailed observations cannot be overstated. It is important that attention be given, not only to sample collection, but also to site reconnaissance. In many instances the project manager spends much less time on site than the field technician. Therefore, it is essential that the sampling crew provide as much information as possible. The following is a listing of the steps that need to be followed in conducting the site inspection:

4.1 Obtain site map and/or tax maps of property from project manager prior to departing the office.

4.2 Upon arrival at the site attempt to identify all relevant features on the map and add those that are not noted. If no map is available, prepare a site sketch by pacing or measuring distances relative to a reference. A compass is useful in preparing a site sketch and should be used when possible. A "north arrow" should be placed on the sketch and identified as to whether it is true north, magnetic north, or site-grid north. The following should be located on any site sketch or map:

- storm sewers
- septic systems
- sanitary sewers
- water lines
- topographic relief
- buildings identified to the extent possible

- description of surrounding neighborhood (i.e., industrial. residential. rural. etc.)
- wells. particularly drinking water wells
- existence of a public water system
- potential contaminant sources
- surface water. seeps. springs. dry stream beds
- monitoring wells and other sampling points
- existence and nature of any treatment systems including type. manufacturer. model number. and serial number
- outcrops of bedrock
- utility/gas lines

4.3 Prior to sampling each well the condition of the well and surrounding area should be noted. This should include but should not be limited to the following:

- security (Is the well locked? Is there evidence of tampering?)
- evidence of physical damage
- well integrity
- evidence of breakage or heaving of the concrete pad. if present
- evidence of surface infiltration or accumulation of standing water around the casing

The information gathered should be recorded in a bound field notebook for inclusion in the field sampling report.

5. DETERMINATION OF WATER LEVEL

Water level relative to a noted reference must be determined in all wells to be sampled prior to initiation of ANY purging and sampling activities. Because these data are often used to construct water table maps, it is essential that they be as accurate as possible. All water level determinations must be made to the nearest 0.01 ft. Water level determinations should be sequenced such that the least contaminated wells are addressed first. EA currently determines water level using a variety of devices. Utilization of each device is provided in the sections that follow.

Upon arrival at each well, unlock the lock and remove the cap. Wells installed by EA have a permanent reference for water levels established at the time of construction. This reference is described on boring logs and identified in the field sampling plan. For sites which do not have established reference elevations, the following protocol should be followed. Measure the height of the stick up (or stick down) to the nearest 0.01 ft relative to the ground surface and record same on the Field Record of Well Gauging, Purging, and Sampling (Figure 5-1) along with the location of the stick up reference. This reference should then be used in all subsequent measurements. This having been accomplished, apply the appropriate technique from the following according to the specifications in the project sample plan. Note, in particular, Section 5.5 (Cleansing).

Wells with strong organic odors or which are otherwise suspected of containing a floating organic phase (i.e., gasoline or diesel) should be appropriately gauged to determine product thickness as well as water level. This can be accomplished by either using probes designed for that purpose (as described in Section 5.3) or by utilizing a clear or opaque bottom-filling bailer carefully lowered through the liquid interface. Unless directed otherwise by the project manager no well containing a measurable layer of floating product should be either purged or sampled.

FIELD RECORD OF WELL GAUGING, PURGING AND SAMPLING

Site: ____________________

Well No: __________ Gauge Date: __________ Time: __________

Weather: ____________________

Well Condition: ____________________

____

Well Diameter (inches): ____________________

Odor (describe): ____________________

Sounding Method: __________ Measurement Reference: __________

Stick up/down (ft): ____________________

(1) Well Depth (ft): __________ Purge Date: __________ Time: __________

(2) Depth to Liquid (ft): __________ Purge Method: __________

(3) Depth to Water (ft): __________ Purge Rate (gpm): __________

(4) Liquid Depth [(1)-(2)]: __________ Purge Time (min): __________

(5) Liquid Volume [(4)xF] (gal): __________ Purge Volume (gal): __________

Did Well Pump Dry? Describe: ____________________

____

Samplers: ____________________

Sampling Date: __________ Time: __________

Sample Type: __________ Split? __________ With Whom: __________

Comments and Observations: ____________________

____

____

*Conversion: Liquid Depth to Volume

Well Diameter	Gallon/ft
2"	0.16
4"	0.65
6"	1.47
8"	2.61
12"	5.87

Conversion Inches to Fractional Feet

1	.08	5	.42	9	.75
1 1/2	.12	5 1/2	.46	9 1/2	.79
2	.16	6	.50	10	.83
2 1/2	.21	6 1/2	.54	10 1/2	.87
3	.25	7	.58	11	.91
3 1/2	.29	7 1/2	.62	11 1/2	.95
4	.33	8	.56		
4 1/2	.37	8 1/2	.70		

* Multiply liquid depth by gallons/ft.

Figure 5-1. Field record of well gauging, purging and sampling.

Purging and sampling wells with raw product serves no real purpose save determination of the water solubility of the compounds in the product which is generally available in a chemistry reference. Such purging and sampling also heavily contaminates gear. thereby increasing the potential for cross-contamination. If samples are being split with another party who is conducting the purging, and they collect samples from wells containing floating product. a sample should be collected and the presence of product noted in the field activities report.

5.1 ELECTRONIC SOUNDERS

EA currently uses several types of electronic water level sounders all of which function based on completion of an electrical circuit (conductivity). Penetration of water is indicated by activation of an audible tone. light. or meter. These electrical sounders are highly efficient and effective in most instances. An exception to this is a well in which floating hydrocarbon is present (i.e., gasoline or oil). These materials serve as insulators and not only does the sounder fail to indicate the level of the floating hydrocarbon but the hydrocarbon coats the probe and renders it ineffective in determining the level of the water. In instances when floating hydrocarbon is anticipated a steel tape or interface probe should be employed.

Determination of water level using an electronic sounder is made by lowering the pre-cleaned (wipe probe and cable with methanol) probe of the sounder into the well slowly until the indicator (audible tone. light. or meter) is activated. Contact between the probe and the well casing should be avoided as condensation may cause an erroneous reading. After a positive indication of water penetration has been achieved. the probe should be slowly raised and lowered until the indicator accurately registers the water surface. The water level should be measured from the reference on the casing marked when the casing stick up was measured. This reference should be permanently marked so that future measurements can be made to the same point. It is generally necessary for the reference elevation to be on the well riser casing rather than the outer protective casing. Once the water level has been determined the point on the sounder cable, which is generally calibrated in 5- or 1-ft intervals, should be marked and water level determined to the nearest 0.01 ft with a folding ruler or steel tape. The water level should be recorded on the field data sheet (Figure 5-1).

5.2 STEEL TAPE AND CHALK

Ground-water levels in wells and piezometers can also be determined using a steel tape and chalk. Fiberglass tapes should not be used to determine water levels as they tend to absorb contaminants and release them randomly thereby creating a potential for cross-contamination.

The steel tape is prepared for water level determination by attaching a weight to the terminus and attaching a 48-in. (nominal) strip of masking tape to the back side of the tape. Prior to insertion into the well carpenters chalk is applied to the masking tape. The tape is then lowered into the well until it penetrates the water surface as indicated by a splash. After the tape has penetrated the water it is lowered an additional foot. The tape is referenced to the well casing as described in Section 5.1 and the reading recorded (Figure 5-1). The tape is retrieved and the water level on the chalked tape recorded. The water level is then determined by subtracting the masking tape reading from the casing referenced reading. The result of this computation is the depth to water which is reported to an accuracy of 0.01 ft.

5.3 INTERFACE PROBES

In instances in which a multi-phase system is anticipated (i.e., floating hydrocarbon), an interface probe is used to determine water level. Three types of interface probes are currently available at EA. The first is the Emtec which is a float operated probe. The float responds differentially to water and materials less dense than water. The Emtec probe has a visual and auditory indicator system. It is equipped with a red and green light and with a beeper. When the probe is immersed in water, both lights shine and a steady beep is heard. When the probe is immersed in material less dense than water only the red light shines and the beeping is intermittent. When using the Emtec, the probe, which is attached to a steel tape, is lowered into the well until it activates (lights and beeps) which is an indication that it has penetrated a liquid. The type of liquid is determined according to the pattern described above. If the indication is that a material less dense than water has been encountered the tape is referenced to the casing, the value recorded to the nearest 0.01 ft, and the probe is lowered until it indicates penetration of the water/hydrocarbon interface. The tape is again referenced to the casing and the value recorded to the nearest 0.01 ft. The thickness of the floating material is determined by difference. When making water level determinations with the Emtec it is necessary to add approximately 1.65 ft to all readings to correct for the length of the probe. This length must be field measured and verified as it may change slightly depending on the method of attachment to the tape. Caution must be exercised in using the Emtec as its sensors are in the probe head and when a substantial layer of floating material is present or the depth to liquid is very deep the lights are difficult to see and the beeps difficult to hear.

The second type of interface probe available is MCC Oil-Water Interface Probe. This probe operates on the principal of sonic conductivity. The MCC probe produces an audible signal when immersed in liquid. The signal is continuous when the probe is immersed in material less dense, and less sonically conductive than water (i.e., gasoline) and is intermittent when immersed in water. The signal is produced in the tape reel mechanism and thus the problems associated with the Emtec are absent. The MCC probe is attached to a steel tape housed in a reel and therefore determination of floating material and water levels is made as described above for the

Emtec. Because the MMC probe is configured such that probe length has been considered, it is unnecessary to correct measurements.

The third type of interface probe available is the Oil Recovery System's Interface Probe. This unit is a self-contained tape, reel, and dual sensing probe which utilizes an optical liquid sensor along with electrical conductivity to distinguish between water and hydrocarbon. Care must be taken to ensure that the conical prism situated on the end of the probe does not become scratched which would render the probe useless. The signal is transmitted from the probe to an audible alarm on the reel assembly, thereby eliminating the problems with the Emtec. A continuous tone sounds when the probe is immersed in material less dense and with a lower electrical conductivity than water. An oscillating tone sounds when the probe is immersed in water. The length of the probe is accounted for on the tape, thereby making correction of the readings unnecessary.

5.4 WELL DEPTH SOUNDING

After water level has been determined, the depth to the bottom of the well (to the nearest 0.01 ft) is determined by sounding with a decontaminated weighted steel tape and recorded (Figure 5-1). The "feel" of the well bottom (i.e., hard, soft, tape weight sticks to bottom) is noted and recorded. If a thickness of sediment is discernible, it is also recorded. The nature of materials adhering to the weight or tape is also noted and recorded. Interface probes should not be used to determine well depth as immersion in sediment could potentially damage the mechanism. However, these sounders can be used (cf. project plan) to detect the presence of materials more dense than water according to the methods described above.

5.5 CLEANSING

Much of the ground-water work in which EA is involved requires contaminant assessment at the ug/L or lower level. It is therefore essential that every effort be made to avoid cross-contamination. This can best be done by assuring that no equipment coated with or containing contaminants from one well be introduced into another well. The criticality of this step lies in the fact that as little as one drop of contaminant has the potential to contaminate a well to the mg/L level and to possibly render the well unsuited for future monitoring.

In order to ensure that cross-contamination via water level sounding equipment does not occur it is necessary to decontaminate the equipment prior to each field effort and between **EACH** well. This is done by wiping the tape with a paper towel saturated with methanol as it is retrieved. A fresh towel must be used for each well. Probes such as the Emtec. Oil Recovery System's. and MMC must be methanol rinsed (a wash bottle can be used) and fully immersed in a pail of clean water between wells. Fresh water must be used for cleansing between wells. All equipment should again be cleaned in accordance with this section immediately after it is last used for the day. Potentially contaminated equipment must never be stored or transported.

6. WELL PURGING

Prior to sample acquisition it is necessary to purge the well in order to ensure that the sample collected is as representative as possible of the ground water in the aquifer. Failure to purge may result in collection of water that has been isolated from the aquifer in the well casing for an extended period of time any may no longer be representative of the aquifer. Purging is typically accomplished by pumping or bailing. Pumping is done with submersible pumps, centrifugal pumps, or with peristaltic pumps. Bailing is generally done using a bottom-filling bailer. All purging equipment should be handled in a manner which avoids contact with potentially contaminating materials (i.e., generators, fuel containers, the ground, vehicle exteriors, etc.). The manner in which wells are purged is a function of well diameter, depth to water, volume of water, and yield. It is the responsibility of the project manager to determine the purging technique most appropriate for a given project and to specify same in the project sampling plan.

After the method has been selected, the appropriate procedure from among the following should be followed. In order to assure representative ground-water measurements all water level determinations must be completed prior to purging of any wells at a given site.

Unless specifically directed otherwise, <u>no</u> well containing a measurable quantity (not just a sheen) of floating organic phase (i.e., gasoline or diesel) should be purged or sampled; this is of importance to minimize cross-contamination potential.

6.1 DETERMINATION OF VOLUME PURGED

It is EA's routine practice to purge a volume of water equal to four times the volume of standing water in the casing or to dryness. This is consistent with U.S. EPA guidance as stated in the Resource Conservation

Recovery Act (RCRA). However, this volume may or may not be appropriate in all cases. If the project manager deems it necessary, it may be more appropriate to empirically derive the volume to be purged. This is done by choosing a conservative parameter that can easily be determined in the field (e.g., specific conductance) and monitoring it in the pump or bailer discharge as a function of time and volume pumped. Using this procedure, an initial conductivity measurement is made and the pump is activated. Conductivity measurements are then made at 1-minute intervals until three successive readings fall within 10 percent of each other. The volume purged when stability is reached is the well-specific purge volume. This volume can be used in future purging efforts but should be checked annually or whenever the volume has changed significantly due to silt accumulation in the well or whenever well maintenance (i.e., development) is performed.

If it is unnecessary to empirically derive the volume to be purged then four casing volumes are purged or the well is purged to dryness. A casing volume is determined by calculating the volume of standing water. To do this, the well diameter (riser casing ID in inches) is determined and recorded. The height of the standing water in the casing (in feet) is determined next by subtracting the depth to water (water level) from the well depth as determined in Section 5. The volume of water is then determined according to the following formula:

$$V(ft^3) = \pi r^2 h$$

where

v = volume of standing water in ft^3
r = casing radius in feet
h = height of water column in feet
π = 3.14

The volume is converted to gallons by multiplying ft^3 x 7.48, or by:

$$V(gal) = hF$$

where

h = height of water column in feet
F = 0.16 for a 2-in. diameter well
0.65 for a 4-in. diameter well
1.47 for a 6-in. diameter well
2.61 for an 8-in. diameter well
5.87 for a 12-in. diameter well

After this volume has been calculated, it is multiplied by the number of casing volumes to be purged. This represents the volume that must be removed from the well. Under no circumstances should purging be initiated prior to water level determination in ALL wells under observation at the site.

6.2 PURGING WITH PUMPS

6.2.1 Three and Seven-Eighths and Four-Inch Submersible Pumps

Four-inch and larger diameter wells with an adequate yield are generally purged by an AC-powered submersible pump of appropriate diameter. These pumps are powered with a portable generator and are equipped with a safety line to prevent loss in a well should a pump hose or power cord break and to make retrieval easier should the pump become jammed in the well.

Wells should be purged in order of least to most contaminated. It is the project manager's responsibility to specify this order in the project sampling plan and again at the pre-sampling briefing. It is the field technician's responsibility to request this information if the project manager does not specify it. If ordering is not possible based on past sampling information, the field technician must determine the most and least contaminiated wells during gauging based on odor and appearance, organic vapor monitor readings, location relative to contaminant sources, and apparent topographic gradient.

Prior to initiation of purging, the pump should be tested for functionality by plugging into the generator. The pump should be lowered into the well until it just penetrates the water surface at which time it should be energized. The pump is then lowered slowly through the water column to the bottom of the well. The pump is then raised to just beneath the water surface and held static for the duration of purging. During purging the pumping rate should be determined by a method such as timing the filling of a 5-gal pail. The volume to be purged (as determined in Section 6.1) is divided by the pumping rate in gallons per minute to determine the pumping duration required. The pumps discharge must be directed downgradient at all times to prevent infiltration. In some instances, it will be necessary to contain the purged water to prevent infiltration and contaminant migration. When this is the case, the protocol to be followed should be specified in the project sampling plan.

When the required volume of water has been evacuated from the well, the pump is raised to the water surface and allowed to pump for an additional 2 minutes to ensure that surface water that will be sampled has truly been exchanged. At this time the pump is removed from the water and allowed to purge itself and the discharge hose. The pump is then removed from the well and the volume purged is recorded (Figure 5-1).

In the event the well dewaters prior to evacuation of the required volume, the well is allowed 15 minutes to recover and pumping is re-initiated. If the well again dewaters, the pump is removed from the well, as above, and the volume purged is recorded.

6.2.2 Keck Submersible Pumps

If the well diameter will not accommodate a standard submersible pump, the water level is greater than 20 ft below grade, and the well is accessible by a 4-wheel drive vehicle, the Keck Geophysical Instruments, Inc. SP-84 pump and reel can be used for purging. This pump will fit a 2-in. diameter well and is rated from about 1.5 gpm (10-ft head) to about 0.5 gpm (150-ft head). The pump is a progressive cavity pump and will pass silt and fine sand. The SP-84 operates from a 12-volt DC battery. Virgin polyethylene 0.5-in. diameter flexible discharge pipe should be used in each well. Purging with an SP-84 should be done according to the protocol described in Section 6.2.1.

6.2.3 Back-Pack Submersible Pumps

If access to the well is limited or the well diameter will not accommodate a standard submersible pump, a back-pack pump fitted with a head of appropriate diameter can be used for purging. The back-pack pumps have 1.5 and 2-in. heads and self-contained power sources. They can be charged to operate continuously for up to 5 hours. Back-pack submersible pumps should be used according to the procedure described in Section 6.2.1.

All submersible pumps should be equipped with foot values to preclude backflow and carry over.

6.2.4 Centrifugal Pumps

In instances where the depth to water is less than 20 ft below grade, a centrifugal pump can be used for purging. These pumps operate with a gasoline engine and, depending on specific pump characteristics, operate over a discharge range of 1-50 gpm. The discharge rate can be controlled by an in-line ball valve. Virgin polyethylene tubing should be used in each well to minimize cross-contamination.

6.2.5 Peristaltic Pumps

In instances where the depth to water is shallow (less than 20 ft) and the well yield is low, a peristaltic pump can be used for purging. These pumps operate with a 12-volt battery. Care must be exercised in selection of pump tubing, as some types of tubing have the potential to contaminate samples. The laboratory staff and project manager should select a tubing composition appropriate for a given project.

6.2.6 Cleansing Pumps Between Wells

Because the potential for carryover and therefore cross-contamination is great, it is essential that the pumps used to purge wells be cleaned thoroughly between wells. Submersible and back-pack pumps are cleaned by spraying the exterior aspects of the pump and associated plumbing with hot water (40-45 C). However, project-specific requirements may dictate solvent rinses. Whenever feasible, new suction and discharge line should be used for each well.

This is accomplished with a pressure sprayer. Hot water is carried to the field from the office or motel. Under circumstances in which the water cools to less than 40 C, it should be heated with an immersion heater powered by the generator. After the exterior of the pump and plumbing has been pressure-cleaned, the pump is immersed in hot water and hot water is pumped through the system to clean the interior. It is generally necessary to pump 5 to 10 gallons to obtain a clean pump. The pump should be allowed to purge itself and the hose between wells. Except for jacketed cables on 3-7/8 and 4-in. submersible pumps, a new length of safety line should be attached to the pump between wells.

The peristaltic pump is cleansed between wells by installing new tubing. The used tubing should be retained and disposed of at the office or in an appropriate receptacle if available onsite.

No pump which has come into contact with a non-aqueous liquid phase (i.e., hydrocarbon) will be reused until thoroughly hot water washed and hot water purged. All purging equipment will be thoroughly cleaned upon return from the field and prior to storage.

6.3 PURGING WITH BAILERS

In some situations well yield and volume are sufficiently low to make purging with a bailer feasible. A bailer of appropriate size and composition is selected and fitted with an appropriate length of line. For purging, bottom filling polyvinyl chloride (PVC) or poly carbonate bailers may be used. The bailer is lowered into the well, allowed to fill, retrieved, and the contents emptied downgradient or contained as specified in the project plan. This process is repeated until the desired volume has been evacuated or the well dewaters. In the event the well dewaters the protocol described in Section 6.2.1 is followed. New line should be used for each well. A separate bailer should be used for each well if possible. If, however, this is not possible the bailer must be cleaned between wells. This is accomplished by scrubbing the interior and exterior (disassemble bailer if possible) with hot soapy (Alconox) water and a scrub brush. After scrubbing, the bailer is rinsed twice with hot tap water and three times with de-ionized water. Following the de-ionized water rinses, the bailer is rinsed with methanol followed by three additional de-ionized water rinses. If bailer washing is required, a wash blank should be collected every fifth wash. This is accomplished by filling the clean bailer with laboratory-supplied contaminant-free water and filling one set of sample containers.

No bailer which has come into contact with an non-aqueous liquid phase (i.e., hydrocarbon) will be reused without a thorough soap, hot water wash, solvent rinse, and thorough drying.

6.4 PURGING FOR TAP SAMPLES

Some sampling locations are outfitted with taps or faucets. When this is the case, the system is purged by removing the aerator (if present) and allowing the tap to run for 15 minutes (longer if specified in the study plan). Tap samples should be collected at a point preceding treatment if a treatment system exists.

An operating domestic well must be pumped to waste prior to sample collection. Samples taken immediately will be water from the plumbing and not directly from the aquifer. It is therefore essential to evacuate the plumbing and water storage tanks. House storage tanks vary in capacity but 50 gallons is not unusual. A 15-minute interval before sample collection is essential; longer is desirable. Listen for the well pump to come on; this indicates that the plumbing is being evacuated.

7. GROUND-WATER SAMPLING

Most ground-water sampling is accomplished with bottom filling bailers. However, under some circumstances samples may be collected from taps or from peristaltic pumps. Samples should never be collected from a pump discharge as they generally cannot be considered representative. The sample collection phase of the field effort is critical. It is at this stage that the greatest potential for contamination exists. Only sampling gear that has been certified clean should be used. All sampling gear including sample containers, bailers, line, and pump tubing should be handled as if they were sterile. They **MUST NOT** be transported with purging gear, such as generators and fuel containers, due to the potential for contamination (i.e., gasoline). The sampling personnel must take care to ensure that their hands are clean initially and that they are washed between wells. Whenever possible, it is desirable to use disposable gloves for handling sampling gear. This minimizes the potential for contamination and also protects sampling personnel from contaminants that may be present in the samples. New gloves should be worn for each well sampled. Care should be exercised to ensure that sample does not contact the gloves, as materials used to fabricate them have the potential to produce artifact contamination.

7.1 SAMPLING WITH A BAILER

Unless otherwise directed by the project manager, no well containing a measurable layer (not just a sheen) of floating non-aqueous liquid (i.e., gasoline or diesel) will be sampled. This is of importance to reduce the potential for cross-contamination.

Most ground-water sampling is accomplished with a bailer. When this is the case, only cleaned bottom-filling teflon bailers (or a project-specific material) should be used. A clean dedicated piece of non-contaminating (cf. project plan) line is attached to the bailer and the bailer is lowered into the well. Care should be exercised to ensure that the bailer and line do not contact the ground or other sources of contamination. The bailer is lowered into the well until it fills and is retrieved. The water is discarded. This process is repeated three times. The bailer is then filled and the sample is transferred to the sample containers. Containers that contain preservative must not be filled to overflowing and must be mixed after filling. Samples for volatile organics must be collected in a manner that minimizes aeration and the containers must be free of bubbles and headspace. After the containers have been filled, they should be labeled, an entry should be made on the chain of custody, and they should be placed in a cooler on ice. Unless the project plan provides for an alternative, all samples should be shipped to the laboratory by air freight (i.e., Federal Express).

The project manager should specify the order in which the wells are to be sampled so that the least contaminated wells are sampled first. It is the sampling personnel's responsibility to request this direction from the project manager. If information is not available as to level of contamination in wells, the field sampling agent must determine same while gauging and purging, based on odor, organic vapor sensor, or appearance, the most probable sampling order so that the least contaminated wells are sampled first. Ideally, a separate bailer with new line will be used for each well. If this is not possible, new line should be used and the bailers should be washed according to the protocol described in Section 6.

7.2 SAMPLING FROM A TAP

Tap sampling is accomplished by filling the containers from a tap from which the aerator has been removed. The containers are filled, labeled, and handled as described in Section 7.1. Sampling of a flowing discharge (i.e., from a recovery well depression pump) is a special case tap sample. The discharge should be discharged to ensure it has been flowing at least 15 minutes prior to sampling. The flow rate should be estimated and recorded (bucket and a stopwatch technique is adequate).

Sampling Municipal or Industrial Wells

It is desirable to sample as close to the well source as possible. Samples should be taken directly from the well head whenever possible. This will eliminate chlorination or other interferences, possible changes within the piping, mixing of water from other wells, and so on.

Large capacity wells which are "on-line" and producing prior to the visit may be sampled immediately.

Municipal wells which are temporarily shut down at the time of visit must be pumped to waste prior to sampling. Fifteen minutes or more is suggested. Access to municipal well systems, well houses etc., invariably requires the assistance of a water department employee. Prior notification is essential.

Sampling Domestic Wells

Samples should be taken as close to the pumping well as possible. Therefore, basement faucets or outside faucets are preferable.

The well owner should be questioned about any treatment equipment installed on his system. Softening, iron removal, turbidity removal, disinfection, pH adjustment and other equipment is often used; these will give misleading analyses, depending on the parameters one is sampling for. Home carbon filters for the removal of organics also are increasingly popular. Basement and outside faucets will usually avoid such treated water.

If a sample must be taken following a treatment unit, the type, size, and purpose of the unit shall be noted on sample sheets and field notes.

Home faucets, particularly kitchen faucets, usually have a screen installed on the discharge. This must be removed prior to sampling for bacteria, or for volatile organics since the screen tends to agitate the discharge and some organics may be lost. When sampling for bacteria, do not take a sample from a swivel faucet, since these swivel joints may harbor a significant bacterial population.

7.3 SAMPLING WITH A PERISTALTIC PUMP

When sampling from a peristaltic pump is acceptable, samples are collected from the pump discharge after the pump has pumped for at least 2 minutes. The containers are filled, labeled, and handled as described in Section 7.1.

8. FIELD FILTRATION

It is sometimes necessary to filter selected sample aliquots in the field (i.e., trace metals). When this is the case, filtration apparatus is supplied by the laboratory. Two types of apparatus are available. The first is an all glass system with vacuum supplied by an AC-powered pump. A trap and the sampling glassware are attached to the pump and a laboratory-washed 0.45-u filter is applied to the receiver. Care must be taken to avoid touching the filter. About 100 ml of de-ionized water are passed through the system and discarded. The receiver is then charged with about 50 ml of sample which is also discarded. The sample is then filtered and the appropriate container is filled. Between samples, the glassware is rinsed three times with de-ionized water and the washes are discarded. A wash blank is prepared every ten samples by filtering de-ionized water.

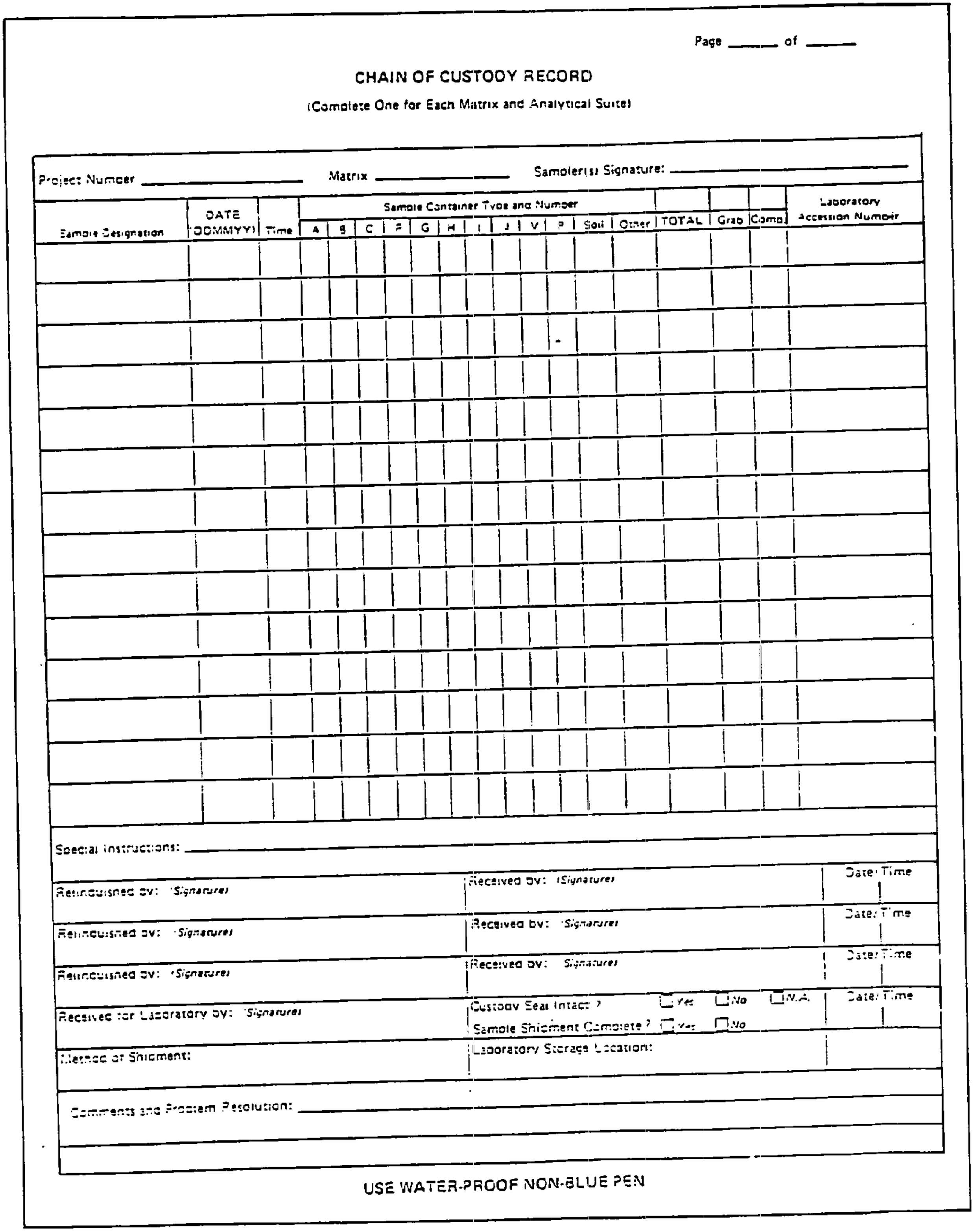
The second type of filtration apparatus is a polycarbonate pressure system. In this system the sample is drawn into the receiver through a silicone tube attached to a three-way stopcock. The stopcock is switched and the sample is filtered through a laboratory-prepared 0.45-u filter cartridge into the sample container. A fresh cartridge is used for each sample. Between samples the system is washed three times with de-ionized water. Wash blanks are prepared every ten samples as described above.

9. WATER QUALITY MEASUREMENTS

Temperature, pH, and specific conductance, when required, are determined in the field. These determinations are made using a multi-function analyzer (Hydrolab) or individual meters. All instruments are calibrated by technical resources staff prior to transport to the field and are standardized in the field prior to use. Standards are obtained from the technical resources staff. Instructions for field-standardization and instrument use are provided by technical resources. Analyses are performed on freshly obtained samples and the results are recorded on the field data sheet (Figure 5-1). The instrumentation is cleaned between samples by flushing with de-ionized water.

10. CHAIN OF CUSTODY

All sampling efforts must be done under a strict chain-of-custody protocol. Failure to follow this directive renders data generated on the samples collected invalid in legal proceedings. The chain of custody (Figure 10-1) is initiated by the sampling technician and is updated each time a sample is collected and each time a set of samples is passed from one person to another. The samples must **NEVER** be left unsecured and they are the responsibility of the individual into whose custody they have been remanded. The chain of custody must accompany the samples at all times. Specific intructions for completing chain-of-custody forms are available in each EA office and should be consulted prior to initiation of sampling efforts. A copy of this protocol is provided as Attachment B. If the samples are shipped, custody must be transferred to the shipper and ultimately received by the laboratory. Sample shipment protocols are generally project-specific and should be specified in the project sampling plan.



Page ______ of ______

CHAIN OF CUSTODY RECORD

(Complete One for Each Matrix and Analytical Suite)

Project Number ______________ Matrix ______________ Sampler(s) Signature: ______________

Sample Designation	DATE (DDMMYY)	Time	Sample Container Type and Number															Laboratory Accession Number
			A	B	C	F	G	H	I	J	V	P	Soil	Other	TOTAL	Grab	Comp	

Special Instructions: ______________

Relinquished by: *(Signature)*	Received by: *(Signature)*	Date/Time
Relinquished by: *(Signature)*	Received by: *(Signature)*	Date/Time
Relinquished by: *(Signature)*	Received by: *(Signature)*	Date/Time
Received for Laboratory by: *(Signature)*	Custody Seal Intact? ☐ *Yes* ☐ *No* ☐ *N.A.* Sample Shipment Complete? ☐ *Yes* ☐ *No*	Date/Time
Method of Shipment:	Laboratory Storage Location:	

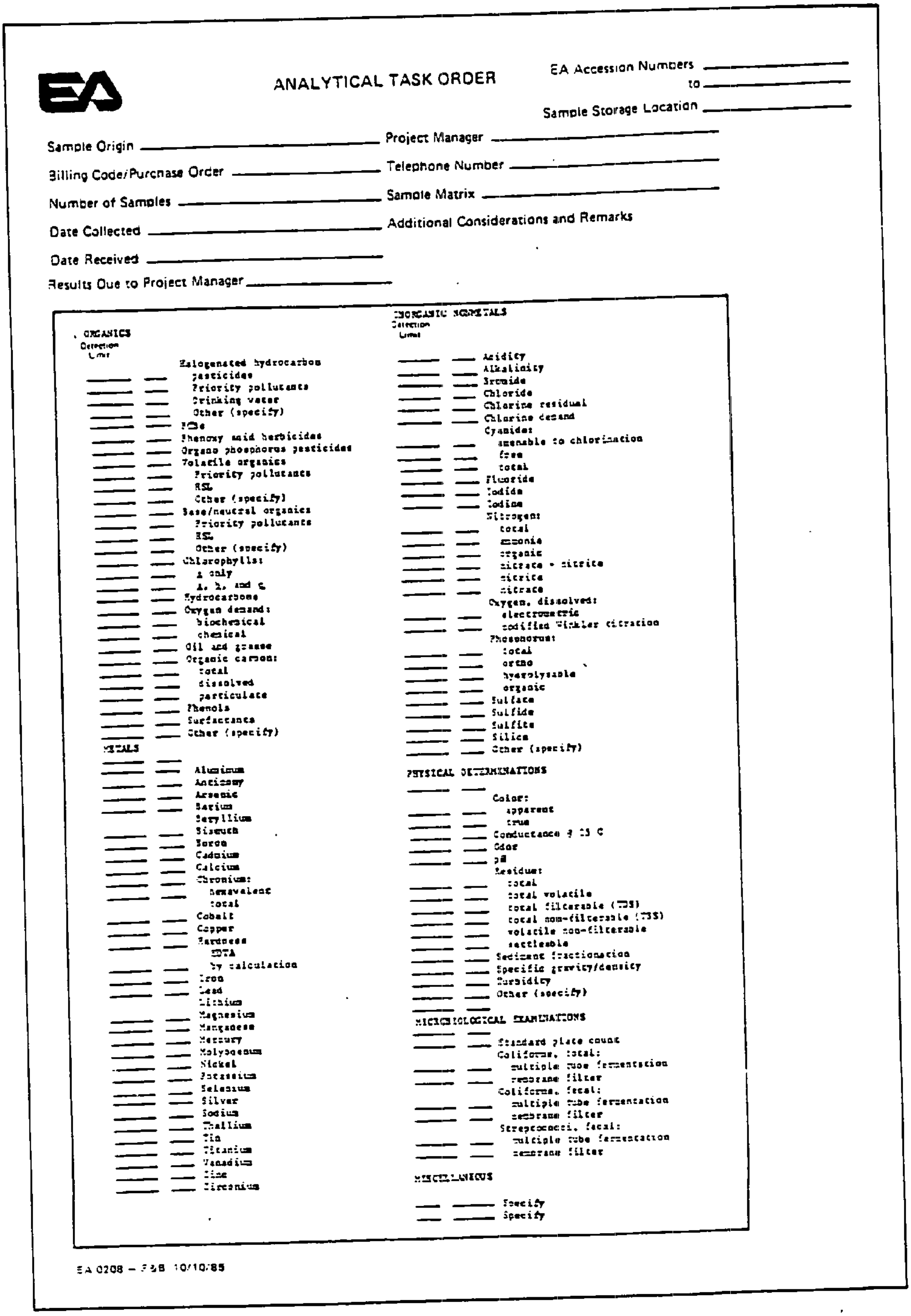
Comments and Problem Resolution: ______________

USE WATER-PROOF NON-BLUE PEN

Figure 10-1. Chain of custody record.

11. DOCUMENTATION

When sampling has been completed, the sampling technician should ship the samples or deliver them to the laboratory. In addition to the chain of custody. the samples should be accompanied by a Completed Analytical Task Order (Figure 11-1). This form must be completed by the project manager according to Appendix B. After the samples have been delivered and/or shipped, the sampling person should provide a copy of the field data sheet (Figure 5-1) to the project manager. The person should also debrief the project manager, paying particular attention to problems encountered. A formal field sampling activity report. including copies of all field notes and observations. should be provided for the project manager and made a part of the project file.



ANALYTICAL TASK ORDER

EA Accession Numbers ______
to ______
Sample Storage Location ______

Sample Origin ______
Billing Code/Purchase Order ______
Number of Samples ______
Date Collected ______
Date Received ______
Results Due to Project Manager ______

Project Manager ______
Telephone Number ______
Sample Matrix ______
Additional Considerations and Remarks

ORGANICS
Detection Limit

Halogenated hydrocarbon
  pesticides
  Priority pollutants
  Drinking water
  Other (specify)
PCBs
Phenoxy acid herbicides
Organo phosphorus pesticides
Volatile organics
  Priority pollutants
  HSL
  Other (specify)
Base/neutral organics
  Priority pollutants
  HSL
  Other (specify)
Chlorophylls:
  a only
  a, b, and c
Hydrocarbons
Oxygen demand:
  biochemical
  chemical
Oil and grease
Organic carbon:
  total
  dissolved
  particulate
Phenols
Surfactants
Other (specify)

METALS

Aluminum
Antimony
Arsenic
Barium
Beryllium
Bismuth
Boron
Cadmium
Calcium
Chromium:
  hexavalent
  total
Cobalt
Copper
Hardness
  EDTA
  by calculation
Iron
Lead
Lithium
Magnesium
Manganese
Mercury
Molybdenum
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Tin
Titanium
Vanadium
Zinc
Zirconium

INORGANIC NONMETALS
Detection Limit

Acidity
Alkalinity
Bromide
Chloride
Chlorine residual
Chlorine demand
Cyanides:
  amenable to chlorination
  free
  total
Fluoride
Iodide
Iodine
Nitrogen:
  total
  ammonia
  organic
  nitrate + nitrite
  nitrite
  nitrate
Oxygen, dissolved:
  electrometric
  modified Winkler titration
Phosphorus:
  total
  ortho
  hydrolysable
  organic
Sulfate
Sulfide
Sulfite
Silica
Other (specify)

PHYSICAL DETERMINATIONS

Color:
  apparent
  true
Conductance @ 25 C
Odor
pH
Residue:
  total
  total volatile
  total filterable (TDS)
  total non-filterable (TSS)
  volatile non-filterable
  settleable
Sediment fractionation
Specific gravity/density
Turbidity
Other (specify)

MICROBIOLOGICAL EXAMINATIONS

Standard plate count
Coliforms, total:
  multiple tube fermentation
  membrane filter
Coliforms, fecal:
  multiple tube fermentation
  membrane filter
Streptococci, fecal:
  multiple tube fermentation
  membrane filter

MISCELLANEOUS

Specify
Specify

EA 0208 – F&B 10/10/85

Figure 11-1. Analytical task order.

12. DEMOBILIZATION

After the samples and documentation have been delivered, the sampling person should clean (Sections 5.4 and 6.2) and stow the gear used. "Clean" tags should be attached to all cleaned equipment. Equipment that does not have a clean tag should not be taken to the field. Under no circumstances should dirty gear be stowed. All vehicles used on contaminated sites should be cleaned and decontaminated prior to return to the respective EA office. Equipment malfunctions and damage should be directed to the Technical Resources Coordinator and an "Out of Service Tag" attached to the equipment.

APPENDIX A:

GROUND-WATER SAMPLING CHECKLIST

GROUND-WATER SAMPLING EQUIPMENT AND SUPPLIES CHECKLIST

	Project Manager Order	Field Agent Checkoff
GENERAL:		
Generic Ground-Water Sampling and Sample Handling Protocol		
Project-Specific Protocol and/or Study Plan		
Health and Safety Plan, Including Health and Safety Equipment and Supply Checklist*		
Order of Sampling Instruction		
Supply of Standard Forms		
- Chemistry Container Form		
- Field Record of Well Gauging, Purging, and Sampling*		
- Summary of Well Gauging, Purging,* and Sampling		
- Chain-of-Custody Record*		
- Analytical Task Order*		
Reusable Equipment Order Form NOTE: With certified laboratory cleaned and operable tags attached		
Equipment and Supplies Checklist NOTE: To be last used by field agent as items are on-loaded to transport vehicle.		

---

* In checkoff columns, indicate number of copies needed for the trip.

	Project Manager Order	Field Agent Checkoff
3.0 PROPER SAMPLE CONTAINERS		
Copy of generic SOP, and/or project-specific study plan		
Ref. Table 3-1, Figure 3-1.		
4.0 PHYSICAL INSPECTION		
Site map, tax map		
Compass		
Sketch pad		
Bound field notebook		
Writing pencils and pen		
5.0 DETERMINATION OF WATER LEVEL		
Keys or combinations for locks on wells		
<u>Stickup</u>		
Steel measuring tape		
<u>Water</u>		
Electronic sounder, or steel tape		
Field data sheets		
Weight for steel tape		
Masking tape		
Carpenter's chalk		
Interface probe (specify type)		
PID or FID		
Clear or opaque bottom-filling bailer		

	Project Manager Order	Field Agent Checkoff
5.5 Cleansing		
Paper towels		
Methanol		
Solvent (specify)		
Wash bottle		
Pail of clean water (NOTE: Define.)		
6.0 WELL PURGING		
Bailer of appropriate size (and nylon line cable?)		
Or 3-in. or 4-in. submersible pump with portable generator		
Or Keck pump		
Or backpack pump		
Or centrifugal pump		
Or peristaltic pump		
Or bottom filling PVC or PC bailer		
Nylon rope (safety line)		
5-gal pail		
Conductivity meter (optional)		
"Pocket" calculator		
Container(s) for purged water		

	Project Manager Order	Field Agent Checkoff
6.2.6 Cleansing Pumps and/or Bailer		
Hot water pressure sprayer		
Hot, soapy (Alconox) water		
Immersion heater		
New tubing for peristaltic		
Scrub brush		
De-ionized rinse water		
Methanol		
Solvent (specify)		
Container for waste cleaning water		
6.4 TAP SAMPLES		
7.0 GROUND-WATER SAMPLING		
All gear maintained scrupulously clean and transported separate from well purging gears		
Disposable gloves (no. of pairs)		
Handwash supplies		
7.1 SAMPLING WITH A BAILER		
Appropriate laboratory pre-cleaned containers (Section 3)		
Laboratory-cleaned, bottom-filling teflon bailers of approx. size and no.		
Reel of clean line		

	Project Manager Order	Field Agent Checkoff
7.0 (Cont.)		
Sample container labels		
Appropriate "water fast" pen or pencil		
Cooler for transport of samples on ice		
Container for discarded water		
7.2 TAP SAMPLES		
Appropriate laboratory cleaned and prepared sample containers		
Appropriate "water fast" pen or pencil		
7.3 PERISTALTIC PUMP		
New tubing for replacement between wells		
8.0 FIELD FILTRATION		
Filtration apparatus supplied by laboratory		
All glass system with AC-powered vacuum pump		
a. 0.45-u filters		
b. Forceps for "handling" filters		
c. De-ionized water for washing apparatus		
d. Container for discarded water		

		Project Manager Order	Field Agent Checkoff
8.0	(Cont.)		
	Polycarbonate pressure system		
	a. 0.45-u replacement cartridges		
	b. De-ionized water for washing apparatus		
9.0	WATER QUALITY MEASUREMENTS IN FIELD		
	Pre-calibrated meters		
	Standards for field standardization		
	De-ionized water		
	Field data sheets		
	Pen or pencil		
10.0	CHAIN OF CUSTODY		
	Chain-of-Custody forms		
11.0	DOCUMENTATION		
	Analytical Task Order forms		

APPENDIX B:

INSTRUCTIONS FOR COMPLETING CHAIN-OF-CUSTODY AND ANALYTICAL TASK ORDER FORMS

INSTRUCTIONS FOR COMPLETING CHAIN-OF-CUSTODY (COC) AND ANALYTICAL TASK ORDER (ATO) FORMS

Chain-of-Custody Record

The Chain-of-Custody Record (COC) Form provides a means of gathering the documentation required to assure the integrity of field-collected samples and the resulting data. This is based on the information the COC contains related to traceability, completeness, method-specific preservation requirements, sample type, number of samples, and shipping method.

The COC also documents the material sampled, location sampled, and the number and type of containers collected and shipped to the laboratory. It is intended that the forms be completed in accordance with the designations stated in the study plans, field sampling plans, or other project design documention to minimize ambiguity and, otherwise, unbounded confusion that can potentially arise. The efficacy of the form depends upon the user's understanding of the information needed to meet the objectives stated above and attention to its accuracy and completeness. The following instructions are provided to facilitate the intended use of this form:

1. Complete one COC for each matrix and analytical suite to be collected: The type of samples recorded on a COC should all be from a single matrix type and all samples logged on a form should have the same suite of parameters as specified on the reverse side of the COC (the Analytical Task Order form, ATO).

2. Project number: Enter the alpha numeric code identifying the client, project, and task as appropriate for the sampling activity.

3. Matrix: Record the materials with which the sample containers are filled (i.e., ground water, surface water, salt water, sediment, tissue, solid waste, product, etc.).

4. Sampler(s) Signature: Sample collector(s) signature(s) with complete name or initials and last name written out.

5. Sample Designation: Enter descriptors as specified in project design documents for each sample source (i.e., station location, well or tank number, map coordinates, etc.) to provide a means by which the laboratory can cross-reference the COC with the containers received.

6. Date: Enter the day, month, and year of collection (<u>completed in field</u>) [to be used as holding time reference in laboratory sample and data management/tracking system].

7. Time: Enter military time (0000-2400 hours) of day each sample was collected (completed in field). This time must agree with that indicated on the container labels.

8. Sample Container Type and Number: Record the number of sample containers filled at each location under each designated container type (A thru other). (This information will be used to assure sample shipment completeness upon receipt in the lab.)

   Other: Specify with footnote in column and identify with description under "Special Instructions."

9. Total: Record the total number of sample containers filled at each collection point as the sum of the container types constituting the sample.

10. Grab: Mark column with an "x" signifying a discrete collection.

11. Comp.: Mark column with an "x" if discrete collections are composited to represent a sample.

12. Laboratory Accession Number: Laboratory sample control number assigned by laboratory sample custodian to each sample upon receipt in laboratory.

13. Special Instructions: May be used to record specific instructions regarding handling, analysis, or treatment of samples and special instruction for reported data (attach separate sheet to COC if space provided is insufficient) if other than standard laboratory practices are to be followed.

14. Relinquished by: Full signature of sampler and subsequent individuals in possession of samples prior to receipt by laboratory (commercial shipper's invoice copy should be retained as part of custody trail in lieu of shipper's signature on COC).

15. Received by: Full signature of each recipient of samples in transport to laboratory (commercial shipper's invoice copy should be retained as part of the custody trail in lieu of shipper's signature on COC).

16. Date/Time: Completed by individual releasing samples to designated recipient in Item 15.

17. Received for Laboratory by: Complete signature of laboratory sample custodian or designee who inspects received samples, checks the Custody Seal if applicable, and completeness check portions of COC, and records date and time of sample receipt.

18. Method of Shipment: Identify the means by which the samples were conveyed to the laboratory and record the shipment invoice code number if a commercial shipper was used.

19. Laboratory Storage Location: Identifies specific storage unit and location completed by lab coordinator/manager or sample custodian.

20. Comments and Problem Resolution: To be completed by sample custodian in the event corrective actions are required to maintain integrity of samples/analysis/data reduction activities in the Chemistry Laboratory. Problem description, records of communications, and problem solutions are documented (attach additional page if required).

    The use of black or red (photocopiable) water-proof pen is essential for completing COC forms and is required by CLP protocols for all data records that may be subject to litigation.

Analytical Task Order

The analytical task order (ATO) is the means by which the project manager communicates his/her analytical needs for a set of samples to the laboratory. The ATO may be completed, prior to sampling, by the project manager. The information provided on the ATO is the only guidance available to the laboratory relative to how the samples submitted should be handled and to what analyses the samples are to be subjected. It is essential that all requested information be provided to ensure that the analytical effort runs as smoothly as possible. The following are the steps that should be followed in filling out an analytical task order:

1. Sample Origin: This is the facility that is under investigation.

2. Billing Code/Purchase Order: This is either the EA alpha numeric project code or the purchase order number to which the cost of the analytical effort is to be billed.

3. Number of Samples: This is the total number of samples collected and submitted under this ATO - COC. This is NOT the total number of bottles.

4. Date Collected: This is the date on which the samples were collected.

5. Date Received: This is the date on which the samples were received in the laboratory.

6. Results Due to Project Manager: This is the date the project manager needs to have the data report in his hands. This date must be provided; otherwise, a 4-week turnaround will be assumed--all turnarounds less than 3 weeks require prior arrangement with the laboratory.

7. Project Manager: This is the person responsible for the analytical effort--the person to whom questions should be directed.

8. Telephone Number: This is the project manager's telephone number.

9. Sample Matrix: This is the physical nature of the samples (i.e., ground water, soil, tissue). A separate ATO should be submitted for each matrix and analytical suite.

10. Additional Considerations and Remarks: This area is to be used to provide special instructions to the laboratory (i.e., samples are hazardous, samples are to be held longer than 30 days, or samples are to be analyzed according to special protocol, CLP).

11. EA Accession Numbers and Storage Location: These are provided by the laboratory.

12. The parameters to be determined in the samples are to be checked on the line immediately adjacent to the parameter.

13. Detection Limit: This is the minimum acceptable concentration that the project can accept. These data must be provided so that the needs of the project can be met. (These should be as specified in project design documents or client requirements.)

APPENDIX C:

SHIPMENT OF CONTAMINATED WATER, SEDIMENT, OR SOIL SAMPLES (NOT WASTE)

SHIPMENT OF CONTAMINATED WATER, SEDIMENT, OR SOIL SAMPLES (NOT WASTE)

The following procedures are to be followed in the shipment of samples that are taken either from the ground or in the form of water or sediment that may be contaminated.

A Restricted Article Airbill is required. This airbill is available at Federal Express offices. EA will supply forms pre-printed to the extent possible. A copy is attached reflecting what should be completed. The format of this airbill may vary with other carriers. However, the following designations should be entered on the airbill:

1. Indicate either HAZARDOUS SUBSTANCE LIQUID -- NOS (this means "NOT OTHERWISE SPECIFIED") or HAZARDOUS SUBSTANCE SOLID -- NOS. You must designate either liquid or solid, as combining a shipment with both liquid and solid will not be accepted by the carrier.

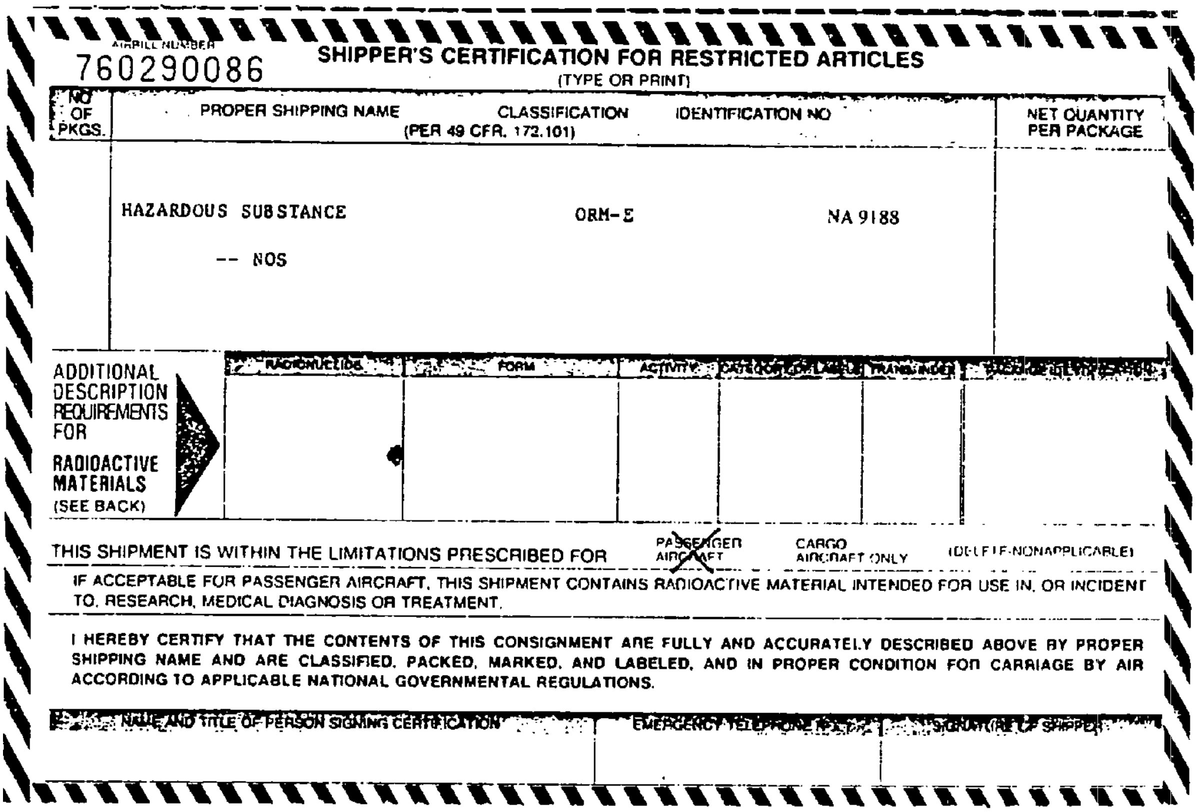
2. Under "Classification" indicate ORM-E.

3. The third item to be filled out under "ID Number" is NA 9188. This interpretation (9188) alludes to environmental sediment or sample.

4. The fourth item that is needed is the "Quantity" in pints or quarts approximately, or if it is a solid, in ounces or pounds.

5. Cross out "Cargo Aircraft Only" unless you are shipping radioactive material or material in the gallons, whereby you must cross out "Passenger Aircraft Only" as large volumes of contaminated material or radioactive material are not allowed on passenger aircraft.

6. You must repeat the information under "Proper Shipping Name, Classification, and Identification No." on the box you are shipping in with a "square" drawn around the information in the event the airbill is separated from the shipment.



AIRBILL NUMBER 760290086

SHIPPER'S CERTIFICATION FOR RESTRICTED ARTICLES

(TYPE OR PRINT)

NO OF PKGS.	PROPER SHIPPING NAME	CLASSIFICATION (PER 49 CFR. 172.101)	IDENTIFICATION NO	NET QUANTITY PER PACKAGE
	HAZARDOUS SUBSTANCE -- NOS	ORM-E	NA 9188	

ADDITIONAL DESCRIPTION REQUIREMENTS FOR RADIOACTIVE MATERIALS (SEE BACK)

RADIONUCLIDE	FORM	ACTIVITY	CATEGORY OF LABEL	TRANS. INDEX	[illegible]

THIS SHIPMENT IS WITHIN THE LIMITATIONS PRESCRIBED FOR ~~PASSENGER AIRCRAFT~~ CARGO AIRCRAFT ONLY (DELETE NONAPPLICABLE)

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS OR TREATMENT.

I HEREBY CERTIFY THAT THE CONTENTS OF THIS CONSIGNMENT ARE FULLY AND ACCURATELY DESCRIBED ABOVE BY PROPER SHIPPING NAME AND ARE CLASSIFIED, PACKED, MARKED, AND LABELED, AND IN PROPER CONDITION FOR CARRIAGE BY AIR ACCORDING TO APPLICABLE NATIONAL GOVERNMENTAL REGULATIONS.

NAME AND TITLE OF PERSON SIGNING CERTIFICATION	EMERGENCY TELEPHONE NO.	SIGNATURE OF SHIPPER