GW - 32

REPORTS

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1990- SAMPLING PLAN

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GENERIC SAMPLING PLAN
RCRA FACILITIES INVESTIGATIVE PROJECT
GIANT REFINERY
GALLUP, NEW MEXICO

A REPORT PREPARED FOR
GIANT INDUSTRIES, INC.
ROUTE 3, BOX 7
GALLUP, NEW MEXICO

AES PROJECT

DECEMBER 15, 1989
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1.0 INTRODUCTION

It is essential to assure that data generated during the Giant Refinery RCRA Facilities Investigation (RFI) are valid. For data to be valid, it must be supported by documented procedures so that it can be used with the appropriate level of confidence to support decisions regarding the need for, and design of, subsequent monitoring and remediation activities.

Through the development and implementation of a comprehensive sample collection plan, all parties involved can consistently strive to achieve data of known and acceptable quality. In order to achieve the data quality objective, the generic sampling plan includes specific Quality Assurance (QA) and Quality Control (QC) procedures to:

- Define responsibilities
- Define sampling and analytical techniques
- Confirm and document correct sample identity
- Establish precision and accuracy of reported data
- Establish detection limits for constituents of concern

° Establish any bias arising from sampling or analytical activities
° Documentation of all analytical steps in determining constituent concentrations

The QA/QC program outlined in this manual must be adhered to during all data collection activities. Before initiating any sample collection activities which are not specifically mentioned in this document, it is imperative to verify that the level of data quality sought (especially in regard to sampling and analytical techniques) is sufficient for its intended use.

It is important to remember that QA/QC is a dynamic process, therefore this plan is subject to periodic updates. One must also remember that data quality needs may vary, depending upon the intended use. This document outlines QA/QC procedures designed to meet or exceed US EPA and New Mexico Environmental Improvements Division guidelines for monitoring at RCRA facilities.

In addition, an important use of this document is in the area of training new personnel in order to maintain a constant high level of data quality. Appendix A contains useful information.

2.0 RESPONSIBILITIES

The importance of defining responsibilities for the implementation of the procedures cannot be stressed enough. Each individual involved with the RFI program must clearly understand her/his responsibilities so the procedures detailed in this document will be conducted successfully and efficiently.

2.1 RFI Project Manager

- Maintain information for the data collection program
- Set up sampling program that complies with regulatory requirements
- Schedule all sampling events
- Review analytical results and submit to proper agencies
- Interact with contractors involved in RFI
- QA/QC report to management
- Determine need to re-sample

2.2 QA/QC Manager

- Notify contract lab of sampling schedule
- Review all data for validity
- Determine analytical methods

2.3 RFI Sampling Personnel

2.3.1 General

- Follow all procedures in this manual to prevent contamination of samples or sampling locations
- Collect samples as prescribed in the site specific sampling plan
- Inventory sample bottles and preservatives
- Affix labels to sample bottles
- Notify QA/QC manager if there are any problems with bottle order
- Maintain all sampling equipment
- Calibrate field instruments

2.3.2 Ground Water Sampling

- Inspect all wells for integrity and notify project manager of any problems.

- Perform field measurements, pH, conductivity, temperature
- Determine water level elevations
- Check wells for immiscible layers
- Evacuate wells and collect samples
- Field filter samples as required
- Check that samples are properly labeled
- Follow prescribed decontamination procedures
- Prepare equipment and field blanks

2.3.3 Soil Sampling

- Collect site specific soil samples
- Check that samples are properly labeled
- Follow prescribed decontamination procedures

2.3.4 Surface Water

- Collect site specific surface water samples
- Check that samples are properly labeled
- Follow prescribed decontamination procedures

2.3.5 Air Sampling

- Collect site specific air samples
- Check that samples are properly labeled
- Follow prescribed decontamination procedures

2.3.6 Sample Transfer

- Complete chain of custody form
- Make sure samples are packed securely and are maintained at 4°C prior to sample pick-up by laboratory
- Relinquish samples to the contract laboratory
- Input sample results into RFI data base

2.4 Contract Laboratory

- Provide high quality analytical services in conjunction with the RFI sampling program
- Assure that all data generated is supported by adequate documentation and QA/QC procedures that meet EID and EPA requirements for RCRA analyses
- Provide sample containers and coolers upon request
- Maintain Standard Operating Procedures (S.O.P.'s) for all analytical methods performed

- Utilize only EPA approved methods for all analyses
- Assure that technical personnel performing analyses are qualified and adequately trained
- Provide feedback to Giant regarding analytical method limitations and quality control data pertinent to the program

3.0 SAMPLING PROCEDURES

Sampling can be divided into four distinct stages: Preparation, Pre-Sampling Operations, Sampling, and Post-Sampling Operations.

3.1 Preparation

Preparation for a sample collection event should be initiated two weeks prior to the anticipated sample collection date whenever possible. This will assure that the sample collection can proceed in an organized and efficient manner. Preparation is one of the most important steps since it defines the scope of the sampling event.

The contract laboratory will be notified of the proposed sampling schedule at the beginning of each RFI investigation. The purpose of sharing the sampling schedule with the contract laboratory is to allow the laboratory to adjust its personnel needs to meet the demands of the sampling requirements. Sampling frequencies for specific sites will be contained in the site specific RFI work plans.

Two weeks prior to sampling, the sample collector will arrange for delivery of sample bottles from the contract laboratory.

The laboratory will sort the bottles into sets prior to placing them into the coolers. The bottles will be delivered to Giant and stored in a secure area prior to the sampling event.

The sampling personnel will inventory the bottles to verify receipt of all bottles. Sampling personnel will notify the laboratory of any discrepancies between the requested bottles and the contents received. Labels will be affixed to each bottle. It is imperative that the preservative listed on the label match the preservative label placed on the sample bottle by the contract lab.

The day before sampling, the sampling personnel should review the pertinent field checklist (Table 1 for surface and ground water, Table 2 for soil and sludge, and Table 3 for air) to assure all equipment is available, operational, and calibrated if necessary. All rechargeable batteries are to be fully charged. Any other battery operated equipment should be checked for adequate power level and the batteries replaced if necessary. Decontamination supplies (gloves, distilled water, etc.) should be inventoried.

Original Date 05/31/89
Revision Date 12/15/89

TABLE 1

Field Equipment Checklist

Surface and Ground Water Sampling

	ITEM		REMARKS
______	pH Meter	______	Calibrated
______	pH Buffers		
______	Conductivity Meter	______	Calibrated
______	Conductivity Standard		
______	Thermometer		
______	Water Level Indicator	______	Battery Checked
______	PID Meter	______	Calibrated
	Bailers		
______	2" Well	______	Decontaminated
______	4" Well	______	Decontaminated
______	Hand Calculator		
______	Site Map With Well Locations		
______	Well Keys		
______	Sample Bottles and Additional Preservatives		
______	Ice Chests		
______	Trip Blanks		
______	Methanol		
______	Deionized Water		
______	Squeeze Bottles		
______	Personal Protective Equipment		
______	Chain of Custody and Sample Record Forms		
______	Tape Measure (0.01 feet increments)		
______	Plastic Bags (to provide clean surfaces) (1 per well)		
______	Watch With Second Hand		
______	(2) 5 Gallon Buckets		
______	Disposable Gloves		
______	Paper Towels		
______	Tape (for labels and dispenser)		
______	Sharpie, Pens, Pencils		
______	Blue Ice or Ice		
______	Zip-Lock Bags, 1 Gallon		

TABLE 2

Field Equipment Checklist
Soil and Sludge Sampling

	ITEM		REMARKS
_____	PID Meter	_____	Calibrated
_____	Site Specific SWMU Work Plan		
_____	Generic Sampling Plan		
_____	Site Map With Sample Locations		
_____	Sample Bottles		
_____	Ice Chests		
_____	Trip Blanks		
_____	Methanol		
_____	Deionized Water		
_____	Squeeze Bottles		
_____	Personal Protective Equipment		
_____	Chain of Custody and Sample Record Forms		
_____	Plastic Bags (to provide clean surfaces)		
_____	Disposable Gloves		
_____	Paper Towels		
_____	Tape (for labels and dispenser)		
_____	Sharpie, Pens, Pencils		
_____	Blue Ice or Ice		
_____	Zip-Lock Bags, 1 gallon		

Original Date 05/31/89
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TABLE 3

Field Equipment Checklist
Air Monitoring

	ITEM	REMARKS
____	Tenax	
____	Tubing	
____	Pumps (+ spare)	
____	Sampler mounting	
____	Batteries	
____	Timer (with alarm)	
____	Record Log Book	
____	Labels	
____	Chain-of-custody certificates	
____	Wind monitoring system	
____	Wind system mounting bracket	
____	Wind recording system	
____	Connector cables	
____	Tripod mount for wind system - with anchor stakes	
____	Compass	
____	Level	
____	Sling psychrometer	
____	Ice Bath	

3.2 Pre-Sampling Operations

This section describes the activities which occur prior to the actual collection of the sample.

3.2.1 Calibration of Field Instruments

Before the start of water sampling, calibrate pH and conductivity meters according to procedures described in Section 8. Take pH and conductivity standards along for calibration verification and field re-calibration as required. Obtain a copy of the monitoring well sample record and chain of custody record from the files.

3.2.2 Ice

If Blue Ice is unavailable, ice should be obtained and placed in 1-gallon Zip-Lock bags, and placed in the cooler(s) before departing the lab. If Blue Ice is used, remove it from the freezer and place in the ice chest(s).

3.2.3 Sample Record

A sample record is needed for each sampling event. The following information should be recorded in the field notes:

- Location of sampling
- Sample identification
- Date and time of sampling
- Sample collection method
- Field measurements
- Other comments and observations

It is important that during each sampling event that specific observations regarding site conditions be recorded. These observations include:

- Weather conditions and wind direction
- Physical surroundings (high weeds, standing water, nearby activities)
- Evidence of external contamination
- Odors or color abnormalities

3.3 Fluid Sample Collection

3.3.1 Field Observations and Measurements

All ground water sampling information is to be recorded on the monitoring well sampling form (Figure 1).

3.3.1.1 Well Condition

Observations regarding the well condition include:

- Condition of well identification markings
- Condition of lock
- Condition of well cap
- Condition of concrete pad
- Sediment in the well
- Obstructions

The ground water sampling personnel should notify the RFI manager of any deficiencies noted in the well integrity. If the well is damaged, it will be repaired. If the damage is so extensive that the well integrity cannot be restored, the well will be plugged and a new well installed. If the well screen is found to be blocked or partially blocked with sediment, the well will be redeveloped prior to any sampling activities.

3.3.1.2 Fluid Level Measurements

Upon arrival at the unit to be sampled, obtain static

Ground Water Monitoring
Sample Record
Giant Refinery
Gallup, New Mexico

Job Number ____________
Location ____________
Date ____________
Weather ____________

Purpose ____________

NOTE: 2-in Sch 40=0.163 gal/ft or 0.2
4-in Sch 40=0.653 gal/ft or 0.7
5-in Sch 40=1.020 gal/ft or 1.0

Well Number	Water Level	Casing Storage	Purge Time	Total Purged (gal)	Sample Time	pH	Temp	Cond	Sample Collection Method
	Total Depth, TOC, ft ____ Depth to Water, TOC, ft ____ Length of Water Column ____	Casing Diam ____ 1 Casing Vol (gal) ____	Begin Purge ____ End Purge ____	____ Dry Y N		____	____	____	
	Total Depth, TOC, ft ____ Depth to Water, TOC, ft ____ Length of Water Column ____	Casing Diam ____ 1 Casing Vol (gal) ____	Begin Purge ____ End Purge ____	____ Dry Y N		____	____	____	
	Total Depth, TOC, ft ____ Depth to Water, TOC, ft ____ Length of Water Column ____	Casing Diam ____ 1 Casing Vol (gal) ____	Begin Purge ____ End Purge ____	____ Dry Y N		____	____	____	
	Total Depth, TOC, ft ____ Depth to Water, TOC, ft ____ Length of Water Column ____	Casing Diam ____ 1 Casing Vol (gal) ____	Begin Purge ____ End Purge ____	____ Dry Y N		____	____	____	
	Total Depth, TOC, ft ____ Depth to Water, TOC, ft ____ Length of Water Column ____	Casing Diam ____ 1 Casing Vol (gal) ____	Begin Purge ____ End Purge ____	____ Dry Y N		____	____	____	

FIGURE I

fluid level measurement for each well to be sampled prior to any evacuation. Remove each well cap and perform the following steps:

1) Air in the well head will be sampled for organic vapors. The well cap will be partially removed and a PID reading will be taken of the air escaping the well head.
2) Between each well, decontaminate the probe of the water level indicator following the procedures listed in Section 5.0.
3) Slowly lower the probe into the well until the light comes on.
4) By moving the probe up and down (light on, light off), it is possible to accurately locate the air-fluid interface.
5) The water level will be indicated by a constant light.
6) With a finger, mark this position on the cable, using the surveyed elevation mark at the top of the casing (T.O.C.) as the measurement point .

- Record the measurement on the ground water monitoring sample record to the nearest 0.01 foot.

3.3.1.3 Depth of Well Measurements

Measure the total depth of the well by dropping the weighted probe to the bottom of the well.

- After the static water level measurement is obtained, lower the probe until it reaches the bottom of the well.
- Slowly pull up the probe until the slack is gone and a slight tension is felt.
- Raise the probe up and down slowly until a "feel" for the bottom of the well is established.
- Measure the depth of the well from the cable at the same elevation point as the water level measurement.
- All measurements should be to the nearest 0.01 foot.
- Record measurement on the ground water monitoring sample record.
- After each well reading is completed, thoroughly decontaminate the probe following the procedures listed in Section 5.0.

3.3.1.4 Purge Volume Calculations

In order to assure that the sample collected is indeed representative of actual aquifer conditions, it is necessary to purge the well of stagnant water in the casing. This is accomplished by bailing or evacuating three casing volumes of water from the well or until it is bailed dry, whichever comes first. If a well can be bailed dry, it requires sufficient time to elapse for an adequate volume of water to accumulate for the sampling event.

The casing volume is calculated according to the following formula:

One Casing Volume = L x F where

L = Length of water column = Total Depth - Depth to Water

F = Gallons/Foot based upon well casing diameter

For 2" wells, F = 0.2 gallons/foot

For 4" wells, F = 0.7 gallons/foot

For 5" wells, F = 1.0 gallons/foot

The volume to be purged from each well is calculated as follows:

Purge Volume = Casing Volume x 3

Example:

Total Depth, T.O.C. = 25.01 ft

Depth to Water, T.O.C. = 15.01 ft

Length of Water Column = 25.01-15.01 = 10.00 ft

Casing Diameter = 4" = 0.7 gallons/foot

Casing Volume = 0.7 gal./ft x 10 ft = 7 gal.

Purge Volume = 7 x 3 = 21 gallons

3.3.1.5 Well Evacuation

Before sample collection can begin, the water collected from the monitoring well must be fresh aquifer water. Well evacuation replaces stagnant well water with representative aquifer water. An interface probe will be used to measure the water level in the well, the total depth of the well, and measure the thickness of floating product, if present. A bailer may be used to check for the visual presence and measure the thickness of floating product. If product is present, a ground water sample is typically not obtained.

Wells are evacuated by handbailing or by pumping. The actual method of evacuation is based upon site conditions. Each of the methods are discussed below.

In low yielding wells, the standing water will be removed until the well is essentially dry. The water level in the well will be allowed to recover until a sufficient volume is present to obtain a sample.

The first sample should be tested for pH, temperature, and specific conductance. Samples should then be collected and containerized in the order of the parameter's volatilization sensitivity (See Section 3.3.2.4). The well should be retested for pH, temperature and specific conductance after sampling as a measure of purging efficiencey and as a check on the stability of the water samples over time. All well evacuation information should be recorded on the Ground Water Monitoring Sample Record (Figure 1).

3.3.1.5.1

Hand bailing is conducted by lowering a Teflon(TM) or stainless steel bailer slowly into the well, allowing water to enter the bailer, and lifting the collected water out of the well. The bailer is positioned just below the top of the standing water in the well, so that the bailed water is removed from the top of the water column. A minimum of three standing well volumes are removed.

When using a bailer to evacuate a well, place a new trash can liner in a 5-gallon bucket so that as the bailer is lowered and raised, the rope stays in the bucket and does not contact the ground.

1) New rope should be used at each well when using non-dedicated bailers.

2) New disposable gloves should be worn at each well.

3) The bailer should be emptied into a 5-gallon bucket each time it is raised so that the volume of water evacuated can be measured.

4) Lower the bailer slowly into the well until it contacts the water.

5) Allow the bailer to fill and raise it.

6) Empty the bailer into the 5-gallon bucket.

3.3.1.5.2 Pumping

A Well Wizard is a pneumatic pump used to remove water from the well. During sample collection a maximum flow rate of 100 milliliters/minute (0.03 gal/min) should be used. The actual flow rate should be measured using a graduated container and timed using a watch with a second hand. This rate can change as the water level in the well drops.

The flow rate can be calculated by:

$$\text{Flow Rate, gpm} = \frac{\text{Volume Collected (gallons)}}{\text{\# seconds to fill container}} \times 60 \text{ sec}$$

- If a gasoline generated engine is used, place the engine at least 10 feet downwind from the well to eliminate sample contamination from the exhaust.
- Wells MW-1, 2, 4, 5 and OW-11 will be evacuated using a well wizard pump.

3.3.2 Monitor Well Sampling

3.3.2.1 Collection of Light Immiscible Layers (Floaters)

The floater must be collected prior to any purging activities. If the thickness of the floater is two feet or greater, a bottom valve bailer will be used.

When the thickness of the floating layer is less than two feet, then the bailer will be modified to allow filling only from the top. The bottom check valve will be disassembled and modified to allow filling only from the top. A Teflon™ sheet is placed between the ball and ball seat to seal off the bottom value. The ball from the top check valve is removed to allow the samples to enter from the top. To overcome buoancy a stainless steel pipe is placed on the retrieval line above the bailer. The bailer should be lowered to one-half thickness of the floating layer and the sample collected.

3.3.2.2 Collection of Heavy Immiscibles (Sinker)

The bailer will be lowered to the bottom of the well and remain there for a few minutes before removing the bailer out of the well.

3.3.2.3 Bottle Filling Procedure

If the well was not bailed dry and the water level is recovering to provide sufficient water to fill all of the sample bottles, then samples should be collected immediately. If the well was completely evacuated and /or recovery is slow, wait for a sufficient volume of water to recover in the well to fill all of the sample bottles before beginning to collect samples.

Do not over flow the bottles when filling them as this will dilute the preservative.

When filling VOA and TOX containers, slowly fill the container until the meniscus is just above the lip of the container. Place the cap (Teflon (TM) side towards sample) on the container and tighten. Check for air bubbles by inverting the container and tapping gently. There should be no headspace (air) in the container. If headspace is present the sample should be discarded and the container refilled. (Note: If the sample is discarded, additional preservative will need to be added to the container.)

Do not touch the inside of the bottle cap. Caps should never be placed on the ground. If a cap is accidentally dropped, it should be rinsed with deionized water followed by a rinse with the sample prior to being placed on the bottle. Note in the field notes if this occurs.

Replace the well cap and lock the well.

3.3.2.4 Order of Collection

Sample bottles should be filled in the order listed below:

Parameter	Bottle Type & Preservatives
Volatile Organics	VOA vials/ Septa cap of Teflon (TM) material
TOX	Pint amber glass/Septa cap, H2SO4
TOC, Phenols, Nitrate, Ammonia	Quart glass H2SO4
Extractable Organics	Quart glass/TFE
Chloride and Sulfate	Quart plastic, none
Cynade	Quart glass, NaOH
Radionuclides	Quart plastic, HNO3
Metals	Pint plastic

3.3.2.5 Filtration

Ground water samples may require filtering prior to metals analysis. The filtering of samples is performed with 0.45 micron filter paper when analyzing for dissolved metals. The sample is not filtered if analyzing for total metals. The liquid is preserved with nitric acid when analyzing for metals.

3.3.2.6 Disposition of Fluids

Excess sample water (with the bailed water) will be retained in drums on the site until the analytical results determine if the water is contaminated. If the analytical results indicate that the waters need no special handling, the water will be discharged into the wastewater treatment system onsite. When the purged water is deemed a hazardous material, it will be drummed and disposed properly. The amount of water from the decontamination effort is expected to be relatively small. This water will be disposed of in the Giant Refinery wastewater treatment plant system.

3.4 Soil Sampling

3.4.1 Soil Sampling Locations and Techniques

The purpose of the soil sampling plan is to initially determine if a release has occurred at a particular Solid Waste Management Unit (SWMU). If the soil sample results indicate a significant release, then additional soil sampling locations and/or the installation of wells adjacent to the particular SWMU will be required.

Soil sampling locations will be selected in order to adequately determine if a release has occurred. The number and depth of each soil sampling location will be specified in each SWMU Site-Specific Facility Investigation Work Plan.

The choice of which sampling technique to be used will be determined on the basis of a number of factors; such as depth of the sample to be collected and the composition of the material to be sampled.

3.4.2 Surficial Sampling

3.4.2.1 Shovels, Spatulas and Scoops

Surface grab samples may be obtained with shovels, spatulas, or scoops. These implements will be of stainless steele construction if available. Grab samples are an efficient collection technique and the samples may be indicative of the range of contamination at the site.

3.4.2.2 Hand Augers

Manual soil probes, referred to as hand augers, may be used to collect samples up to several feet in depth, depending upon soil conditions. The soil sampler tube will be of stainless steel construction. The tube has a T-shaped handle which is used to push or auger the tube into the ground. When the tube has been filled with soil to the desired depth of sampling, it is removed and the soil sample extruded from the tube. The sample is placed in the appropriate sample bottles for delivery to the laboratory.

Samples may be collected by using the combination of a backhoe and hand auger. This will be accomplished by using the backhoe to excavate the area where samples will be collected. A hand auger will then be used to bore horizontal soil cores at the desired sample depths. Verticle samples may also be collected from the bottom of the excavated area.

3.4.3 Boreholes/Core Samples

Boreholes for samples will be advanced by a drilling rig employing hollow stem augers. There will be no compositing of soil sampling.

Core samplers are used in conjunction with hollow-stem augers to collect soil samples from depths which cannot be reached by a soil probe. Samples are collected by removing the stem of the auger and inserting a core sampler. three types of core samples which may be used in the RFI are described below.

3.4.3.1 Shelby Tube

A Shelby tube is a metal cylinder with sharpened ends for cutting into the soil. The tube is pushed into the soil by applying downward pressure from a drilling rig or other apparatus. Shelby tubes will be of stainless steel construction. Shelby tubes will not be used in loose soils because the soil will fall out of the tube during removal of the tube. The soil will be extruded from the tube and a sample collected at the desired point of the core. The sample will be placed into a wide-mouth jar for chemical analysis. Alternatively, the ends of the tube may be capped and the entire core transported intact, depending upon the nature of the analyses to be performed.

3.4.3.2 Split-Spoon Samplers

A split spoon consists of a hollow steel cylinder split in half and screwed into an outer tube and tip. The split-spoon is typically "hammered" into the soil. After the tube is pulled from the soil, the soil cylinder is removed from the drill rod and opened to remove the soil core. Split-spoons will be used for obtaining samples of unconsolidated soil and may also be used to penetrate some types of rock.

3.4.3.3 "Five Foot CME Tubes"

A five foot CME tube is a 3-1/2 inch diameter split core barrel which is placed into the lead auger. The tube is pushed into the soil at the same drilling rate as the augers. After the tube is pulled from the soil, it is detached from the drill rod and opened to remove the soil core. CME tubes will be used for obtaining samples of consolidated soil and used to penetrate some types of rock.

3.4.4 Soil Sampling Screening Techniques

Field instruments are useful to provide a limited degree of onsite characterization of soil contamination. A photo-ionization detection meter (PID) will be used to screen for volatiles. The PID meter will be calibrated to benzene. Other methods for soil screening will include visual signs of contamination and/ or noticeable odors.

3.4.5 Lithologic Logging

Detailed logs will be maintained for each boring. Listed below is a general description of soils to be used to describe their physical characteristics:

1) Lithology
2) Color (adjectives -light, dark, mottled, mixed)
3) Size (fine, medium, coarse)
4) Moisture (dry, moist, wet)
5) Odor (or no odor)
6) Other descriptive terms:
    a. Lens < 1 inch
    b. Layer > 1 inch
    c. Interbedded
    d. Slickensided-soils having inclined planes of weakness, glossy in appearance

3.4.6 Disposition of Soils

All drill cuttings generated by borehole advancement for soil samples will be placed back in the hole or collected and containerized at each SWMU. Following receipt of the analytical results from each SWMU the containerized soils will be transported to the land treatment area at

Giant Refinery. Soils placed back in the bore holes or excavated area must be compacted with a probe or the backhoe unit used for excavation. If the drill cuttings must be taken to another regulated facility, appropriate laboratory samples of cuttings from borings will be collected.

3.5 Surface Water Sampling

3.5.1 Sampling Criteria and Methods

Samples will be collected from locations which will adequately define if a release has occurred from a particular SWMU. The locations for each sampling event will be specified in each SWMU Site Specific Facility Investigation Work Plan.

Beakers, jars or dippers may be used to obtain a surface water sample. They can be attached to a rod or pole to extend the reach of the samples away from the bank (this type of sampling device is commonly called a pond sample). The sample collection container should be constructed of glass, linear polyethylene (LPE), Teflon (TM), or stainless steel.

Weighted bottles may be used to collect a water sample at depth. These devices are basically a jar with a cork or plug ;in the mouth that can be opened after the bottle is lowered on a rope or chain to a desired depth; once the sample fills the jar, the apparatus is raised to the surface.

If a multiple phase contaminant (for exapmle, immiscible organic liquids) or stratified water layers are suspected, a sampler such as the Coliwasa Sampler may be used to obtain composite water samples in the vertical profile. This sampler is a tube with a stopper at the bottom connected through the tube to a locking handle at the top. The stopper is locked into its open position before the sampler is lowered through the water. As the sampler is slowly lowered into the water the layers of contaminants or other fluids encountered will enter the tube. After the sampler reaches bottom (or the desired depth), the stopper is pulled upward and locked into a seal with the bottom of the tube. The sampler is removed from the water and its contents transferred to a sample bottle or multiple bottles if samples of the stratified layers are desired.

Descriptions of the design, construaction and use of the weighted bottle and Coliwasa samplers are contained in EPA publication 600/2-80-018, "Samplers and Sampling Procedures for Hazardous Waste Streams," by E. R. deVera, et al, January 1980; this document is presented as an Appendix to "Test Methods for Evaluating Solid Waste," EPA publication SW-846, 1980.

3.5.2 Running Water

The Giant Refinery facility is located in an arid desert environment, with no perennial streams. Intermittent surface water flow occurs during and immediately after infrequent rainfall events and snow melts. Because of the infrequent surface water flows, no discussions are included on sampling techniques of running waters.

If a low flow rate or shallow channel prohibit direct use of a dipper, a stainless steel shovel can be used to dig a small hole into which water can collect. Sufficient time should be allowed for distrubed sediments to settle before the sample is obtained.

3.6 Air Monitoring

Air monitoring may be required in later sampling events. If this is necessary, monitoring for the hydrocarbons will be done using Tenax tubes. This approach allows for sensitive detection levels and compound analyses. Samples can be obtained from the tubes for detailed gas chromatograph analysis of specific compounds. A diaphragm type pump will be used to draw the air through the tube with a flow meter to check the flow rates. The sampling height will be approximately 1.5 meters. With the availability of personnel onsite, the sampling will be done with manual starts and stops.

A meteorological system, consisting of wind direction, wind speed, and temperature will be installed for the sample period on a tripod approximately three meters above ground surface. The refinery already collects precipitation and these data will be available for the study. Stability will be calculated by the data collection system and recorded. If a strip chart data collection system is used, the stability will be calculated from the fluctuations of wind direction combined with the wind speed and time of day following established EPA procedures. Appendix B contains data on wind direction and speed, temperature, precipitation, and stability for Gallup, New Mexico.

4.0 SAMPLE LABELING

As soon as all sample containers have been properly filled with sample, the bottle labels should be completed with the following information:

- Sample identification or well number
- Location
- Date/Time of collection
- Collector's initials
- Sample preservation techniques
- Analytical parameters
- Comments

The label will be filled out with waterproof, indelible ink. All information except sample ID or well number and date/time of collection shall be completed prior to going into the field. The sample ID and date/time of collection will be handwritten on the label by the sample collector. After filling out the labels, they should be sealed with a piece of two inch wide clear tape. Make sure that the tape is long enough to go completely around the container so that it sticks to itself.

5.0 DECONTAMINATION PROCEDURES

The following procedures are applicable to decontamination of:

- Drilling equipment and vehicles
- Sampling equipment

5.1 Drilling Equipment and Vehicles

Decontamination of large drilling equipment and vehicles is required to prevent cross contamination of boreholes from which soil samples will be retrieved for chemical analysis. This procedure also provides for the protection of personnel subsequent to demobilization from restricted areas.

- Steam or water rinse with potable water if needed to remove mud or dirt.

- Rinse with clean, potable water.

During decontamination of drilling equipment and accessories, it is especially critical to clean the inside of hollow-stem augers flights, drill rods and drill bits (particularly roller bits), as well as all couplings and threads. As a general rule, decontamination can be limited to the back portion of the drill rig and those parts which come in direct contact with samples or casing, or drilling equipment that is placed into the borehole.

5.2 Sampling Equipment

Sampling equipment includes all sampling devices and containers which are used to collect or contain a sample prior to final sample analysis. Before its initial use, all sampling equipment which may contribute to the contamination of a sample must be thoroughly decontaminated. Unless specific documentation exists that sample equipment has been decontaminated, decontamination should be conducted before use.

Sampling equipment can generally be cleaned by hand. The following procedure is given as a sequence which should be modified to be consistent with onsite conditions.

- Scrub with potable water to remove mud and residue.

- Scrub with a non-phosphate detergent if necessary to remove mud and residue.
- Rinse with clean potable water.
- Rinse with an approved organic solvent (i.e. isoproyl or methanol alcohols).
- Allow the equipment to air dry as long as practical.
- Wrap in plastic bags or other appropriate containers if necessary to prevent recontamination.

6.0 SAMPLE CUSTODY

Assuring the integrity of a sample from the time of collection to data reporting is essential. Chain of custody procedures are intended to document sample possession from the time of collection of final disposition.

A sample is considered to be under a person's custody if it is in a person's physical possession, in view of the person after taking possession, secured by that person so that no one may tamper with it, or secured by that person in an area that is restricted to authorized personnel.

6.1 Chain of Custody Record

The chain of custody record shall include the following information:

1) Facility name
2) Type and number of samples
3) Sample location and ID
4) Collection date(s) and time(s)
5) Analyses required

6) Number of containers for each sample

7) Additional remarks or comments as needed

8) Sample team leaders signature

9) Signatures of all individuals involved in the chain of possessio

10) Inclusive dates and time of possession

A sample form is shown in Figure 2. The original chain of custody form must accompany the samples. One copy of the chain of custody form should be kept in the project files.

6.2 Transfer of Custody

This section describes the disposition of the samples after collection.

6.2.1 Onsite Custody

The sample collectors will prepare the requested performance check samples and place the samples in a cooler. The information regarding date and time of

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Arvada, Colorado 80002
303/421-6611 Facsimile: 303/431-7171

CHAIN OF CUSTODY

No.

Attn: __________

Enseco Client __________

Project __________

Sampling Co. __________

Sampling Site __________

Team Leader __________

SAMPLE SAFE™ CONDITIONS

1. Packed by: __________ Seal # __________
2. Seal Intact Upon Receipt by Sampling Co.: Yes No
3. *Condition of Contents:* __________
4. Sealed for Shipping by: __________
5. Initial Contents Temp.: __________ °C Seal # __________
6. Sampling Status: Done *Continuing Until* __________
7. Seal Intact Upon Receipt by Laboratory: Yes No
8. Contents Temperature Upon Receipt by Lab: __________ °C
9. Condition of Contents: __________

Date	Time	Sample ID/Description	Sample Type	No. Containers	Analysis Parameters	Remarks

CUSTODY TRANSFERS PRIOR TO SHIPPING

Relinquished by: (signed)	Received by: (signed)	Date	Time
1			
2			
3			

SHIPPING DETAILS

Delivered to Shipper by: __________

Method of Shipment: __________ Airbill # __________

Received for Lab: __________ Signed: __________ Date/Time __________

Enseco Project No. __________

White and Pink Copies to Lab Yellow to Sampler

SS-001

control sample preparation will be recorded on the chain of custody form at this time.

6.2.2 Contract Laboratory Custody

The delivery person will relinquish the samples to the contract laboratory. The contract lab will notify Giant of samples receipt and condition.

The contract lab will be responsible for documenting custody within their laboratory and documenting custody of samples transferred to their subcontractors for analysis. This documentation is to be made available to Giant upon request.

7.0 ANALYTICAL PROCEDURES

7.1 Methods

In order to adequately evaluate analytical data, consistency of methodologies is crucial. EPA-approved methodologies, such as those identified in the third edition of Test Methods for Evaluating Solid Wastes or equivalent, should be utilized when available. Any and all method modifications of the analytical procedures should be clearly defined and justifiable based upon the nature of the samples being submitted. The following factors are to be considered when selecting methodologies:

- Scope and application of procedure
- Sample matrix
- Potential interferences
- Precision and accuracy
- Method detection limits

A list of methods currently utilized by Giant in the RFI program is listed in Table 4 for ground water sampling, and Table 5 for soil sampling. Appendix C lists analytes and methodologies for Appendix IX. Appendix VIII is a list of approximately 375 constituents, some of which cannot be

TABLE 4

GROUND WATER SAMPLING AND ANALYSIS PLAN
ANALYTICAL PROCEDURES

Parameter	EPA Method SW-846	EPA Method 600	Description	Container	Preservative	Holding Time, Days	Detection Limit*
pH	9040	150.1	Electrode	P	None	On-Site Analysis	NA
Specific Conductivity	9050	120.1	Wheatstone Bridge	P	None	On-Site Analysis	NA
TOC		415.1	Combustion or Oxidation	G/T	H_2SO_4	28	1.0
TOX	9020		Microcoulometric	G/A/T Septa Seal	H_2SO_4	7	0.010
Chloride	9252	325.3	Titration	P	None	28	1-5
Iron	6010	200.7	ICP	P	HNO_3	180	0.02
Manganese	6010	200.7	ICP	P	HNO_3	180	0.01
Sodium	6010	200.7	ICP	P	HNO_3	180	0.02
Phenols	9065	420.1	Colorimetric, 4-AAP Distillation, Solvent Extraction	G	H_2SO_4	28	0.005
Sulfate	----	375.4	Turbidimetric	P	None	28	1.0
Arsenic	7061	206.3 206.2	AA/Hydride GFAA	P	HNO_3	180	0.005 0.005
Barium	6010	200.7	ICP	P	HNO_3	180	0.05
Cadmium	6010	200.7	ICP	P	HNO_3	180	0.01
Chromium	6010	200.7	ICP	P	HNO_3	180	0.02

*All units in mg/L unless otherwise noted.

P - Plastic, G - Glass, A - Amber, T - Teflon

TABLE 4 (Continued)

GROUND WATER SAMPLING AND ANALYSIS PLAN
ANALYTICAL PROCEDURES

Parameter	EPA Method SW-846	EPA Method 600	Description	Container	Preservative	Holding Time, Days	Detection Limit*
Lead	7421	239.2	GFAA	P	HNO_3	180	0.005
Mercury	7470	245.1	Cold Vapor	P	HNO_3	180	0.0005
Selenium	7741	270.3	AA/Hydride	P	HNO_3	180	0.002
		270.2	GFAA				0.005
Silver	6010	200.7	ICP	P	HNO_3	180	0.01
Fluoride	----	340.2	Electrode	P	None	28	0.10
	----	340.1	SPADNS (Distillation Required)	P	None	28	0.10
Nitrate	----	352.1	Colorimetric	P	H_2SO_4	14	0.10
Endrin	8080	608	GC/EC	G/T	None	7	0.0002
Lindane	8080	608	GC/EC	G/T	None	7	0.004
Methoxychlor	8080	608	GC/EC	G/T	None	7	0.10
Toxaphene	8080	608	GC/EC	G/T	None	7	0.005
2,4-D	8150	---	GC/EC	G/T	None	7	0.10
2,4,5-TP Silvex	8150	---	GC/EC	G/T	None	7	0.01
Radium	SM 705		Precipitation	P	HNO_3	180	1pCi/L
Gross Alpha	SM 703			P	None	180	2pCi/L
Gross Beta	SM 703			P	None	180	3pCi/L
Total Coliform	9132		Membrane Filtration	Sterilized	$Na_2S_2O_3$	0.25-1	1/100ml
Vanadium	6010	00.7	ICP	P	HNO_3	180	0.02

*All units in mg/L unless otherwise noted.

P - Plastic, G - Glass, T - Teflon

TABLE 4 (Continued)

GROUND WATER SAMPLING AND ANALYSIS PLAN
ANALYTICAL PROCEDURES

Parameter	EPA Method SW-846	EPA Method 600	Description	Container	Preservative	Holding Time, Days	Detection Limit*
Molybdenum	6010	200.7	ICP	P	HNO_3	180	0.05
Calcium	6010	200.7	ICP	P	HNO_3	180	0.05
Potassium	6010	200.7	ICP	P	HNO_3	180	Variable
Magnesium	6010	200.7	ICP	P	HNO_3	180	0.030
Nickel	6010	200.7	ICP	P	HNO_3	180	0.05
Copper	6010	200.7	ICP	P	HNO_3	180	0.01
Bicarbonate			Titration	P	None	1/14	1
Carbonate			Titration	P	None	1/14	1
Cyanide	9010	335.2	Colorimetric	G	NaOH	14	0.02
Ammonia	----	350.2	Nesslerization Distillation	P	H_2SO_4	28	0.05
VOA's	8240	624	GC/MS	VOA	HCl	14	0.005
Semi-VOA's	8250 or 8270	625	GC/MS	VOA	HCl	14	0.010

*All units in mg/L unless otherwise noted.

P - Plastic, G - Glass, VOA - 40 ml of glass container with Septa seal

TABLE 5

Soil Sampling and Analysis Plan
Analytical Procedures

Parameter	EPA Method SW-846	Description	Container	Preservative	Holding Time, Days	Detection(1) Limit
TPH	Modified 8015	GC-FID	G	4°C	28	25
Oil & Grease	9071	Gravimetric	G	4°C	28	100
Background Metals:						
Antmony	6010	ICP	P,G	4°C	180	0.05
Arsenic	7061	GFAA	P,G	4°C	180	0.005
Barium	6010	ICP	P,G	4°C	180	0.01
Beryllium	6010	ICP	P,G	4°C	180	0.001
Cadmium	6010	ICP	P,G	4°C	180	0.005
Chromium	6010	ICP	P,G	4°C	180	0.01
Copper	6010	ICP	P,G	4°C	180	0.01
Lead	6010	ICP	P,G	4°C	180	0.05
Mercury	7470	Cold Vapor	P,G	4°C	28	0.0002
Nickel	6010	ICP	P,G	4°C	180	0.001
Potassium	6010	ICP	P,G	4°C	180	5.00
Selenium	7710	GFAA	P,G	4°C	180	0.005
Vanadium	6010	ICP	P,G	4°C	180	0.002
Zinc	6010	ICP	P,G	4°C	180	0.01
pH	9045	Electrode	P,G	4°C	14	NA
TOC	9060	Combustion/ Oxidation	G	4°C	28	0.02 percent
Benzene	8020	GC/PID	G	4°C	14	0.005
Toluene	8020	GC/PID	G	4°C	14	0.005
Ethyl-Benzene	8020	GC/PID	G	4°C	14	0.005
Xylenes	8020	GC/PID	G	4°C	14	0.005
Phenolics	9065	Colorimetric	G	4°C	14	1.0
Cyanide	9010	Colorimetric	P,G	4°C	28	0.5
Asbestos	600 - Interim	Phase Contrast Microscopy	P,G	None	180	Particles/ Volume

*All units in mg/kg unless otherwise noted.

(1) Detection limits in soil may vary depending upon the matrix of the individual samples.

P - Plastic

G - Glass

measured. The Appendix IX list contains those analytes in Appendix VIII which can be quantified.

7.2 Detection Limits

It is imperative that the analytical procedures chosen have method detection limits appropriate for the intended use of the data. Ideally, procedures should be selected which have a Method Detection Limit (MDL) that is five times lower than the regulatory threshold limit. The detection limits for ground water samples for the procedures are listed in Table 4. Table 5 lists detection limits for soil samples. Appendix C lists detection limits for soil samples for Appendix IX constituents.

7.3 Sample Container, Preservation and Holding Times

Sample container selection, preservation techniques and holding times (length of time between sample collection and analyses) must be addressed for every sampling activity. This is necessary to assure that the sample does not deteriorate or become contaminated. Sample deterioration can occur through processes such as biological degradation or chemical precipitation. Sample contamination or alteration can occur due to adsorption, absorption, or leaching effects due to the interaction of the sample and the container material. Appropriate sample containers, preservation, and holding times are listed in Table 4 for ground water samples and Table 5 for soil samples. Appendix C lists sample containers, preservation, and holding times for Appendix IX analytes. Additionally, all samples except trace metals preserved with nitric acid should be maintained at $4^{o}C$ from the time of collection until analyses.

Note: Nitric acid for trace metal preservation must be of ultra-trace grade quality. Samples preserved with acids should be at pH <2. Samples preserved with sodium hydroxide should be at pH >12.

7.4 Sample Preparation

Proper sample preparation is an integral part of any analytical program. Sample preparation techniques include filtration, digestion, and distillation. These steps may not be omitted from the various methodologies unless approval is obtained from the Giant RFI Project Manager. Any additional preparation above and beyond normal standard operating procedures should be documented and confirmed by the QA/QC manager.

7.5 Laboratory QA/QC

The laboratory's QA/QC program is included as Appendix D of the Generic Sampling Plan.

8.0 CALIBRATION PROCEDURES AND FREQUENCY

8.1 Field Instruments

8.1.1 pH Meter

The pH meter should be calibrated before leaving the lab using a two point calibration method. Normally, the meter will be calibrated with pH 7 and pH 10 buffers. At each well, pH calibration should be verified using the pH 7 buffer solution. If the result of this calibration does not agree within ± 0.05 units, the meter should be recalibrated as above. Results of all calibration verification and recalibration must be recorded in the field notes for a given sampling event.

8.1.2 Conductivity Meter

The conductivity meter calibration should be checked according to manufacturer's specifications. The conductivity reading should be within 5% of the expected value of the standard. Calibration should be checked at the lab before going into the field and every four hours thereafter. Results of the calibration verifications made in the lab and in the field must be recorded in the field notes for a particular sampling event.

8.1.3 PID Meter

The PID meter should be calibrated each day it is used in the field. Three steps need to be taken in order to calibrate the PID meter:

- Check the battery
- Set the zero point
- Use calibration gas according to manufacture's instructions.

Results of all calibration verification must be recorded in the field notes during a particular sampling event.

8.2 Laboratory Instrumentation

It is recognized that instrument calibration procedures vary from instrument to instrument. Manufacturers' guidelines should be followed. The frequency of calibration for a number of instruments is addressed below. This information is obtained from SW-846, third edition, Test Methods for Evaluating Solid Waste. This section is not intended to be comprehensive in nature. The contract laboratory is responsible for detailing its own QA/QC protocol in addition to the items listed here.

8.2.1 ICP

- Calibrate the instrument according to manufacturer's recommended procedures.
- Two types of blanks are required: calibration blank and reagent blank.
- Check calibration using a blank and two standards.
- Verify calibration every 10 samples and at the end of each run by analyzing blank and check standard. Standard should be within 10% of expected value; if not, terminate analysis, correct problem, and recalibrate. The calibration blank should agree within three standard deviations of the mean blank. If not, terminate analysis, correct problem, recalibrate, and reanalyze the previous 10 samples.
- Analyze interference check sample at the beginning and end of an analytical run or twice during every 8-hour work shift.
- Replicate samples and spiked samples should be run at a frequency of 10%.

- Duplicate spiked samples must be run at a frequency of 20%. The Relative Percent Difference (RPD) shall be ± 20% for sample values greater than 10 times the detection limit. Spike recovery is to be ± 20% of the actual value.
- Serial dilution checks where applicable.
- Detection limit verification on a quarterly basis.

8.2.2 Atomic Absorption Spectrophotometer

- Calibrate each run using a blank and three standards.
- Verify calibration by running blank, and mid-point standard every 10 samples and at the end of each run. Results must be ± 10% of true result or terminate analysis, correct problem, recalibrate, and reanalyze samples.
- Replicate and spikes must be run every 10 samples or with each matrix type, whichever is more frequent.
- Method of standard additions should be employed as required.

8.2.3 TOC Analyzer

- Calibrate according to instrument manufacturer's recommendations each run.
- Verify calibration by analyzing blank and check standard every 10 samples. If results are not ± 10% of expected value, terminate analysis, correct problem, recalibrate, and reanalyze previous 10 samples.
- Quadruplicate analyses are required for most ground water samples.
- Replicates and spikes must be analyzed at a frequency of 10%, or at least one in each analytical batch.

8.2.4 Gas Chromatographs

- Initial demonstration of capability.
- QA/QC as per individual methods in SW-846, 3rd edition.
- Five point calibration curve for each compound.
- Blank and calibration verification every 8 hours.
- Internal standard added to all blanks, standards, and samples.

8.2.5 Gas Chromatography/Mass Spectrometry

- Initial demonstration of capability.
- Meet tuning criteria as per SW-846, 3rd edition
- Internal and surrogate standards added to blanks, standards, samples.
- Blank and standard calibration verification each run.

8.2.6 UV-Vis Spectrophotometer

- Multi-point calibration as specified in individual methods in SW-846, 3rd edition.
- Calibration verification as per individual methods in SW-846.
- Replicates and spikes will be analyzed at a frequency of 10% or at least one in every analytical batch.

8.2.7 TOX Analyzer

- All samples will be analyzed in replicate at a minimum. Most ground water samples are to be analyzed in quadruplicate.

- Check absorption efficiency of each newly prepared batch of carbon.
- Run at least two nitrate wash blanks at the beginning of the day and one nitrate wash blank after every eight pyrolysis determinations.
- Run duplicate instrument calibration standards at the beginning of each day and after every eight pyrolysis determinations.
- Verify calibration with an independently prepared check standard every fifteen samples.
- Analyze duplicate spiked samples every ten samples.

9.0 STATISTICAL METHODOLOGY

In order to determine if a release of metallic constituents has occurred from a unit, a One-Way Parametric Analysis of Variance will be calculated at specific SWMU's. These data will be compared with the background metals data obtained during the Land Treatment Demonstration. One sampling interval with four independent samples per boring and at least three borings will fulfill the minimum sample requirements.

9.1 Statistical Comparison of Background Metals Data

Based on the Demonstration Permit (NMD000333211-1) and the Permit Application Report (June 1986, Appendix A), a Land Treatment Demonstration was conducted to show treatment capabilities for refinery waste generated by Giant Refinery Company. The demonstration period lasted from April 1987 through March 1988. The following table lists the background metallic data, which was collected from a plot of land adjacent to the land treatment demonstration.

Background Metals, Statistical Information

	Background		
Metal	Mean	Variance	N
Sb	0	0	18
As	3.0	9.0	18
Ba	258	2147	18
Be	1.06	0.1	18
Cd	0.04	0.02	18
Cr	4.41	1.74	18
Cu	4.82	0.68	18
Pb	5.25	28.4	18
Hg	0	0	18
Ni	7.75	2.2	18
K	1325	78540	18
Se	0	0	18
V	12.6	3.26	18
Zn	11.2	4.14	18

The statistical methodology as outlined in the "Statistical Analysis of Ground Water Monitoring Data at RCRA (Resource Conservation and Recovery Act) Facilities, Interim Final Guidance, February 1989 follows:

9.2 One-Way Parametric Analysis of Variance

In order to apply a parametric one-way analysis of variance, a minimum number observations is needed to give meaningful results. At least $p \geq 2$ groups are to be compared (i.e., two or more borings). It is recommended that each group (here, borings) have at least three observations and that the total sample size, N, be large enough so that $N-p \geq 5$. A variety of combinations of groups and number of observations in groups will fulfill this minimum. One sampling interval with four independent samples per boring and at least three borings would fulfill the minimum sample size requirements. The borings should be spaced so as to maximize the probability of intercepting a plume of contamination.

9.2.1 Purpose

One-way analysis of variance is a statistical procedure to determine whether differences in mean concentrations among borings, or groups of borings, are statistically significant. For example, is there significant contamination of metals at a SWMU compared to background conditions.

9.2.2 Procedure

Suppose the regulated unit has p borings and that n_i data points (concentrations of a constituent) are available for the ith boring. These data can be from either a single sampling period or from more than one. In the latter case, the user could check for seasonality before proceeding by plotting the data over time. Usually the computation will be done on a computer using a commerically available program. However, the procedure is presented so that computations can be done using a desk calculator, if necessary.

Step 1. Arrange the $N = \overset{p}{\underset{i=1}{\pounds}} n_i$ data points in a data as follows:

(N is the total sample size at this specific regulated unit):

	Observations	Boring Total (from Step 1)	Boring Mean (from Step 2)
Boring No. 1	$X_{11} \, . \, . \, . \, . \, . \, . \, . \, X_{1n_i}$	$X_{1.}$	$\bar{X}_{1.}$
2	.		
3	.		
.	.		
u	X_{u1}	$X_{u.}$	$\bar{X}_{u.}$
.	.		
.	.		
p	$X_{p1} \, . \, . \, . \, . \, . \, . \, . \, X_{pn_p}$	$X_{p.}$	$\bar{X}_{p.}$
		$X_{..}$	$\bar{X}_{..}$

Step 2. Compute boring totals and boring means as follows:

$X_{i.} = \sum_{j=1}^{n_i} X_{ij}$, total of all n_i observations at boring i

$\bar{X}_{i.} = \frac{1}{n_i} X_{i.}$, average of all n_i observations at boring i

$X_{..} = \sum_{i=1}^{p} \sum_{j=1}^{n_i} X_{ij}$, grand total of all n_i observations

$\bar{X}_{..} = \frac{1}{N} X_{..}$, grand mean of all observations.

These totals and means are shown in the last two columns of the table above.

Step 3. Compute the sum of squares of differences <u>between</u> boring means and the grand mean:

$$SS_{Wells} = \sum_{i=1}^{p} n_i \; (\bar{X}_{i.} - \bar{X}_{..})^2 = \sum_{i=1}^{p} \frac{1}{n_i} X^2{}_{i} - \frac{1}{N} X^2$$

(The formula on the far right is usually most convenient for calculation.) This sum of squares has (p-1) degrees of freedom associated with it and is a measure of the variability <u>between</u> borings.

Step 4. Compute the corrected total sum of squares

$$SS_{Total} = \sum_{i-1}^{p} \sum_{j=1}^{n_i} (X_{ij} - \bar{X}_{..})^2 = \sum_{i=1}^{p} \sum_{j=1}^{n_i} X^2{}_{ij} - (X^2{}_{..}/N)$$

(The formula on the far right is usually most convenient for calculation.) This sum of squares has (N-1) degrees of freedom associated with it and is a measure of the variability in the whole data set.

Step 5. Compute the sum of squares of differences of observations <u>within</u> borings from the borings means. This is the sum of squares due to error and is obtained by subtraction:

$$SS_{Error} = SS_{Total} - SS_{Borings}$$

It has associated with it (N-p) degrees of freedom and is a measure of the variability <u>within</u> borings.

Step 6. Set up the ANOVA tables as shown below. The sums of squares and their degree of freedom were obtained from Steps 3 through 5. The mean square quantities are simply obtained by dividing each sum of squares by its corresponding degrees of freedom.

ONE-WAY PARAMETRIC ANOVA TABLE

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares	F
Between borings	$SS_{Borings}$	p-1	$MS_{Borings} = SS_{Borings}/(p-1)$	$F = \frac{MS_{Borings}}{MS_{Error}}$
Error (within borings)	SS_{Error}	N-p	$MS_{Error} = SS_{Error}/(N-p)$	
Total	SS_{Total}	N-1		

Step 7. To test the hypothesis of equal means for all p borings, compute $F = MS_{Borings}/MS_{Error}$ (last column in above table). Compare this statistic to the tabulated F statistic with (p-1) and (N-p) degrees of freedom at the 5% significance level. If the calulated F value exceeds the tabulated value, reject the hypothesis of equal boring means. Otherwise, conclude that there is no significant difference between the concentrations at the p borings and thus no evidence of boring contamination.

In the case of a significant F (calculated F greater than tabulated F in Step 7), the user will conduct the next few steps to determine which compliance boring(s) is (are) contaminated. This will be done by comparing each compliance boring with the background boring(s). Concentration differences between a pair of background borings and compliance borings or between a compliance boring and a set of background borings are called <u>contrasts</u> in the ANOVA and multiple comparisons framework.

Step 8. Determine if the significant F is due to differences between background and compliance borings (computation of Bonferroni t-statistics)

Assume that of the p borings, u are background borings and m are compliance borings (thus u + m = p). The m differences--m compliance borings each compared with the average of the background borings--need to be computed and tested for statistical significance. If there are more than five downgradient borings, the individual comparisons are done at the comparisonwise significance level of one percent, which may make the experiment-wise significance level greater than five percent.

- Obtain the total sample size of all u background borings.

$$n_{up} = \sum_{i=1}^{u} n_i$$

- Compute the average concentration from the u background borings.

$$\bar{X}_{up} = \frac{1}{n_{up}} \sum_{i=1}^{u} \bar{X}_{i.}$$

- Compute the m differences between the average concentrations from each compliance boring and the average background borings.

$$\bar{X}_{i.} - \bar{X}_{up}\ , \quad i = 1, \ldots, m$$

- Compute the standard error of each difference as

  $SE_i = [MS_{Error} (1/n_{up} + 1/n_i)/1/n_i)]^{1/2}$

  where MS_{Error} is determined from the ANOVA table and n_i is the number of observations at boring i.

- Obtain the t-statistic $t = t_{(N-p), \ (1- c/m)}$ from Bonferroni's t-table with c = 0.05 and (N-p) degrees of freedom).

- Compute the m quantities $D_i = SE_i \times t$ for each compliance boring i. If m > 5 use the entry for $t_{(N-p), \ (1-0.01)}$. That is, use the entry at m = 5.

9.2.3 Interpretation

If the difference $\overline{X}_{i.} - \overline{X}_{up}$ exceeds the value D_i, conclude that the ith compliance boring has significantly higher concentrations than the average background borings. Otherwise conclude that the boring is not contaminated. This exercise needs to be performed for each of the m compliance borings individually. The test is designed so that the overall experminent-wise error is five percent if there are no more than five compliance borings.

9.2.4 Cautionary Note

Should the regulated unit consist of more than five compliance borings, then the Bonferroni t-test should be modified by doing the individual comparisons at the one percent level so that the Part 264 Subpart F regulatory requirement pursuant to §264.97(i)(2) will be met. Alternately, a difference analysis of contrasts, such as Scheffe's, may be used.

10.0 DATA REDUCTION, VALIDATION AND REPORTING

The contract lab will send the analytical results to the project manager who will process the report for purchasing. The project manager will review the report for completeness, making sure sample analyses reported correspond exactly with analyses requested on the chain of custody form. If the report is incomplete, the laboratory will be notified immediately of any discrepancies. After the report has been reviewed for completeness, the report will be submitted to the QA/QC manager for technical review. This should be done the day the report is received.

10.1 QA/QC Manager

The QA/QC manager will review the report and assess validity based on:

- Methodology
- Detection limits
- Results of internal quality control checks
- Holding times
- Comparison with historical data base
- Review of precision and accuracy data reported by lab

The QA/QC manager should notify the outside lab of any suspected quality problems within one week of data receipt. The contract laboratory should implement corrective action regarding data quality within one week of notification by the QA/QC manager that a problem exists. After the data has been reviewed and validated by the QA/QC manager, a cover sheet containing the following information will be placed in the project file.

- Summary of internal quality control check samples
- List of invalid data points based upon review of methodology, detection limits, holding time, precision and accuracy review
- List of outliers as compared to historical data base

10.2 RFI Project Manager

The RFI Project Manager will review the report received from the QA/QC manager and will make the decision to resample if necessary due to invalid data or outliers associated with the sampling event.

After data from a particular sampling event is approved, the data will be input into the project data base. The project manager will incorporate the results into a report or submit the results to the appropriate regulatory agencies.

11.0 INTERNAL QUALITY CONTROL CHECKS

11.1 Equipment Blanks

Equipment blanks will be analyzed to check for contamination due to improper/insufficient decontamination procedures. These blanks will be taken only when non-dedicated equipment is used.

To assure that the bailer has been sufficiently decontaminated (in the laboratory or in the field), fill the bailer with deionized water and pour this water into a set of sample bottles and submit to the laboratory for analysis. Sufficient equipment blanks will be collected to assure proper equipment decontamination.

11.2 Trip Blanks

Trip blanks will be analyzed to check for container contamination. Trip blanks will be prepared and labeled by the contract laboratory. One bottle of each type will be filled with Type II reagent grade water, transported to the site with the empty sample bottles, carried with the sample bottles during all sampling activities, and returned to the contract laboratory for analysis. Trip blanks should not be opened at any time prior to analysis. They should be kept with the sample bottles with which they are associated at all times. One trip blank will be used per sampling event. Analyze only if the field blank contained detectable concentrations of a constituent which would indicate cross contamination.

11.3 Field Duplicates

To measure the precision of the sampling activities, duplicate samples will be collected and analyzed. Duplicates will be collected at a frequency of 5% or one with each sample set, whichever is more. For example, if two samples are taken, then one duplicate is needed. If 10 samples are collected, then one duplicate is needed.

The duplicates will be assigned a fictitious identification number and submitted to the laboratory as a blind duplicate. Record the ID number of the real well name and fictitious number on the ground water well information form.

In order to evaluate the precision of the analysis, it is necessary to calculate the relative percent deviation (RPD) between the two results of the duplicate analysis.

Calculate Relative Percent Deviation, RPD =

$$RPD = \frac{(S1-S2)}{(S1+S2)/2} \times 100\% \text{ where}$$

S1 = Sample Result 1

S2 = Sample Result 2

Example: The sulfate result reported for MW-999 is 1000 mg/l. The result for the duplicate sample of MW-999 is 1050 mg/l.

$$\text{The RPD} = \frac{(1050 - 1000)}{(1050 + 1000/2)} \times 100$$

$$= \frac{50}{1025} \times 100\%$$

$$= 4.9\%$$

RPD should be less than or equal to 10% for values five times greater than the MDL and plus or minus the detection limit for values less than five times the MDL.

12.0 SYSTEM AUDITS

A system audit is a qualitative evaluation in order to determine whether the guidelines set forth in this manual are being followed. A system audit will be conducted on a annual basis by the QA/QC manager.

The completed audit results will be given to the project manager so that it may be used as a guide for additional training and continual improvement objectives. It is important that all parties involved recognize that this system audit is <u>NOT</u> to be utilized in a punitive or negative manner, but that it be viewed as a tool to be used to achieve the data quality objectives.

13.0 CORRECTIVE ACTION

Corrective action may be indicated based upon the results of the system audit, performance audit, or normal QC procedures. Corrective action consists of the following steps:

- Identify and define problem
- Assign responsibility to investigate problem
- Investigate and identify cause of problem
- Determine responsibility for implementing corrective action
- Implement and assess effectiveness of corrective action
- Confirm that the problem has been eliminated

Corrective action may be initiated at all levels of responsibility and at all stages of the ground water sampling program. The QA/QC manager is responsible for assuring that the above steps are taken and that the problem initiating corrective action is solved.

14.0 QA/QC REPORTS TO MANAGEMENT

The QA/QC manager and project manager will provide reports to management on a quarterly basis which include:

- Results of System Audit
- Review of problems encountered and solutions obtained
- Review of any unresolved problems
- Recommendations to achieve continual improvements in the sampling program

APPENDIX A

Helpful Information

Source: Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, SW-846 (3rd edition, 1986). *

TABLE 11-1

SAMPLING AND PRESERVATION PROCEDURES FOR DETECTION MONITORING[a]

Parameter	Recommended Container[b]	Preservative	Maximum Holding Time	Minimum Volume Required for Analysis
GROUP I:	Indicators of Ground Water Contamination[c] (Quadruplicate Analyses)			
pH	T, P, G	Field determined	None	25 mL
Specific conductance	T, P, G	Field determined	None	100 mL
TOC	G, Teflon-lined cap	Cool 4°C, H2SO4 to pH <2	28 days	100 mL
TOX	G, amber, Teflon-lined Septa Cap	Cool 4°C, H2SO4 to pH< 2	28 days	250 mL
GROUP II:	Ground Water Quality Characteristics			
Chloride	T, P, G	4°C	28 days	50 mL
Iron Manganese Sodium	T, P	Field acidified to pH <2 with HNO_3	6 months	200 mL
Phenols	G	4°C/H_2SO_4 to pH <2	28 days	500 mL
Sulfate	T, P, G	Cool, 4°C	28 days	50 mL
GROUP III:	EPA Interim Drinking Water characteristics			
Arsenic Barium Cadmium Chromium Lead Mercury Selenium Silver	T, P	Total Metals Field acidified to pH <2 with HNO_3	6 months	500 mL
		Dissolved Metals 1. Field filtration (0.45 micron) 2. Acidify to pH <2 with HNO_3	6 months	600 mL
Fluoride	T, P	Cool, 4°C	28 days	300 mL
Nitrate	T, P, G	4°C/H_2SO_4 to pH <2	14 days	100 mL

(Continued)

TABLE 11-1 (Continued)

SAMPLING AND PRESERVATION PROCEDURES FOR DETECTION MONITORING[a]

Parameter	Recommended Container[b]	Preservative	Maximum Holding Time	Minimum Volume Required for Analysis
Endrin Lindane Methoxychlor Toxaphene 2,4 D 2,4,5 TP Silvex	T, G	Cool, 4°C	7 days	2,000 mL
Radium Gross Alpha Gross Beta	P, G	Field acidified to pH <2 with HNO_3	6 months	1 Quart
Coliform bacteria	PP, G (sterilized)	Cool, 4°C	6 hours	100 mL
		Other Ground Water Characteristics of Interest		
Cyanide	P, G	Cool, 4°C, NaOH to pH >12	14 days	500 mL
Oil and Grease	G only	Cool, 4°C H_2SO_4 to pH <2	28 days	1000 mL
Semivolatile, volatile organics	T, G	Cool, 4°C	7 days	2000 mL + 2 VOA vials

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[a] References: Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, SW-846 (3rd edition, 1986).
Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020.
Standard Methods for the Examination of Water and Wastewater, 16th edition (1985).

[b] Container Types:
P = Plastic (polyethylene)
G = Glass
T = Teflon
PP = Polypropylene

[c] Based on the requirements for detection monitoring (265.93), the owner/operator must collect a sufficient volume of ground water to allow for the analysis of four separate replicates.

VOLATILE ORGANIC COMPOUNDS - EXAMPLES

		Practical Quantitation Limits[b]	
		Ground water	Low Soil/Sediment
Volatiles	CAS Number	ug/L	ug/Kg
1. Chloromethane	74-87-3	10	10
2. Bromomethane	74-83-9	10	10
3. Vinyl Chloride	75-01-4	10	10
4. Chloroethane	75-00-3	10	10
5. Methylene Chloride	75-09-2	5	5
6. Acetone	67-64-1	100	100
7. Carbon Disulfide	75-15-0	5	5
8. 1,1-Dichloroethene	75-35-4	5	5
9. 1,1-Dichloroethane	75-35-3	5	5
10. trans-1,2-Dichloroethene	156-60-5	5	5
11. Chloroform	67-66-3	5	5
12. 1,2-Dichloroethane	107-06-2	5	5
13. 2-Butanone	78-93-3	100	100
14. 1,1,1-Trichloroethane	71-55-6	5	5
15. Carbon Tetrachloride	56-23-5	5	5
16. Vinyl Acetate	108-05-4	50	50
17. Bromodichloromethane	75-27-4	5	5
18. 1,1,2,2-Tetrachloroethane	79-34-5	5	5
19. 1,2-Dichloropropane	78-87-5	5	5
20. trans-1,3-Dichloropropene	10061-02-6	5	5
21. Trichloroethene	79-01-6	5	5
22. Dibromochloromethane	124-48-1	5	5
23. 1,1,2-Trichloroethane	79-00-5	5	5
24. Benzene	71-43-2	5	5
25. cis-1,3-Dichloropropene	10061-01-5	5	5
26. 2-Chloroethyl Vinyl Ether	110-75-8	10	10
27. Bromoform	75-25-2	5	5
28. 2-Hexanone	591-78-6	50	50
29. 4-Methyl-2-pentanone	108-10-1	50	50
30. Tetrachloroethene	127-18-4	5	5
31. Toluene	108-88-3	5	5
32. Chlorobenzene	108-90-7	5	5
33. Ethyl Benzene	100-41-4	5	5
34. Styrene	100-42-5	5	5
35. Total Xylenes		5	5

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[a] Sample PQLs are highly matrix-dependent. The PQLs listed herein are provided for guidance and may not always be achieveable. See the following information for further guidance on matrix-dependent PQLs.

[b] PQLs listed for soil/sediment are based on wet weight. Normally data is reported on a dry weight basis; therefore, PQLs will be higher, based on the % moisture in each sample.

Other Matrices:	Factor[1]
Water miscible liquid waste	50
High-level soil & sludges	125
Non-water miscible waste	500

[1] PQL = [PQL for ground water (Table 2)] X [Factor]. For non-aqueous samples, the factor is on a wet-weight basis.

SEMI-VOLATILE ORGANIC COMPOUNDS - EXAMPLES

Base/Neutral Extractables

Parameter	*CAS No.*
Acenaphthene	*83-32-9*
Acenaphthylene	*208-96-8*
Anthracene	*120-12-7*
Aldrin	*309-00-2*
Benzo(a)anthracene	*56-55-3*
Benzo(b)fluoranthene	*205-99-2*
Benzo(k)fluoranthene	*207-08-9*
Benzo(a)pyrene	*50-32-8*
Benzo(ghi)perylene	*191-24-2*
Benzyl butyl phthalate	*85-68-7*
β-BHC	*319-85-7*
δ-BHC	*319-86-8*
Bis(2-chloroethyl)ether	*111-44-4*
Bis(2-chloroethoxy)methane	*111-91-1*
Bis(2-ethylhexyl)phthalate	*117-81-7*
Bis(2-chloroisopropyl)ether	*108-60-1*
4-Bromophenyl phenyl ether	*101-55-3*
Chlordane	*57-74-9*
2-Chloronaphthalene	*91-58-7*
4-Chlorophenyl phenyl ether	*7005-72-3*
Chrysene	*218-01-9*
4,4'-DDD	*72-54-8*
4,4'-DDE	*72-55-9*
4,4'-DDT	*50-29-3*
Dibenzo(a,h)anthracene	*53-70-3*
Di-n-butylphthalate	*84-74-2*
1,3-Dichlorobenzene	*541-73-1*
1,2-Dichlorobenzene	*95-50-1*
1,4-Dichlorobenzene	*106-46-7*
3,3'-Dichlorobenzidine	*91-94-1*
Dieldrin	*60-57-1*
Diethyl phthalate	*84-66-2*
Dimethyl phthalate	*131-11-3*
2,4-Dinitrotoluene	*121-14-2*
2,6-Dinitrotoluene	*606-20-2*
Di-n-octylphthalate	*117-84-0*
Endosulfan sulfate	*1031-07-8*
Endrin aldehyde	*7421-93-4*
Fluoranthene	*206-44-0*
Fluorene	*86-73-7*
Heptachlor	*76-44-8*
Heptachlor epoxide	*1024-57-3*
Hexachlorobenzene	*118-74-1*
Hexachlorobutadiene	*87-68-3*
Hexachloroethane	*67-72-1*
Indeno(1,2,3-cd)pyrene	*193-39-5*
Isophorone	*78-59-1*
Naphthalene	*91-20-3*
Nitrobenzene	*98-95-3*
N-Nitrosodi-n-propylamine	*621-64-7*
PCB-1016	*12674-11-2*
PCB-1221	*11104-28-2*
PCB-1232	*11141-16-5*
PCB-1242	*53469-21-9*
PCB-1248	*12672-29-6*
PCB-1254	*11097-69-1*
PCB-1260	*11096-82-5*
Phenanthrene	*85-01-8*
Pyrene	*129-00-0*
Toxaphene	*8001-35-2*
1,2,4-Trichlorobenzene	*120-82-1*

Acid Extractables

Parameter	*CAS No.*
4-Chloro-3-methylphenol	*59-50-7*
2-Chlorophenol	*95-57-8*
2,4-Dichlorophenol	*120-83-2*
2,4-Dimethylphenol	*105-67-9*
2,4-Dinitrophenol	*51-28-5*
2-Methyl-4,6-dinitrophenol	*534-52-1*
2-Nitrophenol	*88-75-5*
4-Nitrophenol	*100-02-7*
Pentachlorophenol	*87-86-5*
Phenol	*108-95-2*
2,4,6-Trichlorophenol	*88-06-2*

REGULATORY LIMITS - DRINKING WATER

Contaminant	Unit	MCL
Primary regulations*		
Inorganics		
Arsenic	mg/L	0.05
Barium	mg/L	1.0
Cadmium	mg/L	0.01
Chromium	mg/L	0.05
Fluoride	mg/L	4.0
Lead	mg/L	0.05
Mercury	mg/L	0.002
Nitrate (as N)	mg/L	10.0
Selenium	mg/L	0.01
Silver	mg/L	0.05
Microbials		
Coliforms		1/100 mL
Turbidity	ntu	1-5
Organics		
2,4-D	mg/L	0.1
Endrin	mg/L	0.0002
Lindane	mg/L	0.0004
Methoxychlor	mg/L	0.1
Toxaphene	mg/L	0.005
2,4,5-TP silvex	mg/L	0.01
Trihalomethanes (chloroform, bromoform, bromodichloromethane, dibromochloromethane)		0.10
Radionuclides		
Beta particle and photon radioactivity	mrem	4 (annual dose equivalent)
Gross alpha particle activity	pCi/L	15
Radium-226 + radium-228	pCi/L	5
Volatile organic chemicals		
Benzene	mg/L	0.005
Carbon tetrachloride	mg/L	0.005
1,2-Dichloroethane	mg/L	0.005
1,1-Dichloroethylene	mg/L	0.007
1,1,1-Trichloroethane	mg/L	0.20
para-Dichlorobenzene	mg/L	0.075
Trichloroethylene	mg/L	0.005
Vinyl chloride	mg/L	0.002
Secondary regulations†		
Chloride	mg/L	250
Color	color units	15
Copper	mg/L	1
Corrosivity		noncorrosive
Fluoride	mg/L	2
Foaming agents	mg/L	0.5
Iron	mg/L	0.3
Manganese	mg/L	0.05
Odor	TON	3
pH		6.5-8.5
Sulfate	mg/L	250
Total dissolved solids	mg/L	500
Zinc	mg/L	5

APPENDIX B

Meterological Conditions

CLIMATOGRAPHY OF THE UNITED STATES NO. 20

GALLUP, NM

PERIOD: 1951-80
ELEVATION: 6600 FT

CLIMATOLOGICAL SUMMARY

	TEMPERATURE (F)															PRECIPITATION TOTALS (INCHES)											
	MEANS			EXTREMES						MEAN NUMBER OF DAYS				DEGREE DAYS								SNOW			MEAN NUMBER OF DAYS		
										MAX.		MIN.															
	* DAILY MAXIMUM	* DAILY MINIMUM	* MONTHLY	RECORD HIGHEST	YEAR	DAY	RECORD LOWEST	YEAR	DAY	90 AND ABOVE	32 AND BELOW	32 AND BELOW	0 AND BELOW	* HEATING BASE 65	* COOLING BASE 65	* MEAN	GREATEST MONTHLY	YEAR	GREATEST DAILY	YEAR	DAY	MEAN	MAXIMUM MONTHLY	YEAR	.10 OR MORE	.50 OR MORE	1.00 OR MORE
JAN	43.8	13.7	28.8	65+	54	29	-33+	71	8	0	3	30	4	1122	0	.63	2.64	80	.64	63	11	5.2	17.0	74	1	0	0
FEB	48.8	18.2	33.6	69+	57	14	-23	51	2	0	1	27	1	879	0	.54	2.70	80	.68	62	08	3.1	11.5	62	1	0	0
MAR	54.5	23.3	38.9	77+	78	27	-9	66	4	0	0	28	0	809	0	.63	2.39	54	1.09	54	23	3.4	24.0	69	2	0	0
APR	64.7	29.2	46.9	85+	77	26	7	75	08	0	0	21	0	543	0	.41	2.36	52	.83	52	20	.5	4.5	64	1	0	0
MAY	74.0	36.9	55.5	92	51	26	15+	75	7	0	0	8	0	302	7	.38	1.46	54	.83	73	06	.0	1.2	51	1	0	0
JUN	85.1	45.0	65.1	99+	74	24	26+	51	9	8	0	1	0	67	70	.40	1.54	67	.94	52	02	.0	.0		1	0	0
JUL	88.5	53.3	70.9	101+	79	21	30	78	07	15	0	0	0	5	188	1.52	4.41	55	1.90	54	24	.0	.0		4	1	0
AUG	85.0	52.3	68.7	97+	76	7	35+	78	28	5	0	0	0	10	125	1.61	4.36	64	1.34	74	03	.0	.0		4	1	0
SEP	79.6	44.4	62.0	95+	74	11	23+	73	28	1	0	1	0	116	26	.95	3.35	71	1.28	71	30	.0	.0		3	1	0
OCT	69.1	33.2	51.2	90+	78	1	12+	75	24	0	0	16	0	428	0	1.30	5.75	72	1.34	72	19	.5	14.0	61	3	1	0
NOV	54.7	21.9	38.3	76+	71	11	-31+	76	28	0	0	27	0	801	0	.67	3.12	78	.95	78	24	2.6	16.5	52	2	0	0
DEC	45.8	14.4	30.2	68+	76	14	-21+	78	10	0	3	30	3	1079	0	.62	2.67	65	1.30	65	10	5.6	20.5	67	2	0	0
YEAR	66.1	32.2	49.2	101	JUL 79	21	-33	JAN 71	8	29	7	189	8	6161	416	9.66	5.75	OCT 72	1.90	JUL 54	24	20.9	24.0	MAR 69	25	4	0

*FROM 1951-80 NORMALS

ESTIMATED VALUE BASED ON
DATA FROM SURROUNDING STATIONS

+ ALSO ON EARLIER DATES.

DEGREE DAYS TO SELECTED BASE TEMPERATURES (F)

BASE	HEATING DEGREE DAYS												
BELOW	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
65	1122	879	809	543	302	67	5	10	116	428	801	1079	6161
60	967	739	654	393	171	14	0	0	36	277	651	924	4826
57	874	655	561	308	113	0	0	0	12	192	561	831	4107
55	812	599	499	252	81	0	0	0	5	143	501	769	3661
50	657	459	353	132	24	0	0	0	0	55	355	614	2649

BASE	COOLING DEGREE DAYS												
ABOVE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
55	0	0	0	9	96	303	493	425	215	25	0	0	1566
57	0	0	0	0	66	248	431	363	162	12	0	0	1282
60	0	0	0	0	32	167	338	270	96	0	0	0	903
65	0	0	0	0	7	70	188	125	26	0	0	0	416
70	0	0	0	0	0	16	72	31	0	0	0	0	119

DERIVED FROM THE 1951-80 MONTHLY NORMALS

PROBABILITY THAT THE MONTHLY PRECIPITATION WILL BE EQUAL TO OR LESS THAN THE INDICATED PRECIPITATION AMOUNT

MONTHLY PRECIPITATION (INCHES)

PROBABILITY LEVELS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
.05	.00	.00	.00	.00	.00	.00	.00	.34	.00	.00	.00	.00
.10	.03	.00	.02	.00	.00	.00	.13	.49	.00	.00	.02	.03
.20	.11	.08	.10	.00	.02	.01	.38	.73	.17	.18	.10	.12
.30	.20	.16	.19	.07	.09	.06	.62	.94	.32	.48	.19	.21
.40	.30	.25	.29	.17	.17	.13	.87	1.16	.49	.73	.30	.31
.50	.42	.36	.41	.26	.25	.21	1.15	1.39	.67	1.01	.44	.43
.60	.58	.49	.57	.38	.35	.32	1.48	1.64	.90	1.31	.60	.58
.70	.77	.67	.77	.52	.48	.47	1.88	1.95	1.18	1.68	.81	.76
.80	1.04	.90	1.05	.72	.65	.68	2.44	2.36	1.56	2.18	1.11	1.02
.90	1.51	1.31	1.53	1.05	.95	1.05	3.36	3.01	2.21	2.95	1.63	1.46
.95	1.97	1.72	2.02	1.36	1.24	1.44	4.27	3.62	2.85	3.71	2.15	1.89

THESE VALUES WERE DETERMINED FROM THE INCOMPLETE GAMMA DISTRIBUTION.

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U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ENVIRONMENTAL DATA SERVICE

JOB NO. 51335 (W-1379)

MONTHLY AND ANNUAL
WIND DISTRIBUTION BY PASQUILL STABILITY CLASSES (6)
STAR PROGRAM

STATION: #23081 Gallup, NM

PERIOD: 1/76-12/80 (8 Obs/Day)

SOURCE: TDF 1440

DATE September 15, 1981

NATIONAL CLIMATIC CENTER
FEDERAL BUILDING, ASHEVILLE, N.C.

NOAA Form 47-318
(Rev 7/75)

U S COMM-NOAA-ASHEVILLE

MONTHLY AND ANNUAL
WIND DIRECTION BY PASQUILL STABILITY CLASSES (STAR PROGRAM)
6 Classes

JOB NO.: **51235**

Station: **#23081 Gallup, NM**

Period of Record: **1/76-12/80 (8 Obs/Day)**

Data are presented by stability classes and also combined for the period indicated; first, as a bivariate frequency distribution of wind direction vs. wind speed, and second, as normalized values (i.e., relative frequency). Stability classes are based on Pasquill's class structure (see Journal of Applied Meteorology, February 1964), as follows:

Stability Class (Regular STAR)	Identified in lower left corner in this tabulation as:	Definition
1	A	Extremely Unstable
2	B	Unstable
3	C	Slightly Unstable
4	D	Neutral
5	E	Slightly Stable
6	F	Stable
7	G	Extremely Stable

Tabulations can also be prepared for the Regular STAR in 5 classes (E, F, G combined), 6 classes (F, G combined), or 7 classes

Stability Class (Day/Night STAR	Identified in lower left corner in this tabulation as:	Definition
1	A	Extremely Unstable
2	B	Unstable
3	C	Slightly Unstable
4	D	Neutral/Day
5	E	Neutral/Night
6	F	Slightly Stable
7	G	Stable
8	H	Extremely Stable

The Day/Night STAR can be prepared for 6 classes (F, G, H combined), 7 classes (G, H combined), or 8 classes. The Day/Night STAR is normally used in the climatological display model (CDM)

Average wind speed in knots, to tenths, for each direction and each speed class. Overall average wind speed is computed by: $\frac{\text{Sum of Wind Speed}}{\text{Number of Occurrences}}$

NUMBER OF OCCURRENCES: Number of DIR/SPD observations, plus number of calms (winds are tabulated to 16 points; speeds are in knots.)

RELATIVE FREQUENCY OF OCCURRENCES: $\frac{\text{Number of occurrences/stability class}}{\text{Total number of observations}}$

TOTAL NUMBER OF OBSERVATIONS: Number of observations in each month, season, annual or period.

TOTAL RELATIVE FREQUENCY OF OBSERVATIONS: $\frac{\text{Total number of observations}}{\text{Total number of observations}} = 1.00000$

This normalized (relative frequency) table is self explanatory, except that calm values have been distributed in the 0-3 speed category based on the number of observations in speed categories 1-3 and 4-6 as shown below.

Because of the importance of calm winds in air pollution studies, their occurrences are distributed into 0-3 speed category of the percentage frequency (normalized) tables using a ratio based on the number of observations of speeds of 1-6 knots in each direction category.

Example:

	Season:	MAM
R	Total Obs for Season (all Stabilities):	3680
S	Stability Class:	"C"
T	Total Obs. Class "C" - Speeds 1-3	21
U	Total Obs. Class "C" - Speeds 4-6	142
V	Total Calms - Class "C" (Season: MAM)	8

To find the distribution of calms into a direction category we must also know the number of observations in that direction that had speeds of 1-3 and 4-6 knots. In our example let us assume we want to find how the calms were distributed into the south direction.

W Total Obs. S Direction (Season: MAM) "C" Stability Speeds 1-3 3

X Total Obs. S Direction (Season: MAM) "C" Stability Speeds 4-6 6

Symbolically the Distribution Factor =

$$\left(\frac{V}{R}\right) \quad \left(\frac{W + X}{T + U}\right) + \left(\frac{W}{R}\right)$$

In our example then: % Frequency South Spd 0-3 "C" $= \left(\frac{8}{3680}\right) \left(\frac{3 + 6}{21 + 142}\right) + \left(\frac{3}{3680}\right) = (.002174)\ (.55215) + (.000815) = .000935$

Percentages for Monthly or Annual tables may be determined in a like manner by substituting the proper values.

TABLE A-1. STABILITY CLASS AS A FUNCTION OF NET RADIATION AND WIND SPEED

WIND SPEED (KNOTS)	NET RADIATION INDEX						
	4	3	2	1	0	-1	-2
0, 1	1	1	2	3	4	6	7
2, 3	1	2	2	3	4	6	7
4, 5	1	2	3	4	4	5	6
6	2	2	3	4	4	5	6
7	2	2	3	4	4	4	5
8, 9	2	3	3	4	4	4	5
10	3	3	4	4	4	4	5
11	3	3	4	4	4	4	4
$\geq$12	3	4	4	4	4	4	4

TABLE A-2. INSOLATION AS A FUNCTION OF SOLAR ALTITUDE

SOLAR ALTITUDE (a)	INSOLATION	INSOLATION CLASS NUMBER
60° <a	Strong	4
35° <a$\leq$ 60°	Moderate	3
15° <a$\leq$ 35°	Slight	2
a$\leq$ 15°	Weak	1

JOB NO.

A STABILITY CLASSIFICATION BASED ON HOURLY AIRPORT OBSERVATIONS

The following explanation of the Pasquill Stability classification has been extracted from an article by D. Bruce Turner in the February 1964 Journal of Applied Meteorology.

This system of classifying stability on an hourly basis for research in air pollution is based upon work accomplished by Dr. F. Pasquill of the British Meteorological Office (1961). Stability near the ground is dependent primarily upon net radiation and wind speed. Without the influence of clouds, insolation (incoming radiation) during the day is dependent upon solar altitude, which is a function of time of day and time of year. When clouds exist their cover and thickness decrease incoming and outgoing radiation. In this system insolation is estimated by solar altitude and modified for existing conditions of total cloud cover and cloud ceiling height. At night estimates of outgoing radiation are made by considering cloud cover. This stability classification system has been made completely objective so that an electronic computer can be used to compute stability classes. The stability classes are as follows: 1) Extremely unstable, 2) Unstable, 3) Slightly unstable, 4) Neutral, 5) Slightly stable, 6) Stable, 7) Extremely stable. Table A-1 gives the stability class as a function of wind speed and net radiation. The net radiation index ranges from 4, highest positive net radiation (directed toward the ground), to -2, highest negative net radiation (directed away from the earth). Instability occurs with high positive net radiation and low wind speed, stability with high negative net radiation and light winds, and neutral conditions with cloudy skies or high wind speeds.

The net radiation index used with wind speed to obtain stability class is determined by the following procedure:

1) If the total cloud cover is 10/10 and the ceiling is less than 7000 feet, use net radiation index equal to 0 (whether day or night).

2) For night-time (night is defined as the period from one hour before sunset to one hour after sunrise):
   a) If total cloud cover $\leq 4/10$, use net radiation index equal to -2.
   b) If total cloud cover $> 4/10$, use net radiation index equal to -1.

3) For daytime:
   a) Determine the insolation class number as a function of solar altitude from Table A-2.
   b) If total cloud cover $\leq 5/10$, use the net radiation index in Table A-1 corresponding to the insolation class number.
   c) If cloud cover $> 5/10$, modify the insolation class number by following these six steps:
      1) Ceiling < 7000 ft, subtract 2.
      2) Ceiling ≥ 7000 ft but $< 16{,}000$ ft, subtract 1.
      3) Total cloud cover equal 10/10, subtract 1. (This will only apply to ceilings ≥ 7000 ft since cases with 10/10 coverage below 7000 ft are considered in item 1 above.)
      4) If insolation class number has not been modified by steps (1), (2), or (3) above, assume modified class number equal to insolation class number.
      5) If modified insolation class number is less than 1, let it equal 1.
      6) Use the net radiation index in Table A-1 corresponding to the modified insolation class number.

Since urban areas do not become as stable in the lower layers as non-urban areas, stability classes 5, 6 and 7 computed using the STAR program may be combined into a single class (5), or classes 6 and 7 may be combined and identified as class 6.

```
THIS TABULATION WAS PREPARED USING THE FOLLOWING HEADER CARD INFORMATION
STATION NUMBER = 2   3081
STATION NAME =  GALLUP, NM    8 OBS    1976-80
LATITUDE =   35.517
LONGITUDE =  108.783
TIME ZONE =    105.0
THIS IS A REGULAR STAR RUN
HEMISPHERE = WESTERN
NUMBER OF STABILITY CLASSES = 6
INPUT = MAGNETIC TAPE DECK FAMILY 14 TAPE =4
OUTPUT = MONTHLY AND ANNUAL INPUT MUST BE SORTED IN  STATION-MONTH SEQUENCE
PERIOD OF RECORD = 7601  8012
NUMBER OF OBSERVATIONS USED = 8 OBSERVATIONS PER DAY BEGINNING WITH HOUR 02
A TAPE CONTAINING INDIVIDUAL STABILITY OBSERVATIONS  WAS NOT REQUESTED
```

ANNUAL FREQUENCY DISTRIBUTION STATION =23081 GALLUP, NM 8 OBS 1976-80

SPEED(KTS)

DIRECTION	1 - 3	4 - 6	7 - 10	11-16	17-21	GREATER THAN 21	AVG SP	TOTAL
N	0	6	0	0	0	0	4.7	6
NNE	0	5	0	0	0	0	4.8	5
NE	0	6	0	0	0	0	4.8	6
ENE	0	2	0	0	0	0	5.0	2
E	0	6	0	0	0	0	4.8	6
ESE	1	7	0	0	0	0	4.5	8
SE	0	4	0	0	0	0	4.7	4
SSE	0	2	0	0	0	0	4.5	2
S	1	5	0	0	0	0	4.7	6
SSW	0	4	0	0	0	0	4.7	4
SW	0	7	0	0	0	0	5.0	7
WSW	0	20	0	0	0	0	4.9	20
W	0	12	0	0	0	0	4.8	12
WNW	0	9	0	0	0	0	4.9	9
NW	0	4	0	0	0	0	5.0	4
NNW	0	5	0	0	0	0	4.8	5
AVG	3.0	4.9	.0	.0	.0	.0	1.8	
TOTAL	2	104	0	0	0	0		

NUMBER OF OCCURRENCES OF A STABILITY = 281

NUMBER OF CALMS WITH A STABILITY = 175

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION = 23081 GALLUP, NM 8 OBS 1976-80

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	.000678	.000411	.000000	.000000	.000000	.000000	.001089
NNE	.000565	.000342	.000000	.000000	.000000	.000000	.000908
NE	.000678	.000411	.000000	.000000	.000000	.000000	.001089
ENE	.000226	.000137	.000000	.000000	.000000	.000000	.000363
E	.000678	.000411	.000000	.000000	.000000	.000000	.001089
ESE	.000973	.000479	.000000	.000000	.000000	.000000	.001453
SE	.000452	.000274	.000000	.000000	.000000	.000000	.000726
SSE	.000226	.000137	.000000	.000000	.000000	.000000	.000363
S	.000747	.000342	.000000	.000000	.000000	.000000	.001089
SSW	.000452	.000274	.000000	.000000	.000000	.000000	.000726
SW	.000792	.000479	.000000	.000000	.000000	.000000	.001271
WSW	.002262	.001370	.000000	.000000	.000000	.000000	.003631
W	.001357	.000822	.000000	.000000	.000000	.000000	.002179
WNW	.001018	.000616	.000000	.000000	.000000	.000000	.001634
NW	.000452	.000274	.000000	.000000	.000000	.000000	.000726
NNW	.000565	.000342	.000000	.000000	.000000	.000000	.000908
TOTAL	.012123	.007123	.000000	.000000	.000000	.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF A STABILITY = .019247

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH A STABILITY = .011986

ANNUAL FREQUENCY DISTRIBUTION STATION =23081 GALLUP, NM 8 OBS 1976-80

SPEED(KTS)

DIRECTION	1 - 3	4 - 6	7 - 10	11-16	17-21	GREATER THAN 21	AVG SP	TOTAL
N	2	31	12	0	0	0	5.7	45
NNE	1	11	8	0	0	0	6.0	20
NE	3	23	11	0	0	0	5.8	37
ENE	1	16	11	0	0	0	5.8	28
E	1	16	11	0	0	0	6.3	28
ESE	0	6	4	0	0	0	6.1	10
SE	1	10	6	0	0	0	5.7	17
SSE	1	11	5	0	0	0	5.7	17
S	0	18	14	0	0	0	6.2	32
SSW	3	13	15	0	0	0	6.2	31
SW	0	22	29	0	0	0	6.7	51
WSW	3	39	36	0	0	0	6.3	78
W	2	44	33	0	0	0	6.2	79
WNW	1	20	18	0	0	0	6.3	39
NW	2	26	12	0	0	0	5.9	40
NNW	2	11	12	0	0	0	6.2	25
AVG	2.8	5.3	7.5	.0	.0	.0	2.8	
TOTAL	23	317	237	0	0	0		

NUMBER OF OCCURRENCES OF B STABILITY = 1260

NUMBER OF CALMS WITH B STABILITY = 683

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION = 23081 GALLUP, NM 8 OBS 1976-80

	SPEED(KTS)						
DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	.004677	.002123	.000822	.000000	.000000	.000000	.007623
NNE	.001720	.000753	.000548	.000000	.000000	.000000	.003021
NE	.003783	.001575	.000753	.000000	.000000	.000000	.006112
ENE	.002408	.001096	.000753	.000000	.000000	.000000	.004257
E	.002408	.001096	.000753	.000000	.000000	.000000	.004257
ESE	.000826	.000411	.000274	.000000	.000000	.000000	.001510
SE	.001582	.000685	.000411	.000000	.000000	.000000	.002678
SSE	.001720	.000753	.000342	.000000	.000000	.000000	.002815
S	.002477	.001233	.000959	.000000	.000000	.000000	.004668
SSW	.002407	.000890	.001027	.000000	.000000	.000000	.004325
SW	.003027	.001507	.001986	.000000	.000000	.000000	.006520
WSW	.005984	.002671	.002466	.000000	.000000	.000000	.011121
W	.006466	.003014	.002260	.000000	.000000	.000000	.011740
WNW	.002958	.001370	.001233	.000000	.000000	.000000	.005561
NW	.003990	.001781	.000822	.000000	.000000	.000000	.006592
NNW	.001926	.000753	.000822	.000000	.000000	.000000	.003501
TOTAL	.048356	.021712	.016233	.000000	.000000	.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF B STABILITY = .086301

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH B STABILITY = .046781

ANNUAL FREQUENCY DISTRIBUTION STATION =23081 GALLUP, NM 8 055 1976-80

	SPEED(KTS)							
DIRECTION	1 - 3	4 - 6	7 - 10	11-16	17-21	GREATER THAN 21	AVG SP	TOTAL
N	0	35	36	3	0	0	7.2	74
NNE	1	31	22	3	0	0	6.9	57
NE	0	46	24	4	1	0	6.8	75
ENE	0	47	55	3	1	0	7.1	106
E	0	21	30	3	0	0	7.3	54
ESE	0	8	8	1	0	0	7.2	17
SE	0	6	11	2	1	0	6.3	20
SSE	0	8	13	1	0	0	7.2	22
S	0	25	40	11	4	0	8.8	80
SSW	0	30	56	25	5	4	9.8	120
SW	1	49	96	60	27	11	11.0	244
WSW	0	79	142	66	36	6	10.4	329
W	1	72	88	46	8	1	8.9	216
WNW	0	39	48	16	3	0	8.3	106
NW	0	19	19	7	1	0	7.9	46
NNW	0	15	14	1	1	0	7.0	31
AVG	2.7	5.1	8.7	13.4	19.1	24.0	7.9	
TOTAL	3	530	702	252	88	22		

NUMBER OF OCCURRENCES OF C STABILITY = 1817

NUMBER OF CALMS WITH C STABILITY = 220

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION = 23081 GALLUP, NM 8 OBS 1976-80

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	.000989	.002397	.002466	.000205	.000000	.000000	.006058
NNE	.000973	.002123	.001507	.000205	.000000	.000000	.004809
NE	.001300	.003151	.001644	.000274	.000068	.000000	.006437
ENE	.001329	.003219	.003767	.000205	.000068	.000000	.008589
E	.000594	.001438	.002055	.000205	.000000	.000000	.004292
ESE	.000226	.000548	.000548	.000068	.000000	.000000	.001391
SE	.000170	.000411	.000753	.000137	.000068	.000000	.001539
SSE	.000226	.000548	.000890	.000068	.000000	.000000	.001733
S	.000707	.001712	.002740	.000753	.000274	.000000	.006186
SSW	.000848	.002055	.003836	.001712	.000342	.000274	.009067
SW	.001482	.003356	.006575	.004110	.001849	.000753	.018126
WSW	.002233	.005411	.009726	.004521	.002466	.000411	.024768
W	.002132	.004932	.006027	.003151	.000548	.000068	.016858
WNW	.001103	.002671	.003288	.001096	.000205	.000000	.008363
NW	.000537	.001301	.001301	.000479	.000068	.000000	.003688
NNW	.000424	.001027	.000959	.000068	.000068	.000000	.002547
TOTAL	.015274	.036301	.048082	.017260	.006027	.001507	

RELATIVE FREQUENCY OF OCCURRENCE OF C STABILITY = .124452

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH C STABILITY = .015068

ANNUAL FREQUENCY DISTRIBUTION STATION =23081 GALLUP, NM 8 OBS 1976-80

	SPEED(KTS)							
DIRECTION	1 - 3	4 - 6	7 - 10	11-16	17-21	GREATER THAN 21	AVG SP	TOTAL
N	0	30	61	50	3	2	10.0	146
NNE	1	19	51	38	3	1	10.1	113
NE	0	30	49	35	1	0	9.1	115
ENE	0	31	86	49	7	1	9.8	174
E	0	24	68	43	10	1	10.2	146
ESE	0	14	21	12	1	1	9.4	49
SE	0	10	22	20	4	1	10.7	57
SSE	0	22	48	45	11	3	11.0	129
S	0	45	148	103	15	5	10.3	316
SSW	1	40	188	160	41	10	11.3	440
SW	1	56	294	429	126	48	12.9	954
WSW	0	60	265	474	189	65	13.7	1053
W	0	37	141	226	65	17	12.7	486
WNW	0	20	50	91	24	3	12.1	188
NW	0	10	36	53	8	2	12.0	109
NNW	0	11	22	18	5	0	10.4	56
AVG	3.0	5.2	8.9	13.5	18.9	24.2	11.4	
TOTAL	3	459	1550	1846	513	160		

NUMBER OF OCCURRENCES OF D STABILITY = 4788

NUMBER OF CALMS WITH D STABILITY = 257

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION = 23081 GALLUP, NM 8 OBS 1976-80

	SPEED(KTS)						
DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	.001143	.002055	.004178	.003425	.000205	.000137	.011143
NNE	.000831	.001301	.003493	.002603	.000205	.000068	.008502
NE	.001143	.002055	.003356	.002397	.000068	.000000	.009020
ENE	.001181	.002123	.005890	.003356	.000479	.000068	.013099
E	.000914	.001644	.004658	.002945	.000685	.000068	.010914
ESE	.000533	.000959	.001438	.000822	.000068	.000068	.003890
SE	.000381	.000685	.001507	.001370	.000274	.000068	.004285
SSE	.000838	.001507	.003288	.003082	.000753	.000205	.009674
S	.001715	.003082	.010137	.007055	.001027	.000342	.023358
SSW	.001631	.002740	.012877	.010959	.002808	.000685	.031699
SW	.002240	.003836	.020137	.029384	.008630	.003288	.067514
WSW	.002286	.004110	.018151	.032466	.012945	.004452	.074409
W	.001410	.002534	.009658	.015479	.004452	.001164	.034697
WNW	.000762	.001370	.003425	.006233	.001644	.000205	.013639
NW	.000381	.000685	.002466	.003630	.000548	.000137	.007847
NNW	.000419	.000753	.001507	.001233	.000342	.000000	.004255
TOTAL	.017808	.031438	.106164	.126438	.035137	.010959	

RELATIVE FREQUENCY OF OCCURRENCE OF D STABILITY = .327945

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH D STABILITY = .017603

ANNUAL FREQUENCY DISTRIBUTION STATION =23081 GALLUP, NM 8 OBS 1976-80

	SPEED(KTS)							
DIRECTION	1 - 3	4 - 6	7 - 10	11-16	17-21	GREATER THAN 21	AVG SP	TOTAL
N	0	15	45	0	0	0	7.8	60
NNE	0	28	35	0	0	0	6.9	63
NE	0	27	30	0	0	0	6.7	57
ENE	0	23	30	0	0	0	7.1	53
E	0	31	26	0	0	0	6.3	57
ESE	0	23	13	0	0	0	6.1	36
SE	0	34	11	0	0	0	5.6	45
SSE	0	28	25	0	0	0	6.6	53
S	0	62	114	0	0	0	7.1	176
SSW	0	44	113	0	0	0	7.5	157
SW	0	50	145	0	0	0	7.8	195
WSW	0	59	112	0	0	0	7.5	171
W	0	28	52	0	0	0	7.5	80
WNW	0	12	30	0	0	0	7.2	42
NW	0	10	16	0	0	0	7.0	26
NNW	0	2	14	0	0	0	8.1	16
AVG	.0	5.1	8.5	.0	.0	.0	7.2	
TOTAL	0	476	811	0	0	0		

NUMBER OF OCCURRENCES OF E STABILITY = 1287

NUMBER OF CALMS WITH E STABILITY = 0

```
         ANNUAL                 RELATIVE FREQUENCY DISTRIBUTION         STATION = 23081 GALLUP, NM     8 OBS     1976-80


                                                  SPEED(KTS)
  DIRECTION       0 - 3         4 - 6        7 - 10        11 - 16       17 - 21    GREATER THAN 21       TOTAL

         N       .000000       .001027       .003082       .000000       .000000       .000000               .004110

       NNE       .000000       .001918       .002397       .000000       .000000       .000000               .004315

        NE       .000000       .001849       .002055       .000000       .000000       .000000               .003904

       ENE       .000000       .001575       .002055       .000000       .000000       .000000               .003630

         E       .000000       .002123       .001781       .000000       .000000       .000000               .003904

       ESE       .000000       .001575       .000890       .000000       .000000       .000000               .002466

        SE       .000000       .002329       .000753       .000000       .000000       .000000               .003082

       SSE       .000000       .001918       .001712       .000000       .000000       .000000               .003630

         S       .000000       .004247       .007808       .000000       .000000       .000000               .012055

       SSW       .000000       .003014       .007740       .000000       .000000       .000000               .010753

        SW       .000000       .003425       .009932       .000000       .000000       .000000               .013356

       WSW       .000000       .004041       .007671       .000000       .000000       .000000               .011712

         W       .000000       .001918       .003562       .000000       .000000       .000000               .005479

       WNW       .000000       .000822       .002055       .000000       .000000       .000000               .002877

        NW       .000000       .000685       .001096       .000000       .000000       .000000               .001781

       NNW       .000000       .000137       .000959       .000000       .000000       .000000               .001096

  TOTAL          .000000       .032603       .055548       .000000       .000000       .000000

  RELATIVE FREQUENCY OF OCCURRENCE OF  E    STABILITY  =  .088151

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH  E  STABILITY  =    .000000
```

ANNUAL FREQUENCY DISTRIBUTION STATION =23081 GALLUP, NM 8 OBS 1976-80

	SPEED(KTS)							
DIRECTION	1 - 3	4 - 6	7 - 10	11-16	17-21	GREATER THAN 21	AVG SP	TOTAL
N	0	52	0	0	0	0	5.1	52
NNE	1	52	0	0	0	0	5.1	53
NE	1	104	0	0	0	0	5.0	105
ENE	1	79	0	0	0	0	5.0	80
E	6	106	0	0	0	0	4.7	112
ESE	3	63	0	0	0	0	4.7	66
SE	3	51	0	0	0	0	5.0	54
SSE	1	67	0	0	0	0	5.1	68
S	9	112	0	0	0	0	5.0	121
SSW	2	63	0	0	0	0	5.1	65
SW	2	83	0	0	0	0	5.0	85
WSW	0	109	0	0	0	0	5.1	109
W	3	57	0	0	0	0	5.0	60
WNW	0	18	0	0	0	0	5.2	18
NW	0	13	0	0	0	0	5.3	13
NNW	0	15	0	0	0	0	4.8	15
AVG	2.9	5.0	.0	.0	.0	.0	1.0	
TOTAL	32	1044	0	0	0	0		

NUMBER OF OCCURRENCES OF F STABILITY = 5167

NUMBER OF CALMS WITH F STABILITY = 4091

ANNUAL   RELATIVE FREQUENCY DISTRIBUTION   STATION = 23081 GALLUP, NM   3 OBS   1976-80

	SPEED(KTS)						
DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	.013542	.003562	.000000	.000000	.000000	.000000	.017103
NNE	.013870	.003562	.000000	.000000	.000000	.000000	.017432
NE	.027412	.007123	.000000	.000000	.000000	.000000	.034535
ENE	.020902	.005411	.000000	.000000	.000000	.000000	.026313
E	.029577	.007260	.000000	.000000	.000000	.000000	.036838
ESE	.017393	.004315	.000000	.000000	.000000	.000000	.021708
SE	.014268	.003493	.000000	.000000	.000000	.000000	.017761
SSE	.017777	.004589	.000000	.000000	.000000	.000000	.022366
S	.032127	.007671	.000000	.000000	.000000	.000000	.039798
SSW	.017064	.004315	.000000	.000000	.000000	.000000	.021379
SW	.022272	.005685	.000000	.000000	.000000	.000000	.027957
WSW	.028385	.007466	.000000	.000000	.000000	.000000	.035851
W	.015830	.003904	.000000	.000000	.000000	.000000	.019734
WNW	.004687	.001233	.000000	.000000	.000000	.000000	.005920
NW	.003385	.000890	.000000	.000000	.000000	.000000	.004276
NNW	.003906	.001027	.000000	.000000	.000000	.000000	.004934
TOTAL	.282397	.071507	.000000	.000000	.000000	.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF F STABILITY = .353904

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH F STABILITY = .280205

ANNUAL FREQUENCY DISTRIBUTION STATION =23081 GALLUP, NM 8 OBS 1976-80

SPEED(KTS)

DIRECTION	1 - 3	4 - 6	7 - 10	11-16	17-21	GREATER THAN 21	AVG SP	TOTAL
N	2	169	154	53	3	2	7.8	383
NNE	4	146	116	41	3	1	7.7	311
NE	4	236	114	39	2	0	6.8	395
ENE	2	198	182	52	8	1	7.7	443
E	7	204	135	46	10	1	7.4	403
ESE	4	121	46	13	1	1	6.5	186
SE	4	115	50	22	5	1	7.2	197
SSE	2	138	91	46	11	3	8.1	291
S	10	267	316	114	19	5	8.3	731
SSW	6	194	372	185	46	14	9.6	817
SW	4	267	564	489	153	59	11.3	1536
WSW	3	366	555	540	225	71	11.5	1760
W	6	250	314	272	73	18	10.2	933
WNW	1	118	146	107	27	3	9.5	402
NW	2	82	83	60	9	2	9.2	238
NNW	2	59	62	19	6	0	8.0	148
AVG	2.9	5.1	8.6	13.5	18.9	24.2	6.0	
TOTAL	63	2930	3300	2098	601	182		

TOTAL NUMBER OF OBSERVATIONS 14600

TOTAL NUMBER OF CALMS 5426

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION = 23081 GALLUP, NM 8 OBS 1976-80

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	.021370	.011575	.010548	.003630	.000205	.000137	.047466
NNE	.018900	.010000	.007945	.002808	.000205	.000068	.039927
NE	.030075	.016164	.007808	.002671	.000137	.000000	.056856
ENE	.024971	.013562	.012466	.003562	.000548	.000068	.055177
E	.026680	.013973	.009247	.003151	.000685	.000068	.053803
ESE	.015795	.008288	.003151	.000890	.000068	.000068	.028261
SE	.015050	.007877	.003425	.001507	.000342	.000068	.028270
SSE	.017521	.009452	.006233	.003151	.000753	.000205	.037315
S	.035080	.018288	.021644	.007808	.001301	.000342	.084464
SSW	.025245	.013288	.025479	.012671	.003151	.000959	.080793
SW	.033924	.018288	.038630	.033493	.010479	.004041	.138856
WSW	.046025	.025068	.038014	.036986	.015411	.004863	.166367
W	.032199	.017123	.021507	.018630	.005000	.001233	.095692
WNW	.014845	.008082	.010000	.007329	.001849	.000205	.042311
NW	.010567	.005616	.005685	.004110	.000616	.000137	.026732
NNW	.007711	.004041	.004247	.001301	.000411	.000000	.017711
TOTAL	.375959	.200685	.226027	.143699	.041164	.012466	

TOTAL RELATIVE FREQUENCY OF OBSERVATIONS = 1.000000

TOTAL RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE = .371644

APPENDIX C

Appendix IX - Analyses and Methodology

LABORATORY

TECH NOTES

Analytical Services

RADIAN CORPORATION

Volume 2, Number 3
May 1989

GCMS TARGET LISTS MADE SIMPLE

To simplify project planning and data review, *Tech Note 3* provides a table of gas chromatographic/mass spectrometric (GC/MS) volatile and semivolatile organic chemicals covered by EPA's major water and waste regulations. Pesticides normally analyzed by gas chromatographic methods have been omitted from the lists.

Be aware that the table of GC/MS target compounds can change as EPA amends its regulations or promulgates new ones. Note, also, that there are two separate TCLP lists – Toxicity and Land ban – for solvent wastes (F001-F005) and those containing dioxins (F020-F023; F026-F028). Stay aware of changes in regulations by referring to appropriate technical or trade journals or to the *Federal Register.*

In addition, call us for an update from time to time – we will be happy to advise you on changes to *Tech Note 3.* And as always, Radian's Marketing Managers and Client Service Coordinators will actively help you identify the best analysis methods and the most appropriate compound lists for your monitoring needs when you schedule work with Radian's Analytical Services Laboratories.

VOLATILE COMPOUNDS*

TEST PARAMETERS BY REGULATIONS

ANALYTE	CWA		RCRA					SUPERFUND
	NPDES[a]	624[b]	APPENDIX IX	8240[c]	SKINNER	TCLP		CLP[d]
						Toxicity	Land ban	
A								
Acetone			✓	✓			✓	✓
Acetonitrile			✓					
Acrolein	✓		✓	✓				
Acrylonitrile	✓		✓	✓		✓		
Allyl chloride			✓					
B								
Benzene.	✓	✓	✓	✓	✓	✓		✓
Bromodichloromethane	✓	✓	✓	✓				✓
Bromoform	✓	✓	✓	✓				✓
Bromomethane	✓	✓	✓	✓[e]				✓
Butyl Alcohol							✓	
C								
Carbon disulfide			✓	✓	✓	✓	✓	✓
Carbon tetrachloride	✓	✓	✓	✓		✓	✓	✓

*This list of compounds, which is a comparison of lists and methods as performed at Radian, is current as of publication date. It should not be used as a substitute for consulting the most recent issue of *40 CFR* or SW846 methods for any changes.

[a] *40 CFR*, Pt. 122, Appendix D

[b] *40 CFR*, Pt. 136, Appendix A

[c] *SW-846, 3rd Edition*

[d] *CLP SOW* 7/88

[e] Listed as methyl bromide

(cont ►)

VOLATILE COMPOUNDS (cont.)

TEST PARAMETERS BY REGULATIONS

ANALYTE	CWA		RCRA					SUPERFUND
	NPDES	624	APPENDIX IX	8240	SKINNER	TCLP		CLP
						Toxicity	Land ban	
Chlorobenzene	✓	✓	✓	✓	✓	✓	✓	✓
Chlorodibromomethane	✓[f]	✓[f]	✓[f]	✓				✓
Chloroethane	✓	✓	✓	✓				✓
2-Chloroethylvinyl ether	✓	✓		✓				
Chloroform	✓	✓	✓	✓	✓	✓		✓
Chloromethane	✓	✓	✓	✓				✓
Chloropropene			✓					
D								
1,2 Dichlorobenzene	✓	✓						
1,3 Dichlorobenzene	✓	✓						
1,4 Dichlorobenzene	✓	✓						
1,2-Dibromo-3-chloropropane			✓					
Dibromomethane			✓[g]	✓				
1,2-Dibromoethane			✓		✓[h]			
1,4-Dichloro-2-butane				✓				
trans-1,4-Dichloro-2-butene			✓	✓				
Dichlorodifluoromethane			✓	✓				
1,1-Dichloroethane	✓	✓	✓	✓				✓
1,2-Dichloroethane	✓	✓	✓	✓	✓	✓		✓
1,1-Dichloroethylene	✓	✓	✓	✓		✓		✓
trans-1,2-dichloroethylene	✓	✓	✓	✓				✓
1,2-Dichloropropane	✓	✓	✓	✓				✓
cis-1,3-Dichloropropene	✓	✓	✓	✓				✓
trans-1,3-Dichloropropene	✓	✓	✓	✓				✓
1,4 Dioxane			✓		✓			
E								
Ethanol				✓				
Ethyl acetate							✓	
Ethyl benzene	✓	✓	✓	✓	✓		✓	✓
Ethyl ether							✓	
Ethyl methacrylate			✓	✓				
H								
2-Hexanone			✓	✓				✓

[f] Listed as dibromochloromethane
[g] Listed as methylene dibromide
[h] Listed as ethylene dibromide
[i] Listed as methyl iodide

(cont ►)

VOLATILE COMPOUNDS (cont.)

TEST PARAMETERS BY REGULATIONS

ANALYTE	CWA		RCRA					SUPERFUND
	NPDES	624	APPENDIX IX	8240	SKINNER	TCLP		CLP
						Toxicity	Land ban	
I								
Iodomethane			✓[i]	✓				
Isobutanol						✓	✓	
M								
Methacrylonitrile			✓					
Methanol							✓	
Methylene chloride	✓	✓	✓	✓		✓	✓	✓
Methyl ethyl ketone			✓[j]	✓	✓	✓	✓	✓
Methyl isobutyl ketone			✓[k]	✓[k]			✓	✓
Methyl methacrylate			✓					
P								
Propionitrile			✓					
S								
Styrene			✓	✓	✓			✓
T								
1,1,1,2-Tetrachloroethane			✓			✓		
1,1,2,2-Tetrachloroethane	✓	✓	✓	✓		✓		✓
Tetrachloroethylene	✓	✓	✓	✓		✓	✓	✓
Toluene	✓	✓	✓	✓	✓	✓	✓	✓
1,1,1-Trichloroethane	✓	✓	✓	✓		✓	✓	✓
1,1,2-Trichloroethane	✓	✓	✓	✓		✓		✓
Trichloroethylene	✓	✓	✓	✓		✓	✓	✓
Trichlorofluoromethane		✓	✓	✓			✓	
1,2,3-Trichloropropane			✓	✓				
1,1,2-Trichloro-2,2,1-trifluoroethane							✓	
V								
Vinyl acetate			✓	✓				✓
Vinyl chloride	✓	✓	✓	✓		✓		✓
X								
Xylenes			✓	✓	✓		✓	✓

[j] Listed as 2-butatone
[k] Listed as 4-methyl-2-pentanone

SEMIVOLATILE COMPOUNDS*

TEST PARAMETERS BY REGULATIONS

	CWA		RCRA					SUPERFUND
ANALYTE	NPDES	625[l]	APPENDIX IX	8270[m]	SKINNER	TCLP		CLP
						Toxicity	Land ban	
A								
Acenaphthene	✓	✓	✓	✓				✓
Acenaphthylene	✓	✓	✓	✓				✓
Acetophenone			✓	✓				
2-Acetylaminofluorene			✓					
4-Aminobiphenyl			✓	✓				
Aniline			✓	✓				
Anthracene	✓	✓	✓	✓	✓			✓
Aramite			✓					
B								
Benzenethiol					✓			
Benzidine	✓			✓				
Benzoic acid				✓				✓
[redacted]	✓	✓	✓	✓	✓			✓
[redacted]	✓	✓	✓	✓	✓			✓
[redacted]	✓	✓	✓	✓	✓			✓
Benzo(g,h,i)perylene	✓	✓	✓	✓				✓
[redacted]	✓	✓	✓	✓	✓			✓
Benzyl alcohol			✓	✓				✓
Bis(2-chloroethoxy)methane	✓	✓	✓	✓				✓
[redacted]	✓	✓	✓	✓		✓		✓
Bis(2-chloroisopropyl)ether	✓[n]	✓		✓[o]				✓
Bis(2-ethylhexyl)phthalate	✓	✓	✓	✓	✓			✓
4-Bromophenyl phenyl ether	✓	✓	✓	✓				✓
Butyl benzyl phthalate	✓[p]	✓	✓	✓	✓			✓
C								
4-Chloroaniline			✓[q]	✓				✓
Chlorobenzilate			✓					
4-Chloro-3-methylphenol	✓[r]	✓	✓[r]	✓				✓
1-Chloronaphthane				✓				
2-Chloronaphthane	✓	✓	✓	✓				✓
2-Chlorophenol	✓	✓	✓	✓				✓
4-Chlorophenyl phenyl ether	✓	✓	✓	✓				✓

*This list of compounds, which is a comparison of lists and methods as performed at Radian, is current as of publication date. It should not be used as a substitute for consulting the most recent issue of *40 CFR* or methods for any changes. Chromatographicable pesticides are excluded from this list.

[l] *40 CFR*, Pt. 136, Appendix A.

[m] *SW-846, 3rd Edition*

[n] Listed as 2,2'-oxybis(1-chloropropane)

[o] Listed as bis(2-chloro-1 methylethyl)ether

[p] Listed as benzyl butyl phthlate

[q] Listed as p-chloraniline

[r] Listed as p-chloro-m-cresol

(cont ►)

SEMIVOLATILE COMPOUNDS (cont.)

TEST PARAMETERS BY REGULATIONS

	CWA		RCRA					SUPERFUND
ANALYTE	NPDES	625	APPENDIX IX	8270	SKINNER	TCLP		CLP[d]
						Toxicity	Land ban	
[redacted]	✓	✓	✓	✓	✓			✓
Cyclohexanone							✓	
D Diallate			✓					
[redacted]					✓			
Dibenzo(a,j)acridine				✓				
[redacted]	✓	✓	✓	✓	✓			✓
Dibenzofurans tetrachloro pentachloro hexachloro			✓	✓			*	✓
1,2-Dibromo-3-chloropropane			✓					
[redacted]	✓	✓	✓	✓	✓			✓
[redacted]	✓	✓	✓	✓	✓	✓	✓	✓
[redacted]	✓	✓	✓	✓	✓			✓
[redacted]	✓	✓	✓	✓	✓	✓		✓
3,3'-Dichlorobenzidine	✓	✓	✓	✓				✓
2,4-Dichlorophenol	✓	✓	✓	✓				✓
2,6-Dichlorophenol			✓	✓				✓
[redacted]	✓	✓	✓	✓	✓			✓
p(Dimethylamino)azobenzene			✓	✓				
[redacted]			✓	✓	✓			
3-3'Dimethylbenzidine			✓					
α,α-Dimethylphenethylamine			✓	✓				
[redacted]	✓	✓	✓	✓	✓			✓
[redacted]	✓	✓	✓	✓	✓			✓
m-Dinitrobenzene			✓					
4,6-Dinitro-2-methylphenol	✓	✓	✓[s]	✓[s]				✓
[redacted]	✓	✓	✓	✓	✓			✓
2,4-Dinitrotoluene	✓	✓	✓	✓		✓		✓
2,6-Dinitrotoluene	✓	✓	✓	✓				✓
[redacted]	✓	✓	✓	✓	✓			✓
Dioxins tetrachlorodibenzo-p- pentachlorodibenzo-p- hexachlorodibenzo-p-							*	
Diphenylamine			✓	✓				
1,2-Diphenylhydrazine	✓			✓				

---

[s] Listed as 4,6-dinitro-o-cresol

* Dioxin Wastes (F020, 021, 022, 023, 026, 027, 028)

(cont ►)

SEMIVOLATILE COMPOUNDS (cont.)

TEST PARAMETERS BY REGULATIONS

ANALYTE	CWA		RCRA					SUPERFUND
	NPDES	625	APPENDIX IX	8270	SKINNER	TCLP		CLP
						Toxicity	Land ban	
E								
Ethyl methanesulfonate			✓	✓				
F								
[redacted]	✓	✓	✓	✓	✓			✓
Fluorene	✓	✓	✓	✓				✓
H								
Hexachlorobenzene	✓	✓	✓	✓		✓		✓
Hexachlorobutadiene	✓	✓	✓	✓		✓		✓
Hexachlorocyclopentadiene	✓		✓	✓				✓
Hexachloroethane	✓	✓	✓	✓		✓		✓
Hexachlorophene			✓					
Hexachloropropene			✓					
2-Hexanone			✓					
I								
[redacted]					✓			
Indeno(1,2,3-cd)pyrene	✓	✓	✓	✓				✓
Isodrin			✓					
Isophorone	✓	✓	✓	✓				✓
Isosafrole			✓					
M								
Methapyrilene			✓					
3-Methylcholanthrene			✓	✓				
[redacted]					✓			
Methyl methanesulfonate			✓	✓				
[redacted]					✓			
2-Methylnaphthalene			✓	✓				✓
[redacted]			✓[t]	✓	✓	✓[t]	✓[t]	✓
[redacted]			✓[t]		✓	✓[t]	✓[t]	
[redacted]			✓[t]	✓	✓	✓[t]	✓[t]	✓
N								
[redacted]	✓	✓	✓	✓	✓			✓
1,4-Naphthoquinone			✓					

[t] Listed as o,m,p cresols
[u] Listed as o,m,p nitroanilines
[v] Listed as o nitrophenol

(cont ►)

SEMIVOLATILE COMPOUNDS (cont.)

TEST PARAMETERS BY REGULATIONS

ANALYTE	CWA		RCRA					SUPERFUND
	NPDES	625	APPENDIX IX	8270	SKINNER	TCLP		CLP
						Toxicity	Land ban	
1-Naphthylamine			✓	✓				
2-Naphthylamine			✓	✓				
2-Nitroaniline			✓[u]	✓				✓
3-Nitroaniline			✓[u]	✓				✓
4-Nitroaniline			✓[u]	✓				✓
Nitrobenzene	✓	✓	✓	✓		✓	✓	✓
5-Nitro-*o*-toluidine			✓					
2-Nitrophenol	✓	✓	✓[v]	✓				✓
[redacted]	✓	✓	✓[w]	✓	✓			✓
4-Nitroquinoline-1-oxide			✓					
N-Nitrosodiethylamine			✓					
N-Nitrosodimethylamine	✓		✓	✓				
N-Nitroso-di-n-butylamine			✓	✓				
N-Nitrosodi-n-propylamine	✓	✓	✓	✓				✓
N-Nitrosopiperidine			✓	✓				
N-Nitrosodiphenylamine	✓		✓	✓				✓
N-Nitrosomethylethylamine			✓					
N-Nitrosomorpholine			✓					
N-Nitrosopyrrolidine			✓					
P								
Pentachlorobenzene			✓	✓				
Pentachloroethane			✓					
Pentachloronitrobenzene			✓	✓				
Pentachlorophenol	✓	✓	✓	✓		✓	*	✓
Phenacetin			✓	✓				
[redacted]	✓	✓	✓	✓	✓			✓
[redacted]	✓	✓	✓	✓	✓	✓		✓
p-Phenylenediamine			✓					
2-Picoline			✓	✓				
Polychlorinated dibenzofurans			✓[x]					
Polychlorinated dioxins			✓[x]					
Pronamide			✓	✓				
[redacted]	✓	✓	✓	✓	✓			✓
[redacted]			✓		✓	✓	✓	
Q								
[redacted]					✓			

[w] Listed as p-nitrophenol

[x] Listed as polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans by Method SW8280, *SW-846, 3rd Edition*

* Dioxin Wastes (F020, 021, 022, 023, 026, 027, 028)

(cont ►)

SEMIVOLATILE COMPOUNDS (cont.)

TEST PARAMETERS BY REGULATIONS

	CWA		RCRA					SUPERFUND
ANALYTE	NPDES[a]	625	APPENDIX IX	8270	SKINNER	TCLP		CLP
						Toxicity	Land ban	
S								
Safrole			✓					
T								
1,2,4,5-Tetrachlorobenzene			✓	✓				
2,3,4,6-Tetrachlorophenol			✓	✓		✓	*	
o-Toluidine			✓					
1,2,4-Trichlorobenzene	✓	✓	✓	✓				✓
2,4,5-Trichlorophenol			✓	✓		✓	*	✓
2,4,6-Trichlorophenol	✓	✓	✓	✓		✓	*	✓
sym-Trinitrobenzene			✓					
0,0,0 Triethylphosphorothlate			✓					

* Dioxin Wastes (F020, 021, 022, 023, 026, 027, 028)

RADIAN
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Research Triangle Park, NC 27709
(919)481-0212

SACRAMENTO
10395 Old Placerville Road
Sacramento, CA 95827
(916)362-5332

A company of The Hartford Steam Boiler Inspection and Insurance Co.

Appendix VIII

Appendix VIII is a list of approximately 375 constituents, some of which cannot be measured. The Appendix IX list contains those analytes in Appendix VIII which can be measured. Additional work can be performed upon request to address Appendix VIII concerns on a project-specific basis. Due to the unique and customized nature of this work, standard prices cannot be established.

Appendix IX

On July 9, 1987, the EPA finalized new groundwater monitoring requirements for TSD facilities. The new requirements specify monitoring for a list of 252 organic, metallic and inorganic analytes contained in Appendix IX of 40 CFR Part 264. Although the regulation is specific for groundwater analyses, the analytes can be determined in other matrices.

Title: Volatile Organics - Appendix IX List
Method 8240

Code: #VOAM-AP9-SW
Units: ug/kg (wet weight)
Matrix: Soil

CAS #	TCL #	Analyte	Reporting Limit
67-64-1	6.	Acetone	5000
75-05-8	*	Acetonitrile	5000
107-02-8	*	Acrolein	5000
107-13-1	*	Acrylonitrile	5000
0107-05-1	*	Allyl Chloride (3-Chloroprene)	1000
71-43-2	23.	Benzene	500
75-27-4	17.	Bromodichloromethane	500
75-25-2	25.	Bromoform	500
74-83-9	2.	Bromomethane	1000
78-93-3	13.	2-Butanone (MEK)	5000
75-15-0	7.	Carbon Disulfide	500
56-23-5	15.	Carbon Tetrachloride	500
108-90-7	31.	Chlorobenzene	500
75-00-3	4.	Chloroethane	1000
67-66-3	11.	Chloroform	500
74-87-3	1.	Chloromethane	1000
0126-99-8	*	Chloroprene (2-chloro-1,3butadiene)	500
124-48-1	21.	Dibromochloromethane	500
96-12-8	*	1,2-Dibromo-3-chloropropane (DBCP)	1000
106-93-4	*	1,2-Dibromoethane (EDB)	1000
74-95-3	*	Dibromomethane	500
110-57-6	*	trans-1,4-Dichloro-2-butene	500
75-71-8	*	Dichlorodifluoromethane (Freon 12)	2000
75-34-3	9.	1,1-Dichloroethane	500
107-06-2	12.	1,2-Dichloroethane	500
75-35-4	8.	1,1-Dichloroethene (-ethylene)	500
540-59-0	10.	1,2-Dichloroethene (total)	500
78-87-5	18.	1,2-Dichloropropane	500
10061-01-5	19.	cis-1,3-Dichloropropene	500
10061-02-6	24.	trans-1,3-Dichloropropene	500
123-91-1	*	1,4-Dioxane	10000
100-41-4	32.	Ethyl Benzene	500
74-88-4	*	Iodomethane	500
078-83-1	*	Isobutanol	5000
591-78-6	27.	2-Hexanone	1000
126-98-7	*	Methylacrylonitrile	500
75-09-2	5.	Methylene Chloride(dichloromethane)	2500
108-10-1	26.	4-Methyl-2-pentanone (MIBK)	1000
107-12-0	*	Propionitrile (ethyl cyanide)	500
100-42-5	33.	Styrene	500

630-20-6	*	1,1,1,2-Tetrachloroethane	500
79-3[illegible]-5	30.	1,1,2,2-Tetrachloroethane	500
127-[illegible]8-4	28.	Tetrachloroethene	500
71-5[illegible]-6	14.	1,1,1-Trichloroethane	500
79-0[illegible]-5	22.	1,1,2-Trichloroethane	500
79-0[illegible]-6	20.	Trichloroethene	500
75-6[illegible]-4	*	Trichlorofluoromethane (Freon 11)	500
96-1[illegible]-4	*	1,2,3-Trichloropropane	500
108-[illegible]8-3	29.	Toluene	500
108-[illegible]5-4	16.	Vinyl Acetate	1000
75-0[illegible]-4	3.	Vinyl Chloride	1000
1330-20-7	34.	Xylenes (total)	500

Surrogates:

460-[illegible]0-4	S2	4-Bromofluorobenzene (BFB)
1706[illegible]-07-0	S3	1,2-Dichloroethane-d4
2037-26-5	S1	Toluene-d8

Title: Chlorinated Pesticides and PCB's - Appendix IX List
Method 8080

Code: #OCPM-AP9-SW
Units: ug/kg (wet weight)
Matrix: Soil

CAS #	TCL #	Analyte	Reporting Limit
309-00-2	105.	Aldrin	60
12674-11-2	120.	Aroclor 1016	600
11104-28-2	121.	Aroclor 1221	600
11141-16-5	122.	Aroclor 1232	600
53469-21-9	123.	Aroclor 1242	600
12672-29-6	124.	Aroclor 1248	600
11097-69-1	125.	Aroclor 1254	1200
11096-82-5	126.	Aroclor 1260	1200
319-84-6	100.	alpha-BHC	60
319-85-7	101.	beta-BHC	60
319-86-8	102.	delta-BHC	60
58-89-9	103.	gamma-BHC (Lindane)	60
5103-71-9	117.	alpha-Chlordane	600
5103-74-2	118.	gamma-Chlordane	600
510-15-6	*	Chlorobenzilate	120
72-54-8	112.	4,4'-DDD	120
72-55-9	109.	4,4'-DDE	120
50-29-3	114.	4,4'-DDT	120
2303-16-4	*	Diallate	120
60-57-1	108.	Dieldrin	120
959-98-8	107.	Endosulfan I	60
33213-65-9	111.	Endosulfan II	120
1031-07-8	113.	Endosulfan Sulfate	120
72-20-8	110.	Endrin	120
7421-93-4	*	Endrin Aldehyde	120
76-44-8	104.	Heptachlor	60
1024-57-3	106.	Heptachlor Epoxide	60
465-73-6	*	Isodrin	120
143-50-0	*	Kepone	120
72-43-5	115.	Methoxychlor	600
8001-35-2	119.	Toxaphene	1200

Surrogate:
1770-80-5 S1 Dibutyl Chlorendate (DBC)

Note: Deviation from TCL list - Endrin ketone is replaced with Endrin aldehyde. The * compounds (except endrin aldehyde) can be analyzed as semivolatiles.

The chlordane isomers are the major components of technical chlordane and are reported instead of total chlordane as listed in Appendix IX. EPA has stated the measurement of alpha- and gamma-chlordane is the more accurate and preferred method of determining chlordane in samples.

Title: Semivolatile Organics - Appendix IX List 11/10/88
Method 8270

Code: #BNAM-AP9-SW
Units: ug/kg (wet weight)
Matrix: Soil

CAS#	TCL	#	Analyte	Reporting Limit
83-32-9	1	69.	Acenaphthene	5000
208-96-8	2	66.	Acenaphthylene	5000
98-86-1	3	*	Acetophenone	5000
53-96-3	4	*	2-Acetylaminofluorene	--
92-67-1	6	*	4-Aminobiphenyl	--
62-53-3	7	*	Aniline	5000
120-12-7	8	84.	Anthracene	5000
140-57-8	9	*	Aramite	--
56-55-3	18	90.	Benzo(a)anthracene	5000
50-32-8	19	96.	Benzo(a)pyrene	5000
205-99-2	20	94.	Benzo(b)fluoranthene (11)	5000
191-24-2	21	99.	Benzo(g,h,i)perylene	5000
207-08-9	22	95.	Benzo(k)fluoranthene (11)	5000
100-51-6	24	40.	Benzyl Alcohol	5000
101-55-3	29	80.	4-Bromophenyl-phenylether	5000
85-68-7	30	88.	Butylbenzylphthalate	5000
88-85-7	31	*	2-sec-Butyl-4,6-dinitrophenol	--
106-47-8	33	56.	4-Chloroaniline	5000
510-15-6	34	*	Chlorobenzilate	--
111-91-1	35	52.	bis(2-Chloroethoxy)methane	5000
111-44-4	36	36.	bis(2-Chloroethyl)ether	5000
108-60-1	37	43.	bis(2-Chloroisopropyl)ether	5000
59-50-7	38	58.	4-Chloro-3-methylphenol	5000
91-58-7	40	63.	2-Chloronaphthalene	5000
95-57-8	41	37.	2-Chlorophenol	5000
7005-72-3	42	75.	4-Chlorophenyl-phenylether	5000
218-01-9	43	*	Chrysene	330
84-74-2	47	85.	Di-n-butylphthalate	5000
117-84-0	48	93.	Di-n-octylphthalate	5000
53-70-3	49	98.	Dibenz(a,h)anthracene	5000
132-64-9	51	72.	Dibenzofuran	5000
95-5[illegible]-1	52	41.	1,2-Dichlorobenzene	5000
541-73-1	53	38.	1,3-Dichlorobenzene	5000
106-46-7	54	39.	1,4-Dichlorobenzene	5000
91-9[illegible]-1	55	89.	3,3'-Dichlorobenzidine	10000
120-83-2	56	53.	2,4-Dichlorophenol	5000
87-65-0	57	*	2,6-Dichlorophenol	5000
84-66-2	59	74.	Diethylphthalate	5000
60-5[illegible]-5	60	*	Dimethoate	--
60-1[illegible]-7	61	*	p-Dimethylaminoazobenzene	5000

CAS#	TCL	#	Analyte	Reporting Limit
57-97-6	62	*	7,12-Dimethylbenz(a)anthracene	5000
119-90-4	63	*	3,3'-Dimethylbenzidine	--
122-09-8	64	*	a,a-Dimethylphenethylamine	5000
105-67-9	65	50.	2,4-Dimethylphenol	5000
131-11-3	66	65.	Dimethylphthalate	5000
99-65-0	67	*	1,3-Dinitrobenzene	--
534-52-1	68	78.	4,6-Dinitro-2-methylphenol	25000
51-28-5	69	70.	2,4-Dinitrophenol	25000
121-14-2	70	73.	2,4-Dinitrotoluene	5000
606-20-2	71	67.	2,6-Dinitrotoluene	5000
122-39-4	72	*	Diphenylamine (2)	5000
298-04-4	74	*	Disulfton	--
117-81-7	81	92.	bis(2-Ethylhexyl)phthalate	5000
97-63-2	82	*	Ethyl methacrylate	--
62-50-0	83	*	Ethyl methanesulfonate	5000
52-85-7	84	*	Famphur	--
206-44-0	85	86.	Fluoranthene	5000
86-73-7	86	76.	Fluorene	5000
118-74-1	89	81.	Hexachlorobenzene	5000
87-68-3	90	57.	Hexachlorobutadiene	5000
77-47-4	91	60.	Hexachlorocyclopentadiene	5000
67-72-1	92	46.	Hexachloroethane	5000
70-30-4	93	*	Hexachlorophene	--
1888-71-7	94	*	Hexachloropropene	
193-39-5	95	97.	Indeno(1,2,3-c,d)pyrene	5000
78-59-1	96	48.	Isophorone	5000
120-58-1	97	*	Isosaphrole	--
91-80-5	98	*	Methapyrilene	--
56-49-5	100	*	3-Methylcholanthrene	5000
66-27-3	102	*	Methyl methanesulfonate	5000
80-62-6	104	*	Methylmethacrylate	--
91-57-6	105	59.	2-Methylnaphthalene	5000
298-00-0	106	*	Methylparathion	--
95-48-7	107	42.	2-Methylphenol	5000
108-39-4	108	*	3-Methylphenol (14)	--
106-44-5	109	44.	4-Methylphenol (14)	5000
91-20-3	110	55.	Naphthalene	5000
130-15-4	111	*	1,4-Naphthoquinone	--
134-32-7	112	*	1-Naphthylamine	5000
91-59-8	113	*	2-Naphthylamine	5000

DRAFT

CAS#	TCL	#	Analyte	Reporting Limit
88-74-4	114	64.	2-Nitroaniline	25000
99-09-2	115	68.	3-Nitroaniline	25000
100-01-6	116	77.	4-Nitroaniline	25000
98-95-3	117	47.	Nitrobenzene	5000
88-75-5	118	49.	2-Nitrophenol	5000
100-02-7	119	71.	4-Nitrophenol	25000
56-57-5	120	*	4-Nitroquinoline-1-oxide	--
924-92-2	121	*	N-Nitroso-di-n-butylamine	5000
55-18-5	122	*	N-Nitrosodiethylamine	--
62-75-9	123	*	N-Nitrosodimethylamine (4)	5000
86-30-6	124	79.	N-Nitrosodiphenylamine	5000
621-64-7	125	45.	N-Nitroso-di-n-propylamine	5000
10595-95-6	126	*	N-Nitrosomethylethylamine	--
59-89-2	127	*	N-Nitrosomorpholine	--
100-75-4	128	*	N-Nitrosopiperidine	5000
930-55-2	129	*	N-Nitrosopyrrolidine	--
9-55-8	130	*	5-Nitro-o-toluidine	--
56-38-2	131	*	Parathion	--
76-01-7	133	*	Pentachloroethane	--
82-68-8	134	*	Pentachloronitrobenzene	25000
87-86-5	135	82.	Pentachlorophenol	25000
62-44-2	136	*	Phenacetin	5000
85-01-8	137	83.	Phenanthrene	5000
108-95-2	138	35.	Phenol	5000
106-50-3	139	*	4-Phenylenediamine	--
298-02-2	140	*	Phorate	--
109-06-8	141	*	2-Picoline	5000
23950-58-5	142	*	Pronamide	5000
129-00-0	143	87.	Pyrene	5000
110-86-1	144	*	Pyridine	10000
94-59-7	145	*	Safrole	--
3689-24-5	146	*	Sulfotepp	--
95-94-3	147	*	1,2,4,5-Tetrachlorobenzene	5000
58-90-2	148	*	2,3,4,6-Tetrachlorophenol	25000
95-53-4	149	*	2-Toluidine	--
120-82-1	151	54.	1,2,4-Trichlorobenzene	5000
95-95-4	152	62.	2,4,5-Trichlorophenol	25000
88-06-2	153	61.	2,4,6-Trichlorophenol	5000
126-68-1	154	*	o,o,o-Triethyl phosphorothioate	--
99-35-4	155	*	1,3,5-Trinitrobenzene	--

TABLE III-7 – RECOMMENDED CONTAINERS AND PRESERVATIVES

Techniques and Holding Times for RMAL's Proposed Quantitative Analytical Screen (QAS)

Sample Container	Preservation	Minimum Sample Size	Methods/ Parameters	Recommended Holding Time
A. Ground Water Samples				
2 x 40 ml glass (VOA)[1]	4°C	40 ml ea.	8240	14 days
6 x 1 liter glass	4°C	1000 ml ea.	8080,8140,8150, 8270,8320,8330	7 days until extraction 40 days after extraction
Polyethylene	2 ml 50% HNO_3 to pH< 2	500 ml	Metals Mercury	6 months 28 days
Plastic	2 ml 50% NaOH to pH>12, 4°C	500 ml	Cyanide	14 days
Plastic	1 ml in ZnAcetate 1 ml 50% NaOH to pH> 9, 4°C	250 ml	Sulfide	7 days
Plastic	4°C	100 ml	Hexavalent chromium	24 hours
B. Waste Samples				
1 liter wide-mouth glass		500 g	Organics except volatiles; metals; inorganics	nd[2]
40 ml glass vial[1]		40 ml	8240	nd

Notes:

1. Duplicate samples are desirable.
2. nd = Insufficient data to determine.

TABLE 2
APPENDIX VIII COMPOUNDS DETERMINED BY METHODS 6010, 7041, 7061, 7421, 7470, 7740, 7841, 9010, 9030, and 340.2**

6010

Aluminum
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Nickel
Osmium
Potassium
Silver
Sodium
Strontium
Tin
Vanadium
Zinc

7041

Antimony

7061

Arsenic

7470

Mercury

7740

Selenium

7841

Thallium

9010

Cyanide

9030

Sulfide

[redacted]

[redacted]

**40 CFR 136; no method exists in SW-846.

APPENDIX VIII MASS SPECTRA LIBRARY

1-Aceyl-2-thiourea
5-(Aminomethyl)-3-isoxazolol
Amitrole
Auramine
Benz(c)acridine
Benzene, Dichloromethyl
Benzo(j)fluoroanthene
p-Benzoquinone
Benzotrichloride
Benzyl chloride
3-Chloropropionitrile
2-Cyclohexyl-4,6-dinitrophenol
Dibenz(a,h)acridine
Dibenzo(a,j)acridine
7H-Dibenzo(c,g)carbazole
Dibenzo(a,e)pyrene
Dibenzo(a,h)pyrene
Dibenzo(a,i)pyrene
3,3'-Dimethoxybenzidine
1,2-Dinitrobenzene
1,4-Dinitrobenzene
Ethyl carbamate
Ethylenethiourea
Malanonitrile
Methomyl
Methylcholanthrene
4,4'-Methylenebis(2-chloroaniline)
2-Methyl-2-(methylthio) propionaldehyde
Methylthiouracil
1-Naphthyl-2-thiourea
Nicotine
N-nitrosodiethanolamine
N-nitroso-n-ethylurea
N-nitroso-n-methylurea
N-nitroso-n-methylurethane
N-nitrosomethylvinylamine
N-nitrosonornicotine
N-nitrososarcosine
1,3-Propane sulfone
N-propylamine
Resorcinol
Saccharin
2,4-Toluene diamine
2,3-Toluene diamine
2,6-Toluene diamine
3,4-Toluene diamine
Trichloromethanethiol
Tris(1-azridinyl)phosphine sulfide
Tris-(2,3 DBP)phosphate
Warfarin
Allyl alcohol
N,N-bis(2-chloroethyl)-2-naphthylamine
Brucine
2-Butanone peroxide
Dihydrosafrole
1,1-Dimethylhydrazine
1,2-Dimethylhydrazine
Dimethyl sulfate
2,4-Dithiobiuret
Ethleneimine
Ethlene bis dithiocarbamic acid
Formic acid
Hydrazine
Isosafrole
Maleic anhydride
Maleic hydrazine
2-Methylaziridine
2-Methyllactonitrile
Phthalic anhydride
Propylthiouracil
2-Propyn-1-ol
Safrole
Uracil mustard

Dave about values & IDL:

INDUSTRIAL INORGANIC CHEMISTRY

METALS DEPARTMENT

ICP INSTRUMENT DETECTION LIMITS NOVEMBER 1989

ELEMENT	IDL* - changes (mg/L)	ENSECO REPORTING LIMIT	ILL* (mg/L)
Aluminum	0.03	0.1	500
Antimony	0.02	0.05	100
Barium	0.002	0.01	100
Beryllium	0.002	0.002	40
Cadmium	0.004	0.005	100
Calcium	0.02	0.1	500
Chromium	0.01	0.01	100
Cobalt	0.005	0.01	100
Copper	0.004	0.01	100
Iron	0.001	0.1	500
Lead	0.008	0.05	100
Magnesium	0.009	0.2	500
Manganese	0.006	0.01	100
Molybdenum	0.003	0.02	100
Nickel	0.008	0.04	100
Potassium	0.06	5	500
Silver	0.002	0.01	100
Sodium	0.01	5	800
Vanadium	0.003	0.01	100
Zinc	0.001	0.01	100

Additional analytes and levels available

Arsenic	0.02	0.1	100
Boron	0.001	0.02	100
Lithium	0.008	0.05	500
Phosphorus	0.05	0.2	400
Selenium	0.05	0.2	100
Silica as SiO2	0.04	0.2	500
Strontium	0.02	0.05	100
Thallium	0.4	2	100
Tin	0.05	0.05	100
Titanium	0.001	0.005	100

* IDL = Instrument Detection Limit
ILL = Instrument Linear Limit

INDUSTRIAL INORGANIC CHEMISTRY

METALS DEPARTMENT

GRAPHITE FURNACE AND COLD VAPOR AA

INSTRUMENT DETECTION LIMITS NOVEMBER 1989

GFAA

ELEMENT	IDL* (mg/L)	ENSECO REPORTING LIMIT	ILL* (mg/L)
Antimony	0.002	0.01	0.1
Arsenic	0.001	0.005	0.1
Cadmium	0.0001	0.0005	0.005
Chromium	0.0006	0.001	0.1
Lead	0.0002	0.005	0.1
Selenium	0.001	0.005	0.1
Silver	0.0001	0.0005	0.005
Thallium	0.002	0.005	0.1

CVAA

Mercury	0.0001	0.0002	0.002

Arsenic and selenium are analyzed using Zeeman background correction. An Iron lamp is used for background correction in the mercury determination. All other elements are determined using Deuterium arc background correction.

* IDL = Instrument Detection Limit
ILL = Instrument linear Limit

APPENDIX D

Laboratory QA/QC Program

Enseco

ENSECO INCORPORATED QUALITY ASSURANCE PROGRAM PLAN FOR ENVIRONMENTAL CHEMICAL MONITORING

Prepared by:

Enseco Incorporated
2200 Cottontail Lane
Somerset, NJ 08873

Revision 3.3
May, 1989

Approval:

Kathleen Carlberg

Kathleen Carlberg
Vice President
Quality Assurance

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1. INTRODUCTION

Enseco Incorporated (Enseco) is the largest and most experienced environmental testing laboratory in the United States. The environmental component of Enseco consists of the combined resources of:

- Enseco-Erco Laboratory in Cambridge, Massachusetts,
- Enseco-Marblehead in Marblehead, Massachusetts,
- Enseco-East in Somerset, New Jersey,
- Enseco-Rocky Mountain Analytical Laboratory in Denver, Colorado,
- Enseco-Houston in Houston, Texas,
- Enseco-California Analytical Laboratory in Sacramento, California,
- Enseco-CRL in Garden Grove, California,
- Enseco-El Monte in El Monte, California,
- Enseco-Santa Maria in Santa Maria, California,
- Enseco-Ventura in Ventura, California, and
- Enseco-Mobile Laboratories headquartered in Garden Grove, California.

Addresses and telephone numbers for these Enseco laboratories are listed in Table 1-1.

This document describes the Enseco Quality Assurance policies and procedures related to chemical monitoring for environmental pollutants.

TABLE 1-1

ENSECO LABORATORY LOCATIONS

Enseco-California Analytical Laboratory
2544 Industrial Boulevard
West Sacramento, CA 95691
(916) 372-1393
Facsimile (916) 372-1059

Enseco-CRL
7440 Lincoln Way
Garden Grove, CA 92641
(714) 898-6370
Facsimile (714) 891-5917

Enseco-East
2200 Cottontail Lane
Somerset, NJ 08873
(201) 469-5800
Facsimile (201) 469-7516

Enseco-El Monte
9537 Telstar Avenue #118
El Monte, CA 91731
(818) 442-8400
Facsimile (818) 442-3758

Enseco-Erco Laboratory
205 Alewife Brook Parkway
Cambridge, MA 02138
(617) 661-3111
Facsimile (617) 354-5258

Enseco-Houston
1420 East North Belt Suite 120
Houston, TX 77032
(713) 987-9767
Facsimile (713) 987-9769

Enseco-Marblehead
Doaks Lane at Little Harbor
Marblehead, Massachusetts 01945
(617) 639-2695
Facsimile (617) 639-2637

Enseco-Mobile Laboratories
7440 Lincoln Way
Garden Grove, CA 92641
(714) 898-6370
Facsimile (714) 891-5917

Enseco-Rocky Mountain Analytical Laboratory
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611
Facsimile (303) 431-7171

Enseco-Santa Maria
2325 Skyway Drive, Suite K
Santa Maria, CA 93455
(805) 922-2776
Facsimile (805) 922-5897

Enseco-Ventura
2810 Bunsen Avenue, Unit A
Ventura, CA 93003
(805) 650-0546
Facsimile (805) 650-0756

Enseco, Inc. (Corporate Office)
2200 Cottontail Lane
Somerset, NJ 08873
(201) 469-5800
Facsimile (201) 469-7516

2. QUALITY ASSURANCE POLICY

Enseco is committed to providing quality environmental analytical services to both the public and private sectors. To ensure the production of scientifically sound, legally defensible data of known and documentable quality, an extensive Quality Assurance (QA) program has been implemented within Enseco. This program relies on clearly defined objectives, well-documented procedures, a comprehensive audit system, and management support, both Corporate and Divisional, for its effectiveness.

3. PURPOSE AND SCOPE OF DOCUMENT

Purpose

This QA Program Plan presents an overview of the essential elements of the Enseco QA program. Enseco has modeled this plan along EPA guidelines as outlined in "Interim Guidelines and Specifications for Preparing Quality Assurance Program Plans," QAMS-004/80, December 29, 1980 and "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," QAMS-005/80, February, 1983. Both of these documents have been issued by the Office of Monitoring Systems and Quality Assurance, Office of Research and Development, U.S. Environmental Protection Agency (U.S. EPA). Elements above and beyond those specified in these two documents have been included in this QA Program Plan in order to completely describe the Enseco QA/QC system.

Scope

The Enseco QA program is designed to control and monitor the quality of data generated in Enseco laboratories. The program has four key elements.

- Demonstrating laboratory capability by providing information which documents the overall qualifications of the laboratory to perform environmental analyses;
- Controlling laboratory operations by establishing procedures which measure the laboratory's performance on a daily basis;
- Measuring matrix effects to determine the effect of a specific matrix on method performance, and
- Reporting appropriate QC information with the analytical results to enable the end-user to assess the quality of the data.

The specific procedures involved in implementing each aspect of the Enseco program are described in this document. An overview of these QC procedures, along with the section number in which each is discussed, is given in Table 3-1.

The QA/QC policies and procedures described herein are designed to eliminate systematic errors and minimize the occurrence of other errors. However, no QA program, regardless of how elaborate, can eliminate all errors which may occur during an analysis. The QA program forms the framework for minimizing errors and identifying and correcting those errors which do occasionally occur. These QA/QC policies and procedures must be coupled with the professional judgement of the technical staff in interpreting the events surrounding the generation of the final result to ensure that quality data is consistently produced.

Table 3-1

ELEMENTS OF QA PROGRAM PLAN

Evaluation Criteria	Operational Elements	Section of QA Plan
LABORATORY QUALIFICATIONS	Facilities/equipment/staff	*
	Written SOPs for all laboratory procedures, including:	15
	Sample custody	5
	Calibration procedures	6
	Analytical procedures	7
	Data validation	8
	Documented QA program	1-15
	Laboratory certifications	10
LABORATORY PERFORMANCE	Check samples	9
	Method blanks	9
	Calibration data	6
	Method detection limits (determined on method blank)	12
MATRIX EFFECTS	Matrix spike/matrix duplicate/ matrix spike duplicate analyses	9
	Sample surrogate recoveries	9
	Standard additions	9
	Field blanks	9
	Method detection limits (determined with specific sample matrix)	12
DATA REPORTING	Data reduction and validation	10
	Data reporting	10
	Reporting Limits	12

* Described in a separate document available from Enseco.

4. DEFINITION OF TERMS

Quality Assurance (QA): the total integrated program for assuring the reliability of data generated in the laboratory.

Quality Control (QC): the routine application of specific, well-documented procedures to ensure the generation of data of known and accepted quality, thus fulfilling the objectives of the QA program.

Quality Assurance Program Plan (QAPP): an assemblage of management policies, objectives, principles, and general procedures outlining the techniques by which the laboratory produces data of known and accepted quality.

Standard Operating Procedure (SOP): a detailed, written description of a procedure designed to systematize and standardize the performance of the procedure.

Quality Assurance Project Plan (QAPjP): an assemblage of detailed procedures describing how the laboratory will generate data that meet the Data Quality Objective (DQOs) of a specific project.

Holding Time: the period of time during which a sample can be stored after collection and preservation without significantly affecting the accuracy of the analysis.

Sample Delivery Acceptance: the point in time at which Enseco determines that it can proceed with the analytical work. Sample delivery acceptance follows receipt and inspection of the samples and complete definition of analyses required.

Initiate Preparation: the point in time at which the separation of organic extractable compounds or metals from the sample matrix by solvent extraction or acid digestion is begun.

Initiate Analysis: the point in time at which the sample, extract or digestate is introduced into an instrument or process which complies with the SOP for analysis of the parameter of interest.

5. RESPONSIBILITIES AND AUTHORITIES

Executing an effective QA program in a large and complex multi-laboratory system demands the commitment and attention of both management and staff. The QA effort at Enseco is directed by the Vice President of Quality Assurance who manages the Corporate Quality Assurance Office. The VP of QA reports directly to the Chief Executive Officer (CEO) and has the responsibility for overseeing and regulating all laboratory functions (see Figure 5-1). The QA Office operates independently of all areas generating analytical data to ensure complete objectivity in the evaluation of laboratory operations.

The implementation of the QA program within each individual Enseco laboratory is the responsibility of the Division QA Director. The QA Director reports to both the VP of QA and to the Division Director, who manages the laboratory. In addition, all scientists within the organization play a vital role in assuring the quality of their work. We believe that the success of Enseco is dependent upon the continued commitment of all within the organization to a strong and viable QA Program. The responsibilities and levels of authority within the organization are described below.

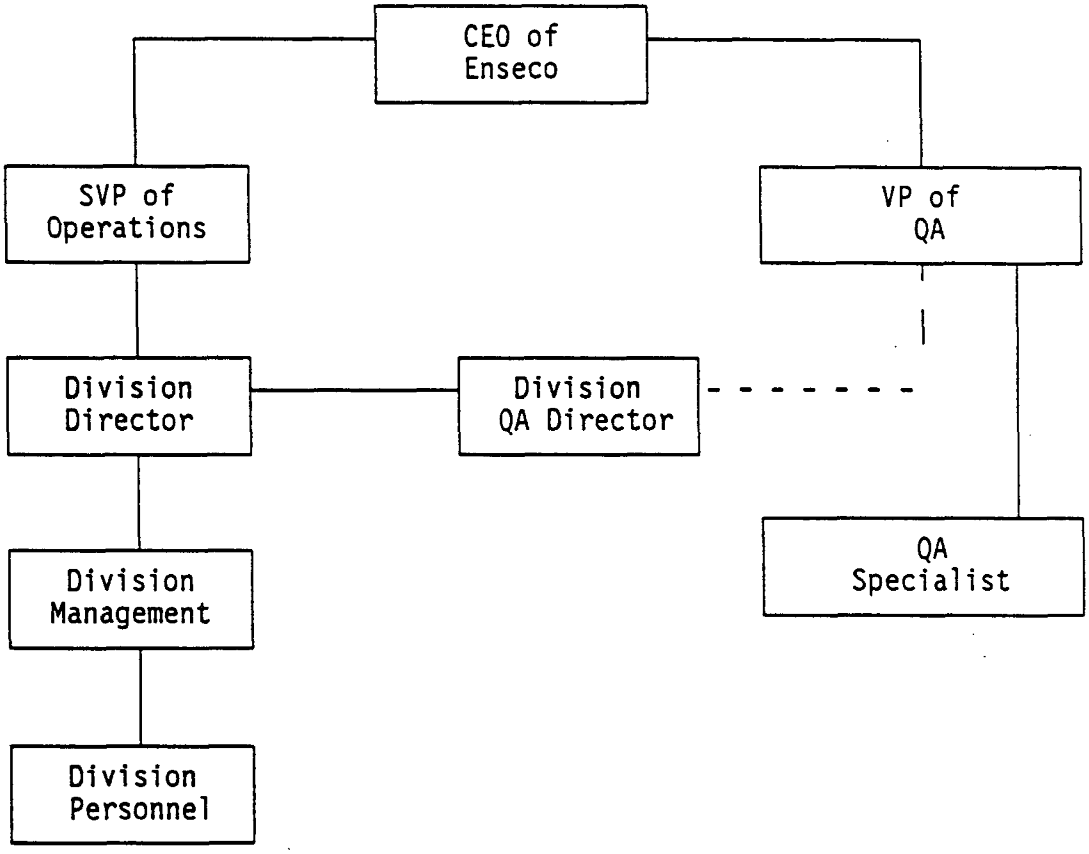
Corporate Quality Assurance Office

Members

The QA effort within Enseco is directed by the VP of QA who reports directly to the CEO of Enseco. The Corporate QA Office also includes a QA specialist who assists the VP in carrying out the responsibilities of the department.

Figure 5-1

ENSECO QA ORGANIZATIONAL CHART



Responsibilities

The VP of QA is responsible for:

- Developing and implementing a Corporate QA program that ensures that all data generated in Enseco laboratories are scientifically sound, legally defensible, and of known precision and accuracy;
- Monitoring the QA Plan to ensure compliance with QA objectives in all Enseco laboratories;
- Developing and implementing new QA procedures within the corporation to improve data quality;
- Conducting audits and inspections of all Enseco laboratories on a regular basis, reporting the results of those audits to management, and applying corrective actions as needed to ensure compliance with the Enseco QA Plan;
- Coordinating the distribution of Performance Evaluation (PE) samples to all Enseco laboratories on a routine basis, evaluating the results of those samples, reporting to management, and applying corrective actions as needed to ensure that all Enseco laboratories are able to generate data that meet the data quality objectives defined in the QA Plan;
- Establishing databases that accurately reflect the performance of each of the Enseco laboratories;
- Directing Division QA Directors in the implementation of the Enseco QA Plan within individual facilities;
- Chairing the Enseco QA Committee, a working committee which includes all of the Division QA Directors and QA Specialists and deals with QA issues on an ongoing basis;
- Coordinating certification programs within Enseco;
- Conducting seminars on QA issues for both clients and laboratory staff; and
- Promoting sound QA practices within the environmental regulatory and analytical communities.

Authority

The VP of QA is the final authority on all issues dealing with data quality and has the authority to require that procedures be amended or discontinued, or analyses suspended or repeated. Also, the VP of QA has the authority to suspend or terminate employees on the grounds of dishonesty, incompetence, or repeated non-compliance with QA procedures. In addition, the VP of QA has the authority to overrule decisions and actions of the Division QA Directors and must approve the termination or transfer of any Division QA Director. The authority of the VP of QA comes directly from the CEO of Enseco.

Divisional Quality Assurance Departments

Members

Each Divisional QA Department is managed by a QA Director. The QA Director reports directly to the Division Director and indirectly to the Corporate VP of QA. The QA Director is supported by a QA staff within the laboratory.

Responsibilities

The Division QA Director is responsible for:

- Implementing Enseco QA policies;
- Monitoring the implementation of the QA Plan within the laboratory to ensure complete compliance with QA objectives;
- Conducting in-house audits to identify potential problems and ensure compliance with written SOPs;
- Performing statistical analyses of QC data and establishing databases that accurately reflect the performance of the laboratory;

- Prescribing and monitoring corrective actions;
- Serving as the in-house client representative on all project inquiries involving data quality issues;
- Monitoring the preparation and verification of analytical standards;
- Assisting chemists in the writing of SOPs;
- Reporting the status of the laboratory QA program to the Corporate VP of QA with formal and informal communications;
- Maintaining records and archives of all QC data, PE results, audit comments, and customer inquiries concerning data quality;
- Assuring that the laboratory staff has access to current SOPs;
- Monitoring laboratory performance in the areas of holding times, turn-around times, and meeting contractual obligations;
- Conducting seminars on QA issues for clients and laboratory staff;
- Preparing QA Project Plans when needed;
- Assisting the Corporate QA office in the writing of QA policies and procedures;
- Serving as a member of the Enseco QA Committee; and
- Auditing subcontractors.

Authority

The Division QA Director is the final authority within each laboratory on all issues dealing with data quality. He/she has the authority to require that procedures be amended or discontinued or analyses suspended or repeated. He/she can make recommendations to the Division Director and the Corporate VP of QA regarding suspension or termination of employees for incompetence or non-compliance with QA procedures. The authority of the Division QA Director comes directly from the Corporate VP of QA.

Divisional Management

Members

The managers and supervisors who direct the analytical work at each laboratory are directly responsible for ensuring that all employees reporting to them are complying with the Enseco QA Plan.

Responsibilities

Laboratory management is responsible for:

- Actively supporting the implementation of the Enseco QA Plan within the laboratory;
- Maintaining accurate SOPs and enforcing their use in the laboratory;
- Maintaining a work environment that emphasizes the importance of data quality; and
- Providing management support to the Corporate and Divisional QA departments.

Authority

The managers and supervisors of the laboratory have the authority to accept or reject databased on compliance with well-defined QC criteria. In addition, managers and supervisors, with the approval of the QA department, can accept or reject data that fall outside of established QC guidelines if, in their judgment, there are technical reasons which warrant the acceptance or rejection of the data. These circumstances must be well documented and any need for corrective action identified by the incident must be defined and initiated. The authority of the laboratory management comes directly from the Corporate VP of Operations and the Division Director.

Divisional Personnel

Members

All laboratory personnel involved in the generation and reporting of data have a responsibility to understand and follow the Enseco QA Plan.

Responsibilities

Laboratory personnel are responsible for:

- Having a working knowledge of the Enseco QA Plan;
- Ensuring that all work is generated in compliance with the Enseco QA Plan;
- Performing all work according to written SOPs;
- Ensuring that all documentation related to their work is complete and accurate; and
- Providing management with immediate notification of quality problems.

Authority

Laboratory personnel have the authority to accept or reject databased on compliance with well-defined QC criteria. The acceptance or rejection of data that fall outside of established QC guidelines must be approved by laboratory management and the QA department. The authority of the laboratory personnel flows from the Division Director.

6. SAMPLING PROCEDURES

The generation of quality data begins with the collection of the sample, and therefore the integrity of the sample collection process is of concern to the laboratory. Samples must be collected in such a way that no foreign material is introduced into the sample and no material of interest escapes from the sample prior to analysis. To ensure sample integrity, the following must be considered:

- Samples must be collected in appropriate containers. In general, glass containers are used for organic parameters and polyethylene containers for inorganic/metal parameters (see Appendix I);
- The sample containers must be properly cleaned to ensure that the sample is not contaminated during the collection process;
- Samples must be preserved appropriately to minimize the loss of materials of interest due to adsorption, chemical or biological degradation, or volatilization (see Appendix I);
- Appropriate volumes of sample must be collected to ensure that the required detection limits can be met and quality control samples can be analyzed (see Appendix I); and
- Samples must be properly shipped to the laboratory, in the appropriate time frame, to ensure that holding times for the analyses can be met (see Appendix I).

Sample Containers and Preservatives

Enseco can assist in the sample collection process by providing consultation and assistance to clients designing sampling programs. Also Enseco can make available to the client the Enseco "Sample Safe^{TM}," a set of sample containers that are properly cleaned and preserved for use in sample collection. Appropriate containers and preservatives, and minimum sample volumes required for analyzing routine organic, metal, and conventional parameters are listed in Appendix I.

Holding Times

EPA has established holding time requirements for some analyses. These holding time requirements are listed in Appendix I, along with container and preservative requirements. As indicated in Appendix I, holding time requirements differ depending on the regulatory program. Enseco follows the holding times given in SW-846, Update I unless otherwise instructed by the client. CLP holding times are followed when CLP protocols are requested by the client. Other holding times can be honored if special arrangements are made with the laboratory.

Enseco is obligated to initiate preparation and/or analysis of the sample within holding times if sample delivery acceptance occurs within 72 hours of sampling or before one-half of the holding time period has expired, whichever is less. (See Section 4 for definition of above terms.)

On occasion, a sample must be reanalyzed to comply with this QA Program Plan. If this reanalysis is conducted outside of the holding time, the laboratory will be considered to have fulfilled its obligation to meet holding times if the first preparation and/or analysis was initiated within the prescribed holding time.

7. SAMPLE CUSTODY

Upon receipt by Enseco, samples proceed through an orderly processing sequence specifically designed to ensure continuous integrity of both the sample and its documentation.

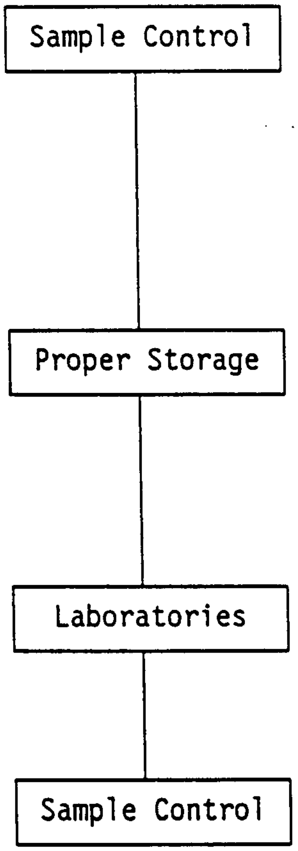
All samples are received by Enseco's Sample Control Group and are carefully checked for label identification, and completed, accurate chain-of-custody records. Photographs document the condition of samples and each sample is then assigned a unique laboratory identification number through a computerized Laboratory Information Management System (LIMS) that stores all identifications and essential information. The LIMS system tracks the sample from storage through the laboratory system until the analytical process is completed and the sample is returned to the custody of the Sample Control Group for disposal. This process is summarized in Figure 7-1. Access to all Enseco laboratories is restricted to prevent any unauthorized contact with samples, extracts, or documentation.

An example of the Enseco Chain-Of-Custody Record used to transmit samples from the client to the laboratory is given in Figure 7-2. The Chain-Of-Custody Record (Interlaboratory Analysis Form) used to transmit samples between laboratories within Enseco is given in Figure 7-3.

Sample bottles provided to the client by Enseco are transmitted under custody using the Enseco "Sample Safe^{TM}".

Figure 7-1

ENSECO SAMPLE PROCESSING FLOW CHART



* Check and document physical condition of sample
* Verify documentation and parameter assignment
* Log into LIMS
* Send acknowledgement letter to client

* Store sample according to preservation guidelines
* Transfer sample to lab with proper documentation

* Document analytical work
* Return unused samples to Sample Control

* Return sample to client or arrange for sample disposal

FIGURE 7-2

Enseco - Rocky Mountain Analytical
4955 Yarrow Street
Arvada, Colorado 80002
303/421-6611 Facsimile: 303/431-7171

CHAIN OF CUSTODY

No. 5068

Attn: ____________________

Enseco Client ____________________

Project ____________________

Sampling Co. ____________________

Sampling Site ____________________

Team Leader ____________________

SAMPLE SAFE™ CONDITIONS

1. *Packed by:* ____________________ Seal # __________
2. Seal Intact Upon Receipt by Sampling Co.: Yes No
3. Condition of Contents: ____________________
4. Sealed for Shipping by: ____________________
5. Initial Contents Temp.: __________ °C Seal # __________
6. *Sampling Status:* *Done* *Continuing Until* __________
7. Seal Intact Upon Receipt by Laboratory: Yes No
8. Contents Temperature Upon Receipt by Lab: __________ °C
9. Condition of Contents: ____________________

Date	Time	*Sample ID/Description*	Sample Type	No. Containers	Analysis Parameters	Remarks

CUSTODY TRANSFERS PRIOR TO SHIPPING

Relinquished by: (signed)	Received by (signed)	Date	Time
1			
2			
3			

SHIPPING DETAILS

Delivered to Shipper by ____________________

Method of Shipment __________ Airbill # __________

Received for Lab __________ Signed __________ Date/Time __________

Enseco Project No ____________________

White and Pink Copies to Lab Yellow to Sampler

SS 001

FIGURE 7-3

Page ________ of ________
File Index ____________

Enseco

INTERLABORATORY ANALYSIS

SHIP TO: *(circle one)*

CAL ERCO CLE GAS MAR HOU

Attention:

SEND RESULTS TO:

Rocky Mountain Analytical Laboratory
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611 FAC: (303) 431-7171

Attention:

CLIENT NAME

PROJECT NO.

Relinquished by: *(Signature)*	Received by: *(Signature)*	Date	Time
Relinquished by: *(Signature)*	Received by: *(Signature)*	Date	Time

Import Lab ID	Enseco ID	Client ID	Matrix (a, s, w)	Date Sampled	Date Rec'd	Date Auth.	Analysis Requested/ P.L. Item #	Sample Condition Upon Receipt

a. Written results required by (date): ____________________ Verbal results required by (date): ____________________

b. QC: ☐ Standard Enseco ☐ CLP Protocol ☐ Project-Specific ____________________

c. Sample Disposal: ☐ Enseco ☐ Return to Client ☐ Phone RMAL

d. Raw Data Copies Needed: ☐ Yes ☐ No

e. Detection Limits: ☐ Standard Product ☐ Other*

f. Holding Times: ☐ Enseco ☐ EPA-CLP ☐ Other*

g. *Special Instructions: ____

**h. Intercompany Rebate: *(circle one)* 0% 5% 10% i. P.O. Number ____________________

8. CALIBRATION PROCEDURES AND FREQUENCY

Standard/Reagent Preparation

A critical element in the generation of quality data is the purity/quality and traceability of the standard solutions and reagents used in the analytical operations. Enseco continually monitors the quality of reagents and standard solutions through a series of well-documented procedures.

To ensure the highest purity possible, all primary reference standards and standard solutions used by Enseco are obtained from the National Institue of Standards and Technology, the EPA Repository or other reliable commercial sources. All standards and standard solutions are logged into a database that identifies the supplier, lot number, purity/concentration, receipt/preparation date, preparer's name, method of preparation, expiration date, and all other pertinent information.

Standard solutions are validated prior to use. Validation procedures can range from a check for chromatographic purity to verification of the concentration of the standard using a standard prepared at a different time or obtained from a different source. Stock and working standards are checked regularly for signs of deterioration, such as discoloration, formation of precipitates, or change in concentration. Care is exercised in the proper storage and handling of standard solutions, and all containers are labeled as to compound, concentration, solvent, expiration date, and preparation data (initials of preparer/date of preparation).

Reagents are examined for purity by subjecting an aliquot or subsample to the analytical method in which it will be used; for example, every lot of dichloromethane (for organic extractables) is analyzed for undesirable contaminants prior to use in the laboratory.

A database is used to store essential information on specific standards or reagents. The system is designed to serve various functions (e.g., the system issues warnings on expiration dates and allows chemists to obtain a list of all working standard solutions prepared from the same stock solution). The program also facilitates the management and auditing of reagents and standards.

Instrument Calibration and Tuning

Calibration of instrumentation is required to ensure that the analytical system is operating correctly and functioning at the proper sensitivity to meet established reporting limits. Each instrument is calibrated with standard solutions appropriate to the type of instrument and the linear range established for the analytical method. The frequency of calibration and the concentration of calibration standards is determined by the manufacturer's guidelines, the analytical method, or the requirements of special contracts.

Gas Chromatography/Mass Spectrometry (GC/MS)

Each day prior to analysis of samples, the instrument is tuned with bromofluorobenzene (BFB) for volatile compounds and decafluorotriphenylphosphine (DFTPP) for semivolatile compounds (according to the tuning criteria specified in the U.S. EPA Contract Laboratory Program (CLP)). No samples are analyzed until the instrument has met tuning criteria.

The instrument is then calibrated for all target compounds. An initial calibration curve is produced and certain key compounds referred to as System Performance Calibration Compounds (SPCC) and Continuing Calibration Compounds (CCC) are evaluated on a daily basis to ensure that the system is within calibration. If the daily standard does not meet the established criteria, the system is recalibrated.

Chromatography

The field of chromatography involves a variety of instrumentation and detection systems. While calibration standards and acceptance criteria vary depending on the type of system and analytical methodology required for a specific analysis, the general principles of calibration apply uniformly. Each chromatographic system is calibrated prior to performance of analyses. Initial calibration consists of determining the linear range, establishing limits of detection, and establishing retention time windows. The calibration is checked on a daily basis to ensure that the system remains within specifications. If the daily calibration check does not meet established criteria, the system is recalibrated and samples analyzed since the last acceptable calibration check are reanalyzed.

Metals

Metals analysis basically involves two types of analytical instrumentation: inductively coupled argon plasma emission spectroscopy (ICP), and atomic absorption spectroscopy (AA).

Each ICP is calibrated prior to any analyses being performed using criteria prescribed in the CLP protocol. The calibration is then verified using standards from an independent source. The linear range of the instrument is established once every quarter using a linear range verification check standard. No values are reported above this upper concentration value without dilution.

A calibration curve is established daily by analyzing a minimum of two standards, one of which is a calibration blank. The calibration is monitored throughout the day by analyzing a Continuing Calibration Blank (CCB) and a Continuing Calibration Verification standard (CCV). The standard must meet established criteria or the system is recalibrated and all samples analyzed since the last acceptable calibration check are reanalyzed.

An interelement check standard is analyzed at the beginning and end of each analytical run, and on a continuing basis, to verify that interelement and background correction factors have remained constant. Results outside of the established criteria trigger reanalysis of samples.

Each AA unit is calibrated prior to any analyses being conducted. A calibration curve is prepared with a minimum of a calibration blank and three standards and then verified with a standard that has been prepared from an independent source at a concentration near the middle of the calibration range. The calibration is then verified on an ongoing basis with a midpoint calibration standard. If the ongoing calibration standard does not meet established acceptance criteria, the system is recalibrated and all samples analyzed since the last acceptable calibration check are reanalyzed. All samples are spiked to verify the absence of matrix effects or interferences. The method of standard additions is used when matrix interferences are present.

Conventional Analyses

The field of conventional, non-metals analysis involves a variety of instrumental and wet chemical techniques. While calibration and standardization procedures vary depending on the type of system and analytical methodology required for a specific analysis, the general principles of calibration apply universally. Each system is

9. ANALYTICAL PROCEDURES

Most analyses performed by Enseco are driven by regulatory concerns. Therefore, methods used at Enseco predominantly originate from regulatory agencies. Generally the methods used are those specified by the U.S. EPA and other federal agencies, state agencies, and professional organizations, as provided in the following references:

- Current EPA (CLP) protocols for the analysis of organic and inorganic hazardous substances including chlorinated dioxins and furans.
- "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act," 40 CFR, Part 136.
- "Methods for Chemical Analysis of Water and Wastes," EPA-600/4-79-020 (revised March, 1983).
- "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," EPA-600/4-82-057 (July, 1982).
- "Test Methods for Evaluating Solid Waste" (SW-846), 2nd Edition (revised), Update I (1984), Update II (1985), 3rd Edition (1986), Update I (1989), Office of Solid Waste and Emergency Response, U.S. EPA.
- "Standard Methods for the Examination of Water and Wastewater," 16th Edition, American Public Health Association, American Water Works Association, Water Pollution Control Federation, Washington, DC (1985).
- "Official Methods of Analysis," 14th Edition, Association of Official Analytical Chemists, Arlington, VA (1984).
- "Methods for the Determination of Organic Compounds in Finished Drinking Water and Raw Source Water," U.S. EPA, Environmental Monitoring and Support Laboratory - Cincinnati (September, 1986).
- "Annual Book of ASTM Standards," Volumes 11.01 and 11.02, American Society for Testing and Materials (ASTM), Philadelphia, PA (1987).
- "Techniques of Water Resources Investigations of the United States Geological Survey (USGS), Book 5, Laboratory Analysis," USGS, Washington, DC (1979).

Analytical data that are generated with a DCS pair which falls within the established control limits are judged to be in control. Data generated with a DCS pair which falls outside of the control limits are considered suspect and are repeated or reported with qualifiers. The procedure used to evaluate data from control samples is given in Figure 11-1. The protocols include examination of instrument performance and preparation and analysis information, consultation with the supervisor, and finally a decision path for determining whether reanalysis is warranted.

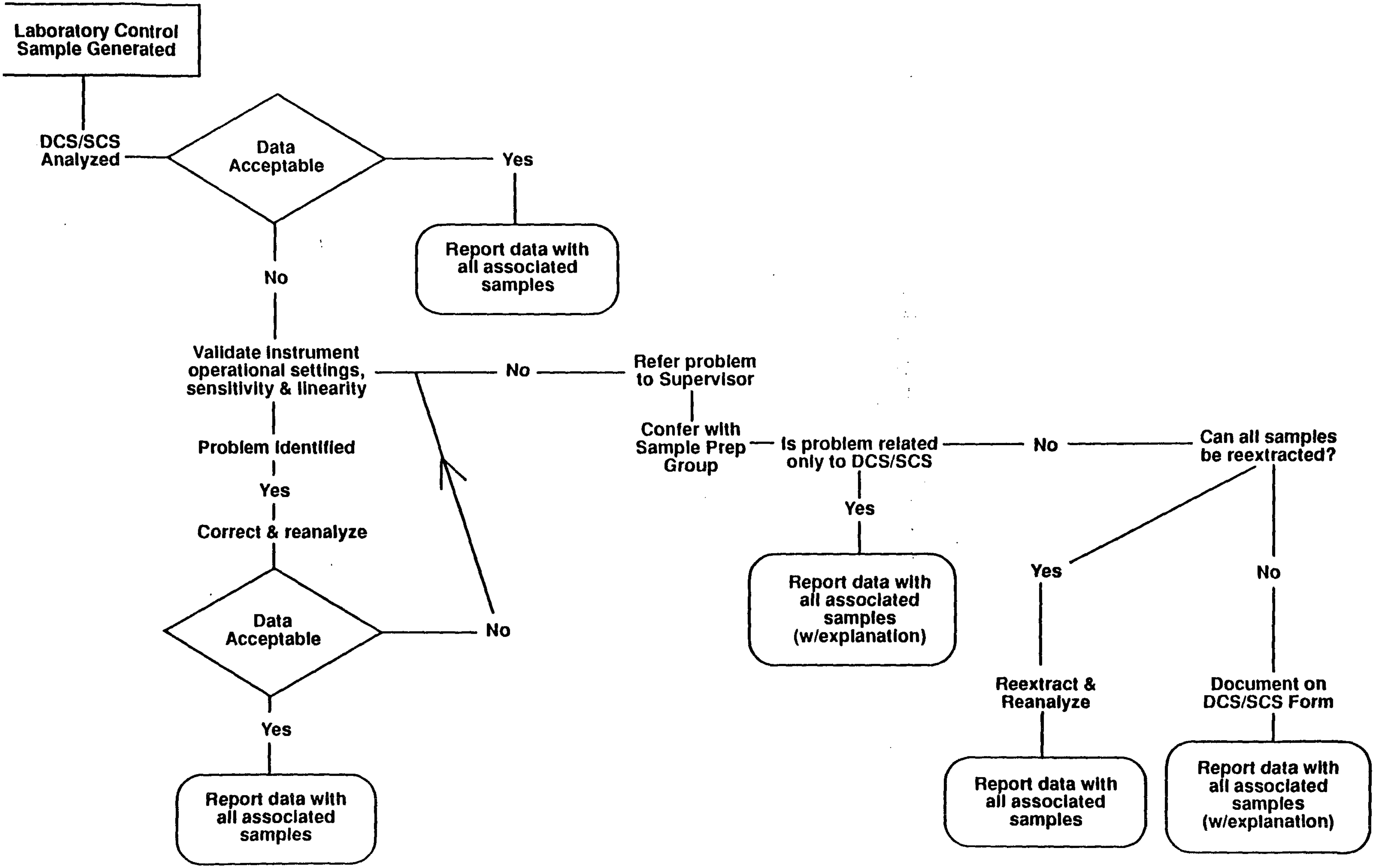
DCS have been established for each routine analytical method. Reagent water is used as the control matrix for the analysis of aqueous samples. The DCS compounds are spiked into reagent water and carried through the appropriate steps of the analysis. The control matrix for solids samples is standard Ottawa sand, an ASTM approved material for use in highway construction, due to its fine degree of homogeneity. The DCS compounds are spiked into the Ottawa sand and carried through the appropriate steps of the analysis.

As stated previously, DCS are analyzed at a frequency of no less than one DCS pair per 20 samples. The DCS program is supplemented with the SCS program to ensure that Laboratory Performance QC is available with each batch of samples processed (see following subsection).

DCS precision and accuracy data are archived in the LIMS. In addition, the associated DCS data are reported with each set of sample results to enable the client to make a quality assessment of the data.

Figure 11-1

Laboratory Performance QC Control Sample Evaluation



Single Control Samples (SCS)

As stated above, a DCS pair is analyzed with every 20 samples to measure the precision and accuracy of an analysis on an ongoing basis. However, samples are often analyzed in lots of less than 20, due to holding time or turn-around time requirements. Since it is necessary to have a measure of laboratory performance with each batch of samples processed, Enseco has instituted the SCS program.

An SCS consists of a control matrix that is spiked with surrogate compounds appropriate to the method being used. In cases where no surrogate is available, (e.g., metals or conventional analyses) a single DCS serves as the control sample. An SCS is prepared for each sample lot for which the DCS pair are not analyzed. Recovery data generated from the SCS are compared to control limits that have been established for each of the compounds being monitored. Initially, CLP control limits or Enseco historical data are used to set the control limits. When sufficient SCS data are available, control limits are redefined based on the most recent nine months of data. Control limits for SCS components are based on the historical average recovery in the SCS plus or minus three standard deviation units.

Analytical data that are generated with an SCS which falls within the control limits are judged to be in control. Data that are generated with an SCS which falls outside of acceptance criteria are considered suspect and are reanalyzed or reported with qualifiers. The protocols for evaluating SCS are identical to those established for DCS (see Figure 11-1).

SCS recovery (accuracy) data are archived in the LIMS. In addition, the associated SCS data are reported with each set of sample results to enable the client to make a quality assessment of the data.

Method Blank

Method blanks, also known as reagent, analytical, or preparation blanks, are analyzed to assess the level of background interference or contamination which exists in the analytical system and which might lead to the reporting of elevated concentration levels or false positive data.

As part of the standard Enseco QC program, a method blank is analyzed with every batch of samples processed. A method blank consists of reagents specific to the method which are carried through every aspect of the procedure, including preparation, clean-up, and analysis. The results of the method blank analysis are evaluated, in conjunction with other QC information, to determine the acceptability of the data generated for that batch of samples.

Ideally, the concentration of target analytes in the blank should be below the Reporting Limit for that analyte. In practice, however, some common laboratory solvents and metals are difficult to eliminate to the parts-per-billion levels commonly reported in environmental analyses. Therefore, criteria for determining blank acceptability must be based on consideration of the analytical techniques used, analytes reported, and Reporting Limits required.

For organic analyses, the concentration of target analytes in the blank must be below the Reporting Limit for that analyte in order for the blank to be considered acceptable. An exception is made for common laboratory contaminants [methylene chloride, acetone, 2-butanone, toluene, and bis(2-ethylhexyl)phthalate] which may be present in the blank at up to 5 times the Reporting Limit and still be considered acceptable. This policy is consistent with the CLP policy and has been established in recognition of the fact that these compounds are frequently found at low levels in method blanks due to the materials used in the collection, preparation, and analysis of samples for organic parameters.

For metals analysis, where the Reporting Limits are typically near the Instrument Detection Limit (IDL) and background levels for certain metals are difficult to completely eliminate, the policy is that the concentration of the target analytes in the blank must be below two times the Reporting Limit. If the blank value for a target analyte lies below the Reporting Limit, the Reporting Limit for that analyte in the associated samples is unaffected. If the blank value lies between the Reporting Limit and two times the Reporting Limit, the Reporting Limit for that analyte in the associated samples is raised to the level found in the blank. A blank containing an analyte(s) above two times the Reporting Limit is considered unacceptable unless the lowest concentration of the analyte in the associated samples is at least ten times the blank concentration (as per CLP protocol).

For conventional inorganic tests, the method SOP directs how the blank is treated. Generally, a reagent blank is used both to zero the equipment and as one of the calibration standards. If a preparation step is required for the analysis, then a prep blank is also analyzed to determine the extent of contamination or background interference. In most cases, the concentration found in the prep blank is subtracted from the concentration found in any associated sample prior to calculating the final result. Blanks have no application or significance for some conventional inorganic parameters (e.g. pH).

If the blank does not meet acceptance criteria, the source of contamination must be investigated and appropriate corrective action must be taken and documented. Investigation includes an evaluation of the data to determine the extent and effect of the contamination on the sample results. Corrective actions may include reanalysis of the blank, and/or repreparation and reanalysis of the blank and all associated samples.

For organic and metals analyses, and selected conventional inorganic tests, method blank results are reported with each set of sample results.

Sample results are not corrected for blank contamination. Occasionally, due to limited sample volume or other constraints, the laboratory reports data associated with an unacceptable blank. In these cases, the Reporting Limit for the each analyte contained in the blank is raised to the level found in the blank.

Matrix-Specific QC

Matrix-Specific QC is used to assess the effects of a sample matrix or field conditions on the analytical data. The main elements of Matrix-Specific QC are:

- The analysis of matrix spikes, matrix duplicates, and matrix spike duplicates;
- Monitoring the recovery of surrogate compounds from environmental samples;
- Monitoring the results of standard additions in environmental samples;
- The analysis of field blanks; and
- The determination of method detection limits in a specific matrix.

Different regulatory programs have different requirements in terms of Matrix-Specific QC. In order to ensure that the data generated meet all Data Quality Objectives, Enseco encourages its clients to include Matrix-Specific QC that fulfills the Data Quality Objectives and regulatory requirements of the project. A discussion of the different elements of Matrix-Specific QC follows.

Matrix Spikes, Matrix Duplicates, and Matrix Spike Duplicates

A Matrix Spike (MS) is an environmental sample to which known concentrations of analytes have been added. The MS is taken through the entire analytical procedure and the recovery of the analytes is calculated. Results are expressed as percent recovery. The MS is used to evaluate the effect of the sample matrix on the accuracy of the analysis.

A Matrix Duplicate (MD) is an environmental sample that is divided into two separate aliquots. The aliquots are processed separately and the results compared to determine the effects of the matrix on the precision of the analysis. Results are expressed as RPD.

A Matrix Spike Duplicate (MSD) is an environmental sample that is divided into two separate aliquots, each of which is spiked with known concentrations of analytes. The two spiked aliquots are processed separately and the results compared to determine the effects of the matrix on the precision and accuracy of the analysis. Results are expressed as RPD and percent recovery.

Surrogate Recoveries and Standard Additions

Surrogates are organic compounds which are similar to the analytes of interest in chemical behavior, but which are not normally found in environmental samples. Surrogates are added to samples to monitor the effect of the matrix on the accuracy of the analysis. Results are reported in terms of percent recovery.

Enseco routinely adds surrogates to samples requiring GC/MS analysis and reports these surrogate recoveries to the client. The laboratory does not control its operations based on surrogate recoveries in environmental samples. As discussed earlier in this section, Enseco controls its operations based on the results of Laboratory Control Samples. The surrogate recoveries are primarily used by the laboratory to assess matrix effects. However, obvious problems with sample preparation and analysis (e.g. evaporation to dryness, leaking septum, etc.) which can lead to poor surrogate spike recoveries must be ruled out prior to attributing low surrogate recoveries to matrix effects.

Standard Additions (SA) is the practice of adding a series of known amounts of an analyte to an environmental sample. The fortified samples are then analyzed and the recovery of the analytes calculated. The practice of SA's is generally used with metal and conventional analyses to determine the effect of the sample matrix on the accuracy of the analyses.

Field Blanks

Field blanks are check samples that monitor contamination originating from the collection, transport or storage of environmental samples. One example of a field blank is an equipment blank. An equipment blank is blank water that is poured through the sample collection device to check the adequacy of the cleaning procedures for the sampling equipment. Another type of field blank is a trip blank. A trip blank is a laboratory control matrix (typically water) which is sent to the field in an appropriate sample container, remains unopened in the field, and then is sent back to the laboratory. The purpose of the trip blank is to assess the impact of field and shipping conditions on the samples. The results from field blanks are reported to the client as samples in the same concentration units as the samples. No correction of the analytical data is done in the laboratory based on the analysis of field blanks.

Matrix-Specific Detection Limits

Method Detection Limits (MDL's) determined on a specific sample matrix are called Matrix-Specific Detection Limits. See Section 14 for a discussion of detection and reporting limits.

12. PERFORMANCE AND SYSTEM AUDITS

Enseco laboratories participate in a variety of federal and state certification programs, (including the U.S. EPA CLP), that subject each of the laboratories to stringent system and performance audits on a regular basis. A system audit is a review of laboratory operations conducted to verify that the laboratory has the necessary facilities, equipment, staff and procedures in place to generate acceptable data. A performance audit verifies the ability of the laboratory to correctly identify and quantitate compounds in blind check samples submitted by the auditing agency. The purpose of these audits is to identify those laboratories that are capable of generating scientifically sound data. Enseco is certified to perform environmental analyses under programs administered by the U.S. EPA, U.S. Army, U.S. Navy, and over 15 states. The most current list of Enseco certifications is available upon request.

In addition to external audits conducted by certifying agencies or clients, Enseco regularly conducts the following internal audits:

- Quarterly systems audits conducted by the Divisional QA Director.
- Periodic (at least yearly) audits conducted by the Corporate QA Office.
- Special audits by the Divisional QA Director or Corporate QA Office when a problem is suspected.

Enseco laboratories also routinely analyze check samples as described below:

- Laboratory Control Samples (DCS, SCS, and method blanks) are analyzed at a frequency equal to at least 10% of the total number of samples analyzed (see Section 11).
- All Enseco laboratories participate in the analyses of EPA check samples provided under the Water Supply (WS) and Water Pollution (WP) Performance Evaluation Studies. The results of these PE samples are tabulated by the Corporate QA Office to identify performance trends within the Enseco laboratories.

- The majority of the Enseco laboratories are CLP labs and thus analyze organic and/or inorganic CLP PE samples on a quarterly basis. The results of these analyses are also tabulated and evaluated by the Corporate QA Office.

- The laboratories participate in multiple state certification programs (including New York, New Jersey and California) which require that PE samples be analyzed periodically.

- Blind check samples from an independent commercial firm are sent to the laboratories periodically by the Corporate QA Office. The frequency and type of samples sent is based on problem areas identified by evaluation of tabulated PE results.

The results of these check samples are used to identify areas where additional training is needed or clarification of procedures is required.

13. PREVENTIVE MAINTENANCE

To minimize downtime and interruption of analytical work, preventive maintenance is routinely performed on each analytical instrument. Designated laboratory personnel are trained in routine maintenance procedures for all major instrumentation. When repairs are necessary, they are performed by either trained staff or trained service engineers employed by the instrument manufacturer.

Each laboratory has detailed SOPs on file that describe preventive maintenance procedures and schedules. The laboratories also maintain detailed logbooks documenting the preventive maintenance and repairs performed on each analytical instrument.

14. SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA QUALITY AND DETERMINE REPORTING LIMITS

Data Quality Assessment

The effectiveness of a QA program is measured by the quality of data generated by the laboratory. Data quality is judged in terms of its precision, accuracy, representativeness, completeness and comparability. These terms are described as follows:

Precision is the degree to which the measurement is reproducible. Precision can be assessed by replicate measurements of DCS, reference materials, or environmental samples. Enseco routinely monitors precision by comparing the RPD between DCS measurements with control limits established at plus three standard deviations from the mean RPD of historical DCS data.

Precision is frequently determined by comparison of replicates. The standard deviation of "n" measurements of "x" is commonly used to estimate precision.

Standard deviation (S) is calculated as follows:

$$S = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (X_1 - \bar{X})^2}$$

where a quantity "x" (e.g., a concentration) is measured "n" times.

The relative standard deviation (or sample coefficient of variation, CV), which expresses standard deviation as a percentage of the mean, is generally useful in the comparison of three or more replicates (although it may be applied in the case of n = 2).

$$RSD = 100\ (s/\overline{X})$$

or

$$CV = 100\ (s/\overline{X})$$

where: RSD = relative standard deviation

CV = coefficient of variation

s = standard deviation

$\overline{X}$ = mean

In the case of duplicates, the RPD between the two samples may be used to estimate precision.

$$RPD = \frac{|D_1 - D_2|}{(D_1 + D_2)/2} \times 100$$

where: RPD = relative percent difference

D_1 = first sample value

D_2 = second sample value (duplicate)

Accuracy is a determination of how close the measurement is to the true value. Accuracy can be assessed using LCS, standard reference materials, or spiked environmental samples. Unless specified otherwise in special contracts, Enseco monitors accuracy by comparing LCS results with control limits established at plus or minus three standard deviation units from the mean of historical LCS results.

The determination of the accuracy of a measurement requires a knowledge of the true or accepted value for the signal being measured. Accuracy may be calculated in terms of percent recovery as follows:

$$\text{Percent Recovery} = \frac{X}{T} \times 100$$

where: X = the observed value of measurement

T = "true" value

Representativeness is the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Analytical data should represent the sample analyzed regardless of the heterogeneity of the original sample matrix. Enseco strives to accommodate all sample matrices. Some samples may require analysis of multiple phases to obtain representative results.

Completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount that was expected to be obtained under normal conditions.

To be considered complete, the data set must contain all QC check analyses verifying precision and accuracy for the analytical protocol. In addition, all data are reviewed in terms of stated goals in order to determine if the database is sufficient.

When possible, the percent completeness for each set of samples is calculated as follows:

$$\text{Completeness} = \frac{\text{valid data obtained}}{\text{total data planned}} \times 100\%$$

Comparability expresses the confidence with which one data set can be compared to another data set measuring the same property. Comparability is ensured through the use of established and approved analytical methods, consistency in the basis of analysis (wet weight, volume, etc.), consistency in reporting units (ppm, ppb, etc.), and analysis of standard reference materials.

Reporting Limits

Assuring the validity of quantitative measurements at low concentrations is an extremely difficult technical problem. With regulatory action levels being pushed lower and lower, the validity of any given measurement becomes even more important. The consequences of false positive or false negative data can be significant.

A number of terms have been used, by the EPA and other technical groups, to express the lowest concentration of an analyte which can be measured. Some of these terms, their definitions, and sources are listed in Table 14-1. A graphical representation of these terms is given in Figure 14-1.

Enseco takes very seriously its responsibility to report technically defensible data. Therefore, we have established a Reporting Limit (RL) for each analyte in each method. The RL represents the value above which we believe reliable data can be routinely obtained.

These Reporting Limits were established by collecting Method Detection Limit (MDL) data for organic analyses and Instrument Detection Limit (IDL) data for metals analyses from each Enseco laboratory. The MDL data were collected using the procedures described in 40CFR136 Appendix B. IDL data were calculated using the procedures outlined in the EPA Contract Laboratory Program (CLP) Statement of Work dated 12/87. The MDL/IDL data were then compared to various limits published in EPA methods and in the regulations. For example for Volatile Organics, the MDL data generated in Enseco laboratories were compared to the Practical Quantitation Limits (PQLs) published in SW-846 method 8240; the PQLs contained in the July 9, 1987, Federal Register Final Rulemaking on Appendix IX; the Contract Required Detection Limits (CRDLs) in the CLP Method for Volatile Organics; and the MDLs in Method 624. Then a Reporting Limit for each analyte was established which considered all of this information. The RL was set at a level above which we were confident that our laboratories could detect and quantify the analyte consistently. Using this procedure, the Reporting Limits established are generally between 2 to 5 times the laboratory MDL/IDL. This range is consistent with the American Chemical Society definition for the Limit of Quantitation (LOQ). (See Table 14-1)

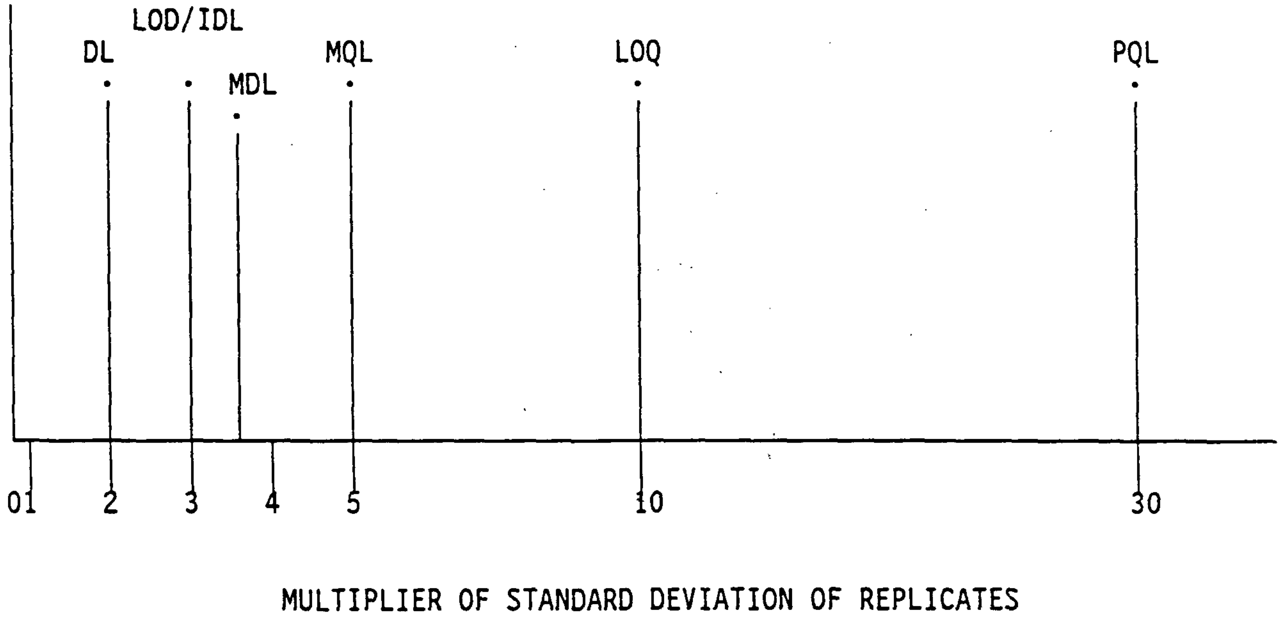
TABLE 14-1

DEFINITION OF DETECTION LIMIT TERMS

	DEFINITION	DETERMINATION	CALCULATION	SOURCE
etection Limit (DL)	The concentration which is distinctly detectable above, but close to a blank.	Analysis of replicate standards	Two times the standard deviation	Methods for Chemical Analysis of Water and Wastes
imit of Detection (LOD)	The lowest concentration that can be determined to be statistically different from a blank	Analysis of replicate samples	Three times the standard deviation	ACS Definition
ethod Detection Limit (MDL)	The minimum concentration of a substance that can be identified, measured and reported with 99% confidence that the analyte concentration is greater than zero.	Analysis of a minimum of seven replicates spiked at 1 to 5 times the expected detection limit.	The standard deviation times the Student t-value at the desired confidence level. (For seven replicates, the value is 3.14)	40 CFR 136 Definition for EPA Water Programs
nstrument Detection imit (IDL)	The smallest signal above background noise that an instrument can detect reliably.	Analysis of three replicate standards at concentrations of 3-5 times the detection limit.	Three times the standard deviation	Contract Laboratory Program
ethod Quantitation Limit (MQL)	The minimum concentration of a substance that can be measured and reported	Analysis of replicate samples	Five times the standard deviation	SW-846
imit of Quantitation (LOQ)	The level above which quantitative results may be obtained witha specified degree of confidence	Analysis of replicate samples	Ten times the standard deviation	ACS Definition
ractical Quantitation imit (PQL)	The lowest level that can be reliably determined within specified limits of precision and accuracy during routine laboratory operating conditions	Interlaboratory analysis of check samples	1) Ten times the MDL 2) Value where 80% of laboratories are within 20% of the true value	RCRA SDWA Programs
ontract Required etection Limit (CRDL)	Reporting limit specified for laboratories under contract to the EPA for Superfund activities	Unknown	Unknown	Contract Laboratory Program

FIGURE 14-1

Graphical Representation of Detection Limit Terms
(See Table 14-1 for Definitions)



NOTE: The values along the horizontal "Standard Deviation (SD)" axis are approximate values and are meant to show the relative, not absolute, relationship between the terms.

15. CORRECTIVE ACTION

When errors, deficiencies, or out-of-control situations exist, the QA program provides systematic procedures, called "corrective actions," to resolve problems and restore proper functioning to the analytical system.

Laboratory personnel are alerted that corrective actions may be necessary if:

- QC data are outside the acceptable windows for precision and accuracy;
- Blanks, DCS or SCS contain contaminants above acceptable levels;
- Undesirable trends are detected in spike recoveries or RPD between duplicates;
- There are unusual changes in detection limits;
- Deficiencies are detected by the QA department during internal or external audits or from the results of performance evaluation samples; or
- Inquiries concerning data quality are received from clients.

Corrective action procedures are often handled at the bench level by the analyst, who reviews the preparation or extraction procedure for possible errors, checks the instrument calibration, spike and calibration mixes, instrument sensitivity, and so on. If the problem persists or cannot be identified, the matter is referred to the laboratory supervisor, manager and/or QA department for further investigation. Once resolved, full documentation of the corrective action procedure is filed with the QA department. Corrective action documentation is routinely reviewed by the VP of QA.

Examples of anomalous situation include: formation of a precipitate in an extract; formation of an emulsion during an extraction step; or missed holding times. These situations are thoroughly documented to enable a thorough review of the data to occur.

Out-of-Control situations are also documented on Anomaly Forms. An Out-of-Control situation occurs when QC data fall outside of established control limits. The documentation associated with and Out-of-Control situation is reviewed by the supervisor and the QA Department. Out-of-Control situations trigger Corrective Action. Corrective Actions taken are also documented on the Anomaly Form.

Project Files

A project file is created for each project handled within the laboratory. The project file contains all documents associated with the project. This includes correspondence from the client, chain-of-custody records, raw data, copies of laboratory notebook entries pertaining to the project, and a copy of the final report. When a project is complete, all records are passed to the Document Custodian who inventories the file, checks for completeness, and puts the file into document archive.

APPENDIX I

MAXIMUM HOLDING TIMES AND SAMPLE COLLECTION/PRESERVATION INFORMATION

Sources: Tables A-E:
Federal Register, October 26, 1984
SW-846, 3rd Edition, Update I
State of California Leaking Underground
Fuel Tank Field Manual, May 1988

Table F:
Contract Laboratory Program Statement of
Work for Organic Analysis dated 10/86
Contract Laboratory Program Statement of
Work for Inorganic Analysis dated 12/87

A. VOLATILE ORGANICS

Matrix	Container	Minimum Sample Size	Preservative	Holding Time (From Date Sampled)
Water Samples				
No Residual Chlorine Present	3 40 mL vials with Teflon lined septum caps	40 mL	4 drops conc. HCl, 4°C	14 days
Residual Chlorine Present	3 40 mL vials with Teflon lined septum caps	40 mL	4 drops of 10% sodium thiosulfate, 4 drops conc. HCl, 4°C	14 days
Acrolein and Acrylonitrile	3 40 mL vials with Teflon lined septum caps	40 mL	Adjust to pH 4-5, 4°C	14 days
Soil/Sediments and Sludges	Glass jar with Teflon liner or core tube	10 g	4°C	14 days
Concentrated Waste Samples	Glass jar with Teflon liner or core tube	10 g	None	14 days

The above information applies to the following parameters and methods:

Parameter	Method
Volatile Halocarbons	601/8010 (GC)
Volatile Aromatics	602/8020 (GC)
Volatile Organics	624/8240/8260 (GC/MS)
Acrolein/Acrylonitrile	603/8030 (GC)

B. SEMIVOLATILE ORGANICS

Matrix	Container	Minimum Sample Size	Preservative	Holding Time (From Date Sampled)
Water Samples				
No Residual Chlorine Present	1 liter glass with Teflon liner	1 liter	$4^{O}C$	Samples must be extracted within 7 days and analyzed within 40 days of extraction.
Residual Chlorine Present	1 liter glass with Teflon liner	1 liter	Add 3 mL 10% sodium thiosulfate per gallon, $4^{O}C$	Samples must be extracted within 7 days and analyzed within 40 days of extraction.
Soil/Sediments and Sludges	Glass jar with Teflon liner or core tube	50 g	$4^{O}C$	Samples must be extracted within 14 days and analyzed within 40 days of extraction.
Concentrated Waste Samples	Glass jar with Teflon liner or core tube	50 g	None	Samples must be extracted within 14 days and analyzed within 40 days of extraction.

The above information applies to the following parameters and methods:

Parameter	Method
Phenols	604/8040 (GC)
Phthalate Esters	606/8060 (GC)
Organochlorine Pesticides/PCBs	608/8080 (GC)
Polyaromaltic Hydrocarbons	610/8310 (HPLC)
Organophosphate Pesticides	614/8140 (GC)
Phenoxy acid Herbicides	615/8150 (GC)
Semivolatile Organics	625/8270 (GC/MS)
Carbamate & Urea Pesticides	632 (HPLC)

C. OTHER ORGANICS

Parameter	Method No.	Matrix	Holding Time(a) (from Date Sampled)	Container	Preservative	Min. Sample Size
Dioxins/Furans	8280	Water	30 days extn. 45 days anal.(b)	One liter glass	4°C	1000 ml
		Soil/Waste	30 days extn. 45 days anal.(b)	core tube or glass jar	4°C	50 g
Petroleum Hydrocarbons as Gasoline	TPH-Gasoline Purge & Trap (LUFT manual)	Water	14 days	3 40 mL vials with Teflon liners	4°C, HCl to pH < 2	40 mL
		Soil/Waste	14 days	Core tube or glass jar	4°C	50 g
Petroleum Hydrocarbons as Gasoline	TPH-Gasoline Extractable (LUFT manual)	Water	14 days extn. 40 days anal.	One liter glass	4°C, HCl to pH < 2	500 mL
		Soil/Waste	14 days extn. 40 days anal.	Core tube or glass jar	4°C	50 g
Petroleum Hydrocarbons as Diesel	TPH-Diesel Extractable (LUFT manual)	Water	14 days extn. 40 days anal.	One liter glass	4°C	500 mL
		Soil/Waste	14 days extn. 40 days anal.	Core tube or glass jar	4°C	50 g
Petroleum Hydrocarbons (TPH)	TPH-IR (418.1)	Water	28 days	One liter glass	4°C, H_2SO_4 to pH < 2	1000 mL

(a) extn: extraction anal: analysis
(b) from date of collection

D. METALS

Parameter	Method No.	Matrix	Holding Time (from Date Sampled)	Container	Preservative(a)	Min. Sample Size
Metals (ICP)	200.7/6010	Water	6 months	Poly	HNO_3 to pH < 2.0	100 ml
		Soil/Waste	6 months	core tube/glass jar	4°C	10 g
Arsenic (GF-AA)	206.2/7060	Water	6 months	Poly	HNO_3 to pH < 2.0	100 ml
		Soil/Waste	6 months	core tube/glass jar	4°C	10 g
Mercury (CV-AA)	245.1/7470	Water	28 days	Poly	HNO_3 to pH < 2.0	100 ml
		Soil/Waste	28 days	core tube/glass jar	4°C	10 g
Selenium (GF-AA)	270.2/7740	Water	6 months	Poly	HNO_3 to pH < 2.0	100 ml
		Soil/Waste	6 months	core tube/glass jar	4°C	10 g
Thallium (GF-AA)	279.2/7841	Water	6 months	Poly	HNO_3 to pH < 2.0	100 ml
		Soil/Waste	6 months	core tube/glass jar	4°C	10 g
Lead (GF-AA)	239.2/7421	Water	6 months	Poly	HNO_3 to pH < 2.0	100 ml
		Soil/Waste	6 months	core tube/glass jar	4°C	10 g
Chromium (III/VI)	220.7/218.4/ 312B/7197	Water	24 hours	Poly	4°C	100 ml
		Soil/Waste	24 hours extn. (b)	core tube/glass jar	4°C	10 g
Silica	200.7/6010	Water	28 days	Poly	4°C	100 ml
		Soil/Waste	28 days	core tube/glass jar	4°C	10 g

(a) Listed preservative is for total metals. Dissolved or suspended metals require filtration prior to pH adjustment.

(b) extn: extraction

E. CONVENTIONALS

Parameter	Method No.	Matrix	Holding Time[(a)] (from Date Sampled)	Container	Preservative	Min. Sample Size
Color	110.2	Water	48 hours	Poly	4°C	100 ml
Oil and Grease	413.1/ 413.2	Water	28 days	Glass	4°C, H_2SO_4 to pH < 2	1000 ml
Specific Conductance	120.1	Water	28 days	Poly	4°C	50 ml
Acidity	305.1	Water	14 days	Poly	4°C	50 ml
pH	150.1	Water	ASAP	Poly	4°C	50 ml
Alkalinity	310.1	Water	14 days	Poly	4°C	50 ml
Hardness	200.7/ 314A/314B	Water	6 months	Poly	HNO_3 to pH < 2	50 ml
Biochemical Oxygen Demand	405.1	Water	48 hours	Poly	4°C	200 ml
Chemical Oxygen Demand	410.4	Water	28 days	Glass	4°C, H_2SO_4 to pH < 2	100 ml
Organic Carbon (TOC)	415.1	Water	28 days	Glass	4°C, H_2SO_4 to pH < 2	100 ml

C. CONVENTIONALS (Cont.)

Parameter	Method No.	Matrix	Holding Time[(a)] (from Date Sampled)	Container	Preservative	Min. Sample Size
Orthophosphate	365.3	Water	48 hours	Poly	4°C	100 ml
Total Phosphorus	365.3	Water	28 days	Glass	H_2SO_4 to pH < 2	100 ml
Total Kjeldahl Nitrogen	351.2	Water	28 days	Glass	4°C, H_2SO_4 to pH < 2	100 ml
Ammonia	350.1	Water	28 days	Glass	4°C, H_2SO_4 to pH < 2	50 ml
Nitrite	354.1	Water	48 hours	Poly	4°C	50 ml
Nitrate	353.2/300.0	Water	48 hours	Poly	4°C	50 ml
Nitrite plus Nitrate	353.2	Water	28 days	Glass	4°C, H_2SO_4 to pH < 2	50 ml
Total Solids	160.3	Water	7 days	Poly	4°C	100 ml
Total Suspended Solids	160.2	Water	7 days	Poly	4°C	100 ml
Total Dissolved Solids	160.1	Water	7 days	Poly	4°C	100 ml

C. CONVENTIONALS (Cont.)

Parameter	Method No.	Matrix	Holding Time[a] (from Date Sampled)	Container	Preservative	Min. Sample Size
Total Volatile Solids	160.4	Water	7 days	Poly	4°C	100 ml
Turbidity	180.1	Water	48 hours	Poly	4°C	50 ml
Sulfate	300.0	Water	28 days	Poly	4°C	50 ml
Sulfite	377.1	Water	ASAP	Poly	4°C	100 ml
Sulfide	376.2	Water	7 days	Poly	4°C, NaOH to pH > 9 $Zn(C_2H_3O_3)2$	100 ml
Cyanide	335.1/ 335.2/335.3	Water	14 days	Poly	4°C, NaOH to pH > 12	250 ml
Coliform, Total & Fecal	909A/ 909C	Water	6 hours	Sterile poly	4°C, $Na_2S_2O_3$	100 ml
Bromide	Dionex	Water	28 days	Poly	4°C	50 ml
Chloride	300.0	Water	28 days	Poly	4°C	50 ml
Chlorine, residual	330.1	Water	ASAP	Poly	4°C	100 ml

C. CONVENTIONALS (Cont.)

Parameter	Method No.	Matrix	Holding Time[(a)] (from Date Sampled)	Container	Preservative	Min. Sample Size
Fluoride	340.2	Water	28 days	Poly	4^oC	50 ml
Iodide	Dionex	Water	28 days	Poly	4^oC	50 ml
Organic Halogen (TOX)	9020	Water	28 days	Glass	4^oC, H_2SO_4 to $pH < 2$	200 ml
Phenolics	420.1/ 420.2	Water	28 days	Glass	4^oC, H_2SO_4 to $ph < 2$	100 ml
Surfactants (MBAS)	425.1	Water	48 hours	Poly	4^oC	100 ml
Gross Alpha, Beta and Radium	9310/ 9315	Water	6 months	Poly	HNO_3 to $ph < 2$	2000 ml
Odor	140.1	Water	ASAP	Glass	4^oC	1000 mL

a) Parameters with holding times of 24 hours or less are analyzed on the day of receipt in the laboratory. Parameters with holding times between 24 and 48 hours are analyzed within one day of receipt in the laboratory.

F. CLP HOLDING TIMES

Parameter	Matrix	Holding Time[a] (from Date Received)	Container	Preservative	Min. Sample Size
Volatile Organics	Water	10 days	2 40 mL vials with Teflon lined caps	4°C	40 mL
	Soil	10 days	Glass jar with Teflon liner or core tube	4°C	10 g
Extractable Organics	Water	5 days extn. 40 days anal.	1 liter glass with Teflon liner	4°C	1000 mL
	Soil	10 days extn. 40 days anal.	Glass jar with Teflon liner or core tube	4°C	50 g
Metals (other than Mercury)	Water	180 days	P,G [b]	HNO_3 to pH < 2	100 mL
	Soil	180 days	P,G	4°C	10 g
Mercury	Water	26 days	P,G	HNO_3 to pH < 2	100 mL
	Soil	26 days	P,G	4°C	10 g
Cyanide	Water	14 days	P,G	0.6 g ascorbic acid,[c] NaOH to pH >12, 4°C	100 mL
	Soil	14 days	P,G	4°C	10 g

(a) Holding times calculated from date of receipt in laboratory
(b) Polyethylene (P) or glass (G)
(c) Only used in the presence of residual chlorine

APPENDIX II

FORMATS FOR STANDARD OPERATING PROCEDURES (SOP)

FORMAT FOR SOP - LABORATORY, ANALYTICAL METHOD

Title (includes method number)

1. Scope and Application
    - 1.1 Analytes
    - 1.2 Detection limit (instrument and method)
    - 1.3 Applicable matrices
    - 1.4 Dynamic range
    - 1.5 Approximate analytical time (i.e., 5 minutes, 2 days)

2. Summary of Method
    - 2.1 Generic description of method and chemistry behind it (i.e., extract with solvent, convert to methyl ester, analyze by electron-capture gas chromatography)

3. Comments
    - 3.1 Interferences
    - 3.2 Helpful hints

4. Safety Issues (specific to the method)

5. Sample Collection, Preservation, Containers, and Holding Times

6. Apparatus

7. Reagents and Standards

8. Procedure (detailed step-by-step)
    - 8.1 Sample preparation
    - 8.2 Calibration
    - 8.3 Analysis

FORMAT FOR SOP - LABORATORY, ANALYTICAL METHOD
(cont.)

9. QA/QC Requirements
    - 9.1 QC samples
    - 9.2 Acceptance criteria (precision and accuracy, % of multi-component QC analytes which must be within windows)
    - 9.3 Corrective action required (reference current QC manual)

10. Calculations

11. Reporting
    - 11.1 Reporting units
    - 11.2 Reporting limits
    - 11.3 Significant figures and reporting values below detection limit
    - 11.4 LIMS data entry

12. References
    - 12.1 Method source
    - 12.2 Deviations from source method and rationale

FORMAT FOR SOP - LABORATORY, STANDARDS AND REAGENTS

Title

1. Reagent/Standard Name

2. Type (reagent, calibration standard, DCS, SCS, stock solution, etc.)

3. Constituents/concentration

4. Solvent

5. Safety Issues (specific to the reagent or standard)

6. Shelf Life

7. Procedure

    7.1 Preparation
    7.2 Documentation (purchase date, open date, labeling, etc.)
    7.3 Verification

FORMAT FOR SOP - LABORATORY, EQUIPMENT OPERATION, CALIBRATION, AND MAINTENANCE

Title

1. Purpose

2. Safety Issues (applicable to the specific equipment)

3. Procedure

    3.1 Initial start-up
    3.2 Calibration and performance documentation
    3.3 Example output
    3.4 *Shut-down*
    3.5 Maintenance and maintenance records

4. Responsibilities

5. Comments

6. Definitions

FORMAT FOR SOP - LABORATORY, PROCEDURAL

Title

1. Purpose
2. Policies
3. Safety Issues
4. Procedure
5. Responsibilities
6. Comments
7. Definitions

TABLE 14-1

DEFINITION OF DETECTION LIMIT TERMS

	DEFINITION	DETERMINATION	CALCULATION	SOURCE
Detection Limit (DL)	The concentration which is distinctly detectable above, but close to a blank.	Analysis of replicate standards	Two times the standard deviation	Methods for Chemical Analysis of Water and Wastes
Limit of Detection (LOD)	The lowest concentration that can be determined to be statistically different from a blank	Analysis of replicate samples	Three times the standard deviation	ACS Definition
Method Detection Limit (MDL)	The minimum concentration of a substance that can be identified, measured and reported with 99% confidence that the analyte concentration is greater than zero.	Analysis of a minimum of seven replicates spiked at 1 to 5 times the expected detection limit.	The standard deviation times the Student t-value at the desired confidence level. (For seven replicates, the value is 3.14)	40 CFR 136 Definition for EPA Water Programs
Instrument Detection Limit (IDL)	The smallest signal above background noise that an instrument can detect reliably.	Analysis of three replicate standards at concentrations of 3-5 times the detection limit.	Three times the standard deviation	Contract Laboratory Program
Method Quantitation Limit (MQL)	The minimum concentration of a substance that can be measured and reported	Analysis of replicate samples	Five times the standard deviation	SW-846
Limit of Quantitation (LOQ)	The level above which quantitative results may be obtained witha specified degree of confidence	Analysis of replicate samples	Ten times the standard deviation	ACS Definition
Practical Quantitation Limit (PQL)	The lowest level that can be reliably determined within specified limits of precision and accuracy during routine laboratory operating conditions	Interlaboratory analysis of check samples	1) Ten times the MDL 2) Value where 80% of laboratories are within 20% of the true value	RCRA SDWA Programs
Contract Required Detection Limit (CRDL)	Reporting limit specified for laboratories under contract to the EPA for Superfund activities	Unknown	Unknown	Contract Laboratory Program

GENERIC SAMPLING PLAN
RCRA FACILITIES INVESTIGATIVE PROJECT
GIANT REFINERY
GALLUP, NEW MEXICO

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