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REMD

# PERFORMANCE OF REMEDIAL RESPONSE ACTIVITIES AT UNCONTROLLED HAZARDOUS WASTE SITES

## U.S. EPA CONTRACT NO. 68-01-6939

1012198

CAMP DRESSER & McKEE INC.
PRIME CONTRACTOR

035

PROJECT OPERATIONS PLAN
FOR
SOUTH CAVALCADE SITE
WORK PLAN
HOUSTON, TEXAS
SITE NO. 143

DOCUMENT NO. 143-WP1-OP-ATAD-1

000651

## 1. APPROVAL SIGNATURES

Nancy B. Johannesmeyer

Robert Kier

South Cavalcade Project Operation Plan - South Cavalcade Site

The undersigned have read and agree to implement and follow the guidelines and procedures identified in this Project Operations Plan for tasks to be undertaken as part of the Sampling and Analysis Plan at south Cavalcade Site, Houston, Texas.

Site Manager _____ Date _____

Regional Manager _____ Date _____

Quality Assurance Coordinator _____ Date _____

Technical Operations Manager _____ Date _____

Health & Safety Manager _____ Date _____

EPA Regional Quality/Assurance Coordinator _____ Date _____

Nancy B. Johannesmeyer

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## 2. INTRODUCTION

This Project Operations Plan has been developed specifically for use at South Cavalcade Site, Houston, Texas. As part of Task 1 - Preinvestigation Activities, of a Health and Safety Plan, Sampling and Analytical Plan and Quality Assurance Project Plan are to be developed for this project.

The purpose of this document is to suggest the specific field investigation sampling and analytical quality assurance/quality control procedures which may be utilized in the field investigation activities conducted as part of the South Cavalcade Site Sampling and Analytical Plan.

This document, the Project Operations Plan, is a suggested guidance for all field activities associated with this project and presents field investigation, sampling, analytical, quality assurance and health and safety information in an integrated format.

By providing this information in one document a considerable amount of redundancy inherent in preparing separate documents is avoided. It also ensures that all pertinent information which needs to be disseminated to the project staff is available as a single reference document.

This document is already in place and has been used to direct numerous remedial investigations as well as numerous state and local hazardous waste projects.

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## 3. SITE DESCRIPTION

### 3.1 Site History and Background

The South Cavalcade site is currently bounded by the Houston Belt Terminal railroad tracks to the east, Cavalcade Road to the north, Missouri Pacific railroad tracks to the west, and Collingsworth Road to the south. The site currently consists of approximately 45 acres on a parcel of land 1-1/2 miles southwest of the intersection between Loop 610 and U.S. Route 59 (Eastex Freeway).

The majority of the site area has formerly been used as a production facility for creosote and other wood preservative products. From 1911 to 1939 the plant was operated by the National Lumber and Creosoting Company. This operaton consisted of a production facility on the southwest corner of the site and "dripping" and drying areas toward the center and northern areas of the site. The National Lumber and Creosoting Company operation was purchased by Koppers Company in 1940. In addition to wood preserving operation, a coal tar distillation process facility was also constructed and operated in the southeast corner of the site. Numerous ponds, tanks, and lagoons existed on the site. Two known buried ponds or lagoons (noted on historical aerial photographs and boring logs) existed in the southwest corner of the site and in the center northern area of the site. The facility was closed by Koppers in 1962. All plant buildings were removed and the site area was covered with soil. Currently, three palletized trucking firms have operations located within the site boundaries; Meridian Transport Company (Merchants Fast Motorized Lines) in the central and southwestern corners of the site, Palletized Trucking Inc. in the southeastern corner of the site and Transcon Trucking Lines, on the northern portion of the site. AJF Leasing also operates within the property boundry on the northeast corner of the site. Both AJF and Transcon-operations are situated on a portion of the site owned by the Baptist Foundation of Texas.

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### 3.2 Designation as Superfund Site/Current Activities

In the early 1980's the Harris County Metropolitan Transit Authority (MTA) became interested in the site for a combined railyard, shop, and station for a proposed light rail transit system. During routine geotechnical investigations by McClelland Engineers Inc. (MEI) for preliminary design purposes, several localized areas were found to be contaminated with creosote waste products. Camp Dresser & McKee Inc. (CDM) was then retained to perform a contaminant survey and to develop remedial measures that would mitigate the contamination and allow use of the land by MTA. During the course of CDM's work MTA revised their construction plans to largely exclude the area north of Cavalcade Street. CDM's report, "Cavalcade Contaminant Survey", dated July 11, 1983, documented the

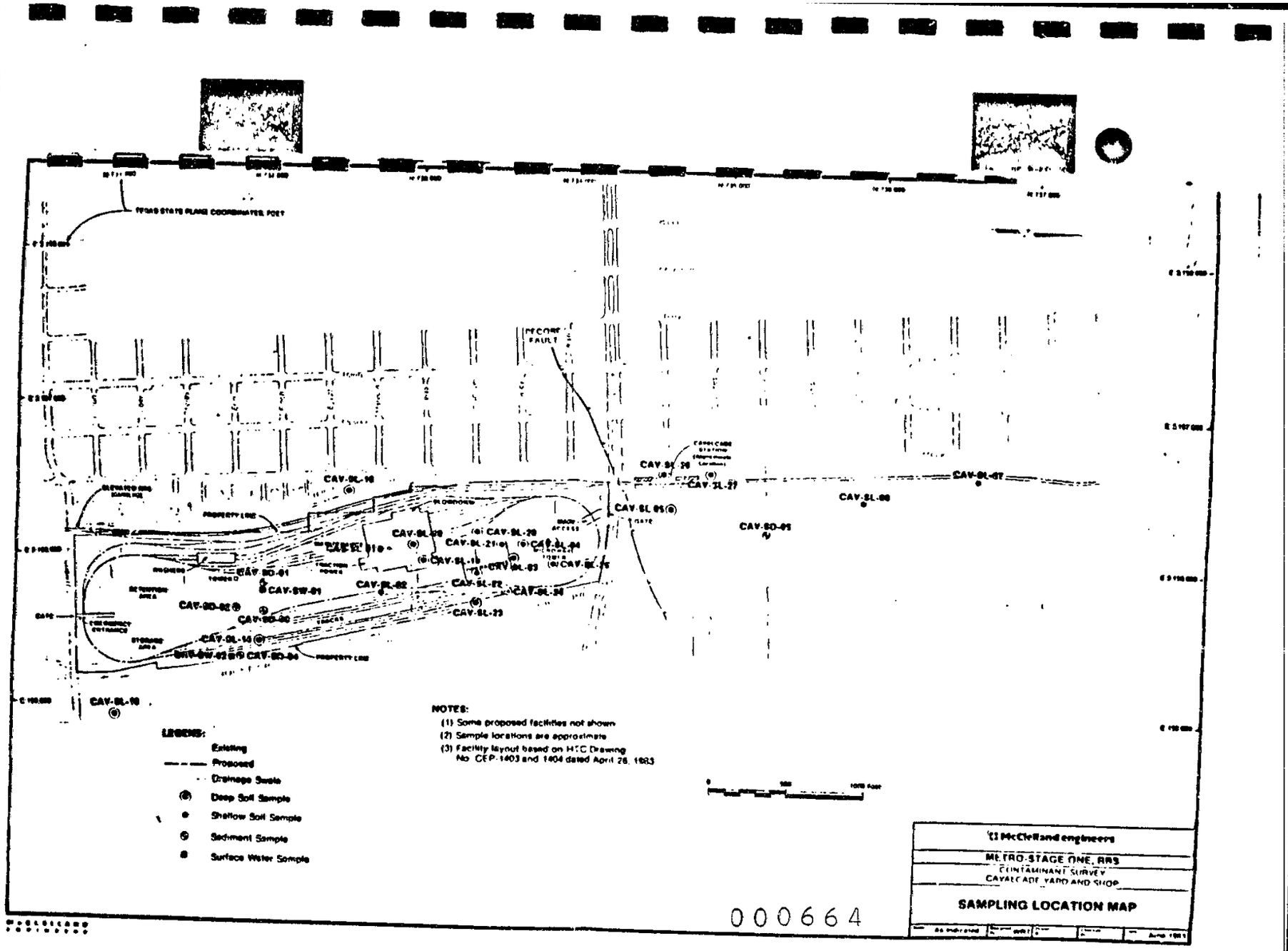
TEXAS STATE PLANE COORDINATES, FEET
RECORD FAULT
CAV-SL-16
CAV-SL-20
CAV-SL-21
CAV-SL-22
CAV-SL-23
CAV-SL-24
CAV-SL-25
CAV-SL-26
CAV-SL-27
CAV-SL-05
CAV-SL-06
CAV-SL-07
CAV-SD-01
CAV-SW-01
CAV-SD-02
CAV-SD-03
CAV-SD-04
CAV-SD-05
CAV-SL-10
PROPERTY LINE
LEGENDS:
Existing
Proposed
Drainage Swale
Deep Soil Sample
Shallow Soil Sample
Sediment Sample
Surface Water Sample
NOTES:
(1) Some proposed facilities not shown
(2) Sample locations are approximate
(3) Facility layout based on HTC Drawing No. CEP-1403 and 1404 dated April 26, 1983
McClelland engineers
METRO-STAGE ONE, RRS
CONTAMINANT SURVEY
CAVALCADE YARD AND SHOP
SAMPLING LOCATION MAP
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TABLE 3-1
CONTAMINANT SURVEY RESULTS
HIGHEST CONCENTRATION DETECTED (SAMPLE NO. DETECTED IN)

| | SEDIMENT SAMPLES | SURFACE WATER SAMPLES | SURFACE SOIL SAMPLES | SUBSURFACE GROUNDWATER SAMPLES | SHALLOW GROUNDWATER SAMPLES | DEEP GROUNDWATER SAMPLES | PRODUCTION WELL SAMPLES |
|---|---|---|---|---|---|---|---|
| Volatile Organics | (ug/kg) | (ug/l) | (ug/kg) | (ug/kg) | (ug/l) | (ug/l) | (ug/l) |
| Methylene Chloride | 110(SD-04) | | 59(SL-01,03) | 73(SL-04-03) | | | |
| Ethylbenzene | | | 160(SL-04) | | 58(OW-02) | | |
| Toluene | | | 23(SL-04) | | 110(OW-02) | 49(OW-06) | |
| Benzene | | | | | 21(OW-02) | | |
| Refractory Organics | (ug/kg) | (ug/l) | (ug/kg) | (ug/kg) | (ug/l) | | |
| Anthracene | 4700(SD-02) | | 240000(SL-04) | 520000(SL-04-02) | | | |
| Benzo (a) anthracene | 18000(SD-04) | 10(SW-02) | 32000(SL-03) | 32000(SL-03-01) | | | |
| Benzo (a) pyrene | 5400(SD-04) | 10(SW-02) | 21000(SL-03) | 32000(SL-04-03) | 29(OW-02) | | |
| 3,4-Benzofluoranthene | 4800(SD-04) | 21(SW-02) | 46000(SL-03) | 46000(SL-03-01) | | | |
| Benzo (g,h,i) perylene | 430(SD-01) | | 7200(SL-03) | 7200(SL-03-01) | | | |
| Bis (2-ethyhexyl)phthalate | 210(SD-01) | | | | 17(OW-02) | | |
| Chrysene | 14000(SD-04) | 12(SW-02) | 42000(SL-03) | 42000(SL-03-01) | | | |
| Fluoranthene | 25000(SD-04) | 17(SW-02) | 260000(SL-04) | 440000(SL-04-02) | 34(OW-02) | | |
| Ideno (1,2,3,c,d)pyrene | 600(SD-03) | | 7200(SL-03) | 7200(SL-03-01) | | | |
| Phenanthrene | 14000(SD-01) | | 240000(SL-04) | 240000(SL-04-02) | 240(OW-02) | | |
| Pyrene | 22000(SD-04) | 14(SW-02) | 170000(SL-04) | 280000(SL-04-02) | 27(Ow-02) | | |
| Fluorene | 520(SD-04) | | 80000(SL-04) | 110000(SL-04-02) | 300(OW-02) | | |
| Aceraphthene | 580(SD-04) | | | | | | |
| Benzo(k)fluoranthene | | 21(SW-02) | 46000(SL-03) | 46000(SL-03-01) | | | |
| Di-n-butyl phthalate | | 18(SW-02) | | | 34(OW-02) | | |
| Acenaphthene | | | 100000(SL-04) | 360000(SL-04-02) | 380(OW-02) | | |
| Acenaphthylene | | | 3000(SL-04) | 3200(SL-04-03) | 30(OW-02) | | |
| Naphthalene | | | 340000(SL-04) | 200000(SL-04-03) | 17000(OW-02) | | |
| Di-n-octal phthalate | | | 11(SL-02) | | | | |
| Dibenzo(a,h)anthracene | | | | 5000(SL-04-03) | | | |
| 2,4 Dimethyphenol | | | | | 680 (OW-02) | | |
| Pentachlorophenol | | | | | 66(OW-02) | | |
| Phenol | | | | | 59(OW-02) | | |
| Butyl Benzyl Phthalare | | | | | 17(OW-02) | | |

TABLE 3-1 (Cont'd)
CONTAMINANT SURVEY RESULTS
HIGHEST CONCENTRATION/DETECTED (SAMPLE NO. DETECTED IN)

| Toxic Metals and Inorganics | SEDIMENT SAMPLES (mg/kg) | SURFACE WATER SAMPLES (mg/l) | SURFACE SOIL SAMPLES (mg/kg) | SUBSURFACE GROUNDWATER SAMPLES (mg/kg) | SHALLOW GROUNDWATER SAMPLES (mg/l) | DEEP GROUNDWATER SAMPLES (mg/kg) | PRODUCTION WELL SAMPLES (mg/l) |
|---|---|---|---|---|---|---|---|
| Arsenic (AS) | 2.4(SD-02) | | 82(SL-03) | 82(SL-03-01) | 0.13(OW-02) | 12.0(SL-11) | |
| Beryllium (Be) | 0.6(SD-02) | | 0.29(SL-04) | 0.31(SL-04-04) | | 0.31(SL-19) | |
| Cadmium (Cd) | 1.4(SD-04) | .05(OW-01) | 0.88(SL-04) | 0.5(SL-04-03) | | 0.31(SL-19) | 0.04(PW-02) |
| Chromium (Cr) | 13.0(SD-02) | | 79(SL-03) | 79(SL-03-01) | | 17.0(SL-11) | |
| Copper (Cu) | 82.0(SD-04) | | 32(SL-02) | 21(SL-03-01) | 0.06(OW-01) | 4.0(SL-19) | |
| Lead (Pb) | 185(SD-04) | | 54(SL-03) | 54(SL-03-01) | | 7.5(SL-19) | 0.35(PW-01,02) |
| Mercury (Hg) | 0.043(SD-02) | | 0.04(SL-03) | .62(SL-03-02) | | 0.003(SL-11) | |
| Nickel (Ni) | 5.4(SD-03) | | 33(SL-02) | 15(SL-04-03) | | 4.6(SL-19) | |
| Silver (Ag) | 0.40(SD-01) | | 0.7(SL-04) | 1.2(SL-04-03) | | | |
| Thallium (Th) | 0.97(SD-03) | | 0.1(SL-03) | 0.1(SL-03-01) | | 2.1(SL-11) | |
| Zinc(Zn) | 160(SD-01) | .32(SD-01) | 290(SL-03) | 290(SL-03-01) | 0.20(OW-02) | 7.3(SL-19) | .58(PW-01) |
| Total Cyanide (Cn) | | | | | 0.70(OW-01) | | |
| Antimony | | | | | | 0.1(OW-06)* | |
| Selenium | | | | | | 0.26(OW-06)* | |

(*reported as mg/l)



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## 3. SITE DESCRIPTION

presence of soil and shallow groundwater contaminated with creosote waste products and heavy metals. Failure of bond issue in May 1983 resulted in the termination of CDM's work prior to selection of an appropriate remedial alternative and site remediation.

After the bond failure, the site fell under the jurisdiction of the Texas Department of Water Resources (TDWR). Shortly thereafter, the site was handed over the the US EPA and was placed on the National Priority List (NPL).

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# 4. ENVIRONMENTAL SETTING

## 4.1 Physiography

The site is currently bounded by the Houston Belt Terminal railroad tracks to the east, Cavalcade Road to the north, Missouri Pacific railroad tracks to the west, and Collingsworth Road to the south. The site currently consists of approximately 45 acres on a parcel of land 1-1/2 miles southwest of the intersection between Loop 610 and U.S. Route 59 (Eastex Freeway).

## 4.2 Geology

Surfically, exposed soils within the site boundaries consist of a grey silty fine sand. A total of 15 soil borings were drilled ranging in depths from 15 to 80 feet at the South Cavalade Street Site. These soil borings generally indicated four distinct soil strata varying slightly throughout the area of the site. Although there are some variations in the elevations and thicknessess, the following generalized soil strata appear to be continuous throughout the site.

| Stratum | Depth | Description |
|---|---|---|
| I | 0-2 | Fill: Silty fine sand |
| II | 2-10 | Sandy clay and clayey sand |
| III | 10-20 | Very dense fine sand |
| IV | 20-80 | Very stiff and silty clay |

## 4.3 Hydrogeology

The geologic strata underlying the Cavalcade Yard site consist principally of interbedded sands, silts, and clays of the Beaumont Formation. As shown on Plate 5-5, these sediments were deposited in fluvial (river) and deltaic environments during the Pleistocene Epoch. Clay and silt soils predominate in the upper 200 to 300 ft of the Beaumont Formation. Layers of sand frequently occur as thin, discontinuous deposits of rather limited extent. Thicker, more continuous sand deposits occur in the deeper parts of the Beaumont formation and in the upper parts of the underlying Lissie Formation. however, based on published geologic reports, the Lissie Formation outcrops several miles north of the site area.

The Lissie Foundation and the lower Beaumont Formation are commonly used sources of groundwater supplies in the Houston area, although their yields are generally considered too small for major exploitation. The deeper sands from the Chicot and Evangeline Aquifers, located over 1000 feet deep, are high yield aquifers used for major groundwater supplies.

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# 4. ENVIRONMENTAL SETTING

The strata of the Beaumont Formation generally dip to the southeast towards the Gulf of Mexico. Thus, the sediments exposed at the surface become progressively younger toward the coast. The regional dip of the strata and the presence of the interbedding of the sands and clays result in considerable influence on the regional hydrogeology of the Houston area. Based on published geologic literature, the principal areas of groundwater recharge for the Chicot and Evangeline Aquifers (i.e., Lissie Formation) occur several miles north of the site area.

The predominance of clay and silt soils in the upper part of the Beaumont Formation and the southeastward dip of the geologic strata serve to act as a confining layer for the Chicot Aquifer. This produces artesian groundwater conditions in the Chicot Aquifer. The limited sand layers in the upper Beaumont Formation are considered too discontinuos to allow effective recharge to the deeper aquifers.

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## 4.4 Project Overview

The United States Environmental Protection Agency has requested a work plan be established to be performed on the South Cavalcade Site in Houston, Texas. The purpose of the work plan is to establish problem areas on the site and devise a procedure for the design of a clean up program.

# 5. PROJECT ORGANIZATION AND RESPONSIBILITY

Nancy B. Johannesmeyer

Robert Kier

## 5.1 PROJECT ORGANIZATION

### 5.1.1 Overview

The project management organization of the South Cavalcade Site is designed to provide a clear line of functional and program responsibility and authority, supported by a management control structure. Basically, this control structure, centered around the placement of the Officer-in-Charge and Project Manager, provides for:

- o Clearly identified lines of communication and coordination
- o Monitoring of program budget, schedules and financial performance
- o Managing key technical resources
- o Providing periodic financial management and progress reports
- o Health and Safety
- o Quality Control

Following is a listing of the personnel assigned to this project and their area of responsibility.

| Name | Role |
|---|---|
| Gary A. Dunbar | Officer-in-Charge |
| David F. Doyle | Technical Advisor |
| Robert Kier | Project Manager |
| Richard Thompson | Quality Assurance Coordinator |
| To be designated | Health and Safety Officer |
| " | Project Engineer |
| " | On-site Coordinator |
| " | Senior Geologist |
| " | Field Engineer |
| " | Geologist |
| " | Chemist |

### 5.1.2 Subcontractors

Camp Dresser & McKee (CDM) is the prime contractor for the South Cavalcade Site projec and will provide overall project management, coordination and quality control. Subconsultants to CDM and others and their relationship to the project are as follows: [To be specified.]

## 5.2 RESPONSIBILITY

For the purposes of the field investigations program outlined herein, Robert Kier has been delegated responsibility for Project Management. It is the on-site coordinators responsibility to ensure that all field investigation tasks are conducted in strict compliance with the selected procedures.

## 5. PROJECT ORGANIZATION AND RESPONSIBILITY

Nancy B. Johannesmeyer

Robert Kier

Subcontractor personnel and corporations (Section IV.A.2) providing services in support of this project will perform such work in strict compliance with the appropriate contract specification for the activity. Responsibility for the health and safety of corporate and subcontractor personnel rests directly with the corporation or subcontractor. Any observed significant variance from standard Health and Safety Guidelines that is not expeditiously corrected by the subcontractor should be brought to the immediate attention of the Project Manager (Robert Kier), or the Health and Safety Manager as appropriate.

## 6. QUALITY ASSURANCE OBJECTIVES

Nancy Johannesmeyer

Robert Kier

Specific requirements for accuracy, precision, representativeness and completeness for the South Cavalcade Site field investigation program are delineated according to sample collection and analytical (laboratory) quality assurance guidelines. It is recognized that the overall criteria of project accuracy, precision, completeness, representativeness, and comparability are the combination of both these elements.

### 6.1 Field Investigations

Field Investigations conducted in support of this program, to include:

1. Air Sampling
2. Subsurface Soil Sampling
3. Monitoring Well Installation
4. Falling Head Permeability Testing
5. Groundwater Sampling - (Shallow and Deep)
6. Surface Water Sampling
7. Surface Sediment Sampling
8. Miscellaneous Non-soil Tests.

000672

will be executed in strict compliance with specific operational procedures for these activities.

Specific calibration, operational and documentation procedures associated with the individual activities will assure the accuracy, precision, completeness, and traceability of all the field data and observations.

### 6.2 Sample collection

Samples will be collected for the following tasks:

1) Air Sampling
2) Subsurface Soil Sampling
3) Groundwater Sampling
4) Surface Water Sampling
5) Sediment Sampling

All samples collected under these specified tasks will meet all identified quality assurance/quality control requirement as described. These samples will be used as technical data to provide engineering services for site remediation. These samples will not be used as evidence for future enforcement.

### 6.3 Duplicate Samples

One (1) of every twenty (20) samples will be taken in duplicate and analyzed separately for each type (matrix) or material sampled on site (i.e., groundwater, soil/sediments waste). Duplicates will be run for every air sample collected.

## 6.4 Travel/Trip Blank

A travel blank consists of a set of sample containers filled with laboratory demonstrated analate free water. (This water preferably should be of the same quality as th method blank water used by the laboratory performing the specific analysis). These travel blanks should be handled, transported, and analyzed in the same manner as the samples acquired that day.

## 6.5 Field Blank

A field blank consists of two sets of laboratory cleaned sample containers. One set o containers is empty and will serve as the sample containers that will be analyzed. Th second set of containers are filled at the laboratory with laboratory demonstrated ana lyte free water. At the field location, this analyte free water is then passed throug laboratory cleaned sample equipment and placed in the empty set of sample containers for analysis.

## 6.6 Blank Requirements

a) A set of field and travel blanks must accompany all water samples on each day of sampling. Organic priority pollutant blanks are required for these samples.

b) A set of field and travel blanks must accompany all soil and sediment samples on each day of sampling. Purgeable organic blanks are required for these samples.

c) 2 sets of field blanks will be required for the air sampling program.

The criteria and representativeness (does subsample have the same measurable character istics as the total sample?) if defined by the sampling method utilized. Blind duplicate samples collected as part of the field programs monitor the representativeness of specific samples. A precision of sameness of +60% is acceptable for ordinary sample matrices. Representative samples will be collected as follows:

- Groundwater: the site geologist will exercise field judgement to insure that the monitoring wells will be sampling the aquifer of interest. Representative samples will be collected by evacuating three to ten well volumes or by evacuating water until a stabilized specific conductance is reached before collecting the sample for laboratory analysis. The well volumes are evacuated to insure that aquifer water is being sampled. The amount of water evacuated will be documented by the sampling team.

- Soil: Subsurface soil samples or equivalent will be continuously collected an retained. Subsurface soil samples will also be taken at monitoring well installations.

- Surface Water: The site geologist will exercise field judgement in determin exact location of surface water sampling. Sampling will be done in two rounds The first set of samples in each round will be taken at the "first flush" or

when runoff first begins during a storm event. The second set will be taken after rainfall has ceased but runoff continues.

- Sediment: Sediment samples will be taken everywhere a surface water sample ha been taken.

- Air: Air samples will be collected upwind and downwind of the site to characterize emissions emanating from the site.

The groundwater, and soil, representative and judgemental samples will be collected as defined in "Test Methods for Evaluating Solid Waste", USEPA, SW-846 July 1982.

The criteria of completeness is a measure of the amount of valid data obtained from the measurement system compared with the amount that was expected under normal conditions. This criterion is expressed as a percentage. The criterion for South Cavalcade is 90%.

The criterion of accuracy (the comparison of a reported value to a known value) for field programs is usually achieved by introducing some form of randomness into the process. Randomness has been introduced in location selection. Groundwater, surface water, and soil sampling locations were established randomly in general areas of the various media. Accuracy of analytical data is the responsibility of the laboratory.

The criterion of precision (reproducibility of the measurement) may be applied to the field data for South Cavalcade Site. The overall precision of the field measurements i a combination of the analytical and sampling precision. The analytical precision is the responsibility of the laboratory. The sampling precision is defined by the procedures utilized, including equipment calibration and field blank/duplicate samples

## 6.7 Laboratory Quality Assurance/Quality Control

### 6.7.1 Objective

The primary objective of the analytical quality assurance/quality control plan is to ensure the integrity of analytical results. To this end, all samples collected during the project will be analyzed according to the approved methodology and other QA/QC requirements detailed in this plan.

Specific criteria of accuracy and precision for each major measurement parameter are detailed within the individual EPA test method (see Section IX, Analytical Procedures).

### 6.7.2 Laboratory QA/QC Program

Analytical subcontractors maintain active laboratory quality assurance programs to ensure the integrity of all analytical results. The following summarizes some aspects of these programs.

All laboratory instruments have rigorous maintenance and calibration schedules. Where applicable, the instrumentation is calibrated using standard solutions or standardized techniques whenever in use.

## 6. QUALITY ASSURANCE OBJECTIVES

All test methods and analytical results are checked and approved by qualified personnel. Routine sample replicates and blind reference standards are employed in the laboratory as an integral part of the quality assurance program. The laboratories are participants in cooperative split sampling programs to monitor the ability to achieve accurate results.

A comprehensive test quality assurance manual is maintained, which documents all sample collection, storage, and analysis procedures, as well as the instrumentation calibration and maintenance protocol. These procedures do not vary unless revisions are approved through proper channels. The quality assurance plan also includes documented staff training procedures. All laboratory personnel have scientific educational backgrounds.

The laboratories quality assurance programs conform in all detail to that specified by the Environmental Protection Agency (EPA). All testing and analytical procedures used in the laboratories have been developed using the standard methodologies of the EPA, American Society of Testing Material (ASTM), American Public Health Association (APHA), Water Pollution Control Federation (WPCF), American Industrial Hygiene Association (AIHA), Food and Drug Administration (FDA), and the Association of Official Analytical Chemists (AOAC).

Laboratories providing analytical support for the South Cavalcade Site Sampling and Analytical Plan are all active participants in the Environmental Protection Agency's performance evaluation test program for conventional and organic pollutants.

Specific laboratory QA/QC procedures to be followed for this project are included in Appendix II, Laboratory, QA/QC procedures. Quality assurance programs for the subcontractor laboratories are available on request.

# 7. SAMPLING PROTOCOL/ FIELD INVESTIGATIONS

## 7.1 Introduction

The purpose of this section is to identify the specific sampling and analytical, quality assurance/quality control and health and safety procedures to be utilized in the field investigation conducted during the South Cavalcade Program. Procedures for air sample collection, exploration well installation, falling head permeability testing, subsurface soil sampling, surface water sampling, sediment sampling and groundwater sample collection are based upon the specific standard operating procedure (SOPs) identified in the REM-II - Field Investigations Protocols. Specific procedures for meeting quality assurance/quality control requirements to be utilized during this activity are based upon the REM-II Quality Assurance/Quality Control Plan. Requirements used to meet health and safety needs for on-site and off-site activity ar based upon the REM-II Health and Safety Assurance Manual. It is intended that this plan be used as a guide to select field procedures and that these identified procedures be followed to assure valid analytical results.

## 7.2 Health and Safety Procedures

7.2.1 Overview: The purpose of these procedures is to identify the specific health and safety requirements necessary to implement the field activities identified in the project operations plan (POP). Specific criteria used to determine fiel monitoring and personal protective equipment are based upon guidelines identified in the REM-II Health and Safety Assurance Manual. It is intended that this plan be used as a guide to select field procedures and that these identified procedures be followed to assure that appropriate health and safety concerns ar met.

7.2.2 Site Description: A comprehensive discussion of site history and environmental setting is contained in Section 3 part 3.1.

7.2.3 Health and Safety Procedures: The REM-II Health and Safety Assurance Manual which outlines the specific health and safety procedures is to be implemented during investigations at hazardous sites and controlled substances work areas. The procedures outlined in that document will be followed during the South Cavalcade investigations.

The following pages present some of the information critical to maintaing the established Health and Safety procedures. This information includes:

- Site personnel safety forms.
- Required and contingent personal protection.
- Emergency phone numbers and services (all emergency phone calls to be made from the front gate.
- Health and Safety data on chemicals that may be encountered during the investigation.

**SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM**



EPA WA NO. _____ REM II DOC. NO. 143-WP1-OP-ATAD-

SITE: South Cavalcade Site EPA REGION: VI

LOCATION: Cavalcade St. Houston, Tx EVALUATOR: N. Johannesmeyer

**SITE DESCRIPTION:** Former wood treating operation on approximately 45 acres of land. Plant was in operation from 1911 to 1962. Suspected contaminants include creosote, pentachlorophenol and heavy metals.

**SITE MAPS ATTACHED:** [X] See Figure 7.1

**BACKGROUND ENVIRONMENT:** Known subsurface contamination, possible subsurface contamination.

**AIR** No contamination noted during site survey 1/1983.

**SURFACE WATER** Some ponded areas and drainage pathways off the site.

**SOIL** Known subsurface soil contamination. Possible surface contamination in drainage pathways.

**GROUNDWATER** Evidence of groundwater contamination during monitoring well sampling 4/83

**ADDITIONAL HAZARDS ON SITE** A packing and trucking operation currently exists on the site. Site is situated in a high crime area.

**INFORMATIONAL SOURCES USED** Camp Dresser & McKee Contaminant Survey 7/83.

Camp Dresser & McKee Site Inspection Report 2/85

000677

REM II DOC. NO. 143-WP1-OP-ATAD

FIELD INVESTIGATION ACTIVITIES COVERED UNDER THIS SEF

POP DOCUMENT CONTROL NO. _____

| TASK NO | DESCRIPTION | PRELIMINARY SCHEDULE |
|---|---|---|
| 01 | Monitoring well installation | To be decided |
| 02 | Falling Head Permeability Test | To be decided |
| 03 | Groundwater Sampling (Shallow and Deep) | To be decided |
| 04 | Surficial Soil Sampling | To be decided |
| 05 | Subsurface Soil Sampling | To be decided |
| 06 | Surface Water Sampling | To be decided |
| 07 | Sediment Sampling | To be decided |

# SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM



REM II DOC. NO. 143-MP1-OP-ATAD-

## CONTAMINANTS OF CONCERN

| CONTAMINANT | GUIDELINE SHEET ATTACHED | I.D.L.H. (PPM) | SOURCE/QUANTITY CHARACTERISTICS | ROUTE OF EXPOSURE | SYMPTOMS OF ACUTE EXPOSURE | INSTRUMENT RESPONSE FACTORS PID[1] | FID[2] | OTHER |
|---|---|---|---|---|---|---|---|---|
| Ethylbenzene | Y | 100 | 160ug/kg soil<br>58 ug/l water | Con, Inh, Ing. | MVC Memb.<br>Irrt. Skin, Eyes | | | |
| Benzene | Y | 2000 | 21 ug/l water | Abs, Inh, Ing | Resp. sys.<br>Irrt. skin, eyes | | | |
| Methylene Chloride | Y | 5000 | 110 ug/l soil | Con, Inh, Ing | Fatique, Nausea<br>Burns Skin, eyes | | | |
| Toluene | Y | 2000 | 23 ug/kg soil<br>110 ug/l water | Abs, Inh, Ing | Fatique, Head-ache, Nausea | | | |
| Naphtahlene | Y | 500 | 200000 ug/kg soil<br>17000 ug/l water | Abs, Inh. Ing | Eye Irrt.<br>Headache, Nausea | | | |
| Pentachlorophenol | Y | 150 mg/m$^3$ | 66 ug/l water | Abs, Inh, Ing | Weak, Nausea<br>Irrt. eys, nose | | | |
| Phenol | Y | .5 mg/m$^3$ | 59 ug/l water | Con, Abs, Inh, Ing | Weak, Skin burn<br>Irrt eyes, nose | | | |
| Di-n-butylphthalate | Y | 1 mg/m$^3$ | 34 ug/l water | Con, Inh, Ing | Irrt nose<br>stomach | | | |
| Chromium | Y | - | 79 mg/kg soil<br>.58 mg/l water | Inh, Ing | lung fibrosis | | | |
| Zinc | Y | - | 290 mg/kg soil<br>27 ug/l water | Inh, Con | Irrt skin, eyes | | | |
| Pyrene | | - | 280000 ug/kg soil<br>34 ug/l water | - | - | | | |
| Fluoranthene | | - | 440000 ug/kg soil<br>300 ug/l water | - | - | | | |
| Fluorene | | - | 110000 ug/kg soil | - | - | | | |
| Acenaphthene | | - | 360000 ug/kg soil | - | - | | | |

1. Ionization potential(eV) 2. %AS $CH_4$

000679

# SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM



REM II DOC. NO. 143-WP1-OP-ATAD-1

**SITE PERSONNEL/EQUIPMENT** SITE ACTIVITY (1) Monitoring well Installation

**PERSONNEL**

| NAME | S.S. NO. | FIRM | REGION | LEVEL OF PROTECTION | CONTINGENCY | VERIFY |
|---|---|---|---|---|---|---|
| To be designated | | | | | | ( ) |
| Person at drill bit | | | VI | C | B | ( ) |
| Onlookers | | | VI | D | C | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |

| PERSONNEL PROTECTIVE EQUIPMENT | VERIFY | FIELD MONITORING EQUIPMENT | VERIFY |
|---|---|---|---|
| ~~Neoprene Boots Hard Hats~~ | ( ) | HNu photoanalyzer | ( ) |
| Neoprene Gloves | ( ) | Organic Vaport Analyzer | ( ) |
| Air Purifying respirator | ( ) | Geiger Counter | ( ) |
| Organic vapor cartridges | ( ) | | ( ) |
| Tyvek cover alls (onlookers) | ( ) | | ( ) |
| Saranex coveralls (person at drill bit) | ( ) | | ( ) |
| PVC inner gloves | ( ) | | ( ) |
| SCBA contingency | ( ) | | ( ) |
| Butyl bootcovers | | | |

000680

**DECON:** Dispose of all expendables on-site. Decon Equipment w/Algonox detergent solution.

# SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM



REM II DOC. NO. 141-WP1-OP-ATAD-1

**SITE PERSONNEL/EQUIPMENT** SITE ACTIVITY (2) Falling Head Permeability Test

**PERSONNEL**

| NAME | S.S. NO. | FIRM | REGION | LEVEL OF PROTECTION | CONTINGENCY | VERIFY |
|---|---|---|---|---|---|---|
| To be designated | | VI | | D | C | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |

| PERSONNEL PROTECTIVE EQUIPMENT | VERIFY | FIELD MONITORING EQUIPMENT | VERIFY |
|---|---|---|---|
| Tyvek Coveralls | ( ) | HNu | ( ) |
| Neoprene Boots | ( ) | Organic Vapor Analyzer | ( ) |
| PVC Inner Gloves | ( ) | | ( ) |
| Neoprene Outer Gloves | ( ) | | ( ) |
| Respirator - GMCH Cartridges - Contingency | ( ) | | ( ) |
| Saranex Coveralls - contingency | ( ) | | ( ) |
| Butyl bootcovers | ( ) | | ( ) |
| | ( ) | | ( ) |

**DECON:** Same

000681

# SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM



REM II DOC. NO. 143-WP1-OP-ATAD-1

**SITE PERSONNEL/EQUIPMENT** **SITE ACTIVITY** (3) Groundwater Sampling

**PERSONNEL**

| NAME | S.S. NO. | FIRM | REGION | LEVEL OF PROTECTION | CONTINGENCY | VERIFY |
|---|---|---|---|---|---|---|
| To be designated | | | VT | D | C | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |

| PERSONNEL PROTECTIVE EQUIPMENT | VERIFY | FIELD MONITORING EQUIPMENT | VERIFY |
|---|---|---|---|
| Respirator - GMCH Cartridge | ( ) | HNu Photoanalyzer w/10.2 probe | ( ) |
| PVC Splashsuits | ( ) | OVA | ( ) |
| Neoprene Boots | ( ) | | ( ) |
| PVC Inner Gloves | ( ) | | ( ) |
| Neoprene Outer Gloves | ( ) | | ( ) |
| Butylrubber Bootcovers | ( ) | | ( ) |
| Tyvek Coveralls | ( ) | | ( ) |
| | ( ) | | ( ) |

**DECON:** Same

000682

# SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM



REM II DOC. NO. 141-WP1-CP-ATAD-

**SITE PERSONNEL/EQUIPMENT** SITE ACTIVITY (5) Subsurface Soil Sampling

**PERSONNEL**

| NAME | S.S. NO. | FIRM | REGION | LEVEL OF PROTECTION | CONTINGENCY | VERIFY |
|---|---|---|---|---|---|---|
| To be designated | | | VI | C | B | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |

| PERSONNEL PROTECTIVE EQUIPMENT | VERIFY | FIELD MONITORING EQUIPMENT | VERIFY |
|---|---|---|---|
| PVC Splashsuit | ( ) | HNu Photoanalyzer | ( ) |
| Tyvek Coveralls | ( ) | Organic Vapor Analyzer | ( ) |
| Neoprene Boots | ( ) | Geiger Counter | ( ) |
| Butyl Bootcovers | ( ) | | ( ) |
| PVC Inner Gloves | ( ) | | ( ) |
| Neoprene Outer Gloves | ( ) | | ( ) |
| Air Purifying Respirator - GMCH Cartridge | ( ) | | ( ) |
| SCBA - Contingency | ( ) | | ( ) |

000683

**DECON:** Same

# SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM



REM II DOC. NO. 143-WP1-OP-ATAD-1

**SITE PERSONNEL/EQUIPMENT** SITE ACTIVITY (6) Surface Water Sampling

**PERSONNEL**

| NAME | S.S. NO. | FIRM | REGION | LEVEL OF PROTECTION | CONTINGENCY | VERIFY |
|---|---|---|---|---|---|---|
| To be designated | | | VI | D | C | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |

| PERSONNEL PROTECTIVE EQUIPMENT | VERIFY | FIELD MONITORING EQUIPMENT | VERIFY |
|---|---|---|---|
| PVC Splashsuit | ( ) | HNu | ( ) |
| Tyvek Coveralls | ( ) | OVA | ( ) |
| Neoprene Boots | ( ) | | ( ) |
| Butyl Bootcovers | ( ) | | ( ) |
| Neoprene Gloves | ( ) | | ( ) |
| PVC Innergloves | ( ) | | ( ) |
| Respirator - GMCH cartridge | ( ) | | ( ) |
| | ( ) | | ( ) |

**DECON:** Same

000684

# SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM



REM II DOC. NO. 143-WP1-OP-ATAI

**SITE PERSONNEL/EQUIPMENT** **SITE ACTIVITY** (7) Sediment Sampling

**PERSONNEL**

| NAME | S.S. NO. | FIRM | REGION | LEVEL OF PROTECTION | CONTINGENCY | VERIFY |
|---|---|---|---|---|---|---|
| To be designated | | | VI | D | C | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |
| | | | | | | ( ) |

| PERSONNEL PROTECTIVE EQUIPMENT | VERIFY | FIELD MONITORING EQUIPMENT | VERIFY |
|---|---|---|---|
| PVC Splashsuit | ( ) | HNu | ( ) |
| Tyvek Coveralls | ( ) | OVA | ( ) |
| Neoprene Boots | ( ) | Geiger Counter | ( ) |
| Butyl Bootcovers | ( ) | | ( ) |
| Neoprene Gloves | ( ) | | ( ) |
| PVC Innergloves | ( ) | | ( ) |
| Respirator - GMCH Cartridge - Contingency | ( ) | | ( ) |
| | ( ) | | ( ) |

000685

**DECON:** Same

# SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM



REM II DOC. NO. 143-WP1-OP-ATAD-1

## CONTINGENCY CONTACTS

• DENOTES REQUIRED INFORMATION

| AGENCY | CONTACT | PHONE NO | AGENCY | CONTACT | PHONE NO |
|---|---|---|---|---|---|
| •FIRE DEPARTMENT | City of Houston | (713) 227-2323 | STATE POLICE | | (713) 463-8261 |
| POLICE DEPARTMENT | City of Houston | (713) 222-3131 | F A A | | |
| HEALTH DEPARTMENT | Harris County | (713) 342-8685 | CIVIL DEFENSE | | (713) 463-8261 |
| •POISON CONTROL CENTER | | | •ON SITE COORDINATOR | Mr. John Cochran | (214) 767-2630 |
| •STATE ENVIRONMENTAL AGENCY | TDWR | (713) 479-5981 | | | |
| •EPA REGIONAL OFFICE | Mr. John Cochran | (214) 767-2630 | | | |
| •EPA ERT, ICOM | | | | | |
| •STATE SPILL CONTRACTOR | | | | | |

## MEDICAL EMERGENCY

NAME OF HOSPITAL Citizen General Hospital ADDRESS 7407 North Freeway - Houston PHONE NO (713) 691-3531

NAME OF CONTACT ____ ADDRESS ____ PHONE NO ____

MAP OR ROUTE TO HOSPITAL: Take Cavalcade east to Route 59, Route 59 to 610 WEst Route 610 West to North Freeway. Exit at Little York Street. Take right on Molly, Hospital on left.

TRAVEL TIME FROM SITE (MINUTES) 25 DISTANCE TO HOSPITAL (MILES) 10 NAME OF 24 HR AMBULANCE SERVICE (713) 222-3434

000686

Spray workers exposed at 0.5% Dursban emulsion in field trials for malaria control on premises showed a measurable decrease in plasma and red cell cholinesterase levels.[10] In this study, 5 of 7 sprayers showed more than 50 per cent reduction in cholinesterase within two weeks after the spraying program began. In another study,[6] human volunteers were exposed to thermal aerosols containing Dursban insecticide for one period. Exposures of 3 to 8 minutes at concentrations of about 0.8 μm/m³ in air produced no significant alteration of cholinesterase levels. This concentration resulted from the recommended application rate in thermal fogging.

Available studies indicate that Dursban is rapidly metabolized in the animal body.[8]

There was evidence of teratologic or reproductive effects in male and female rats fed 1.0 mg/kg per day during a three-generation reporduction and fertility study.[11]

A TLV of 0.2 and a STEL of 0.6 mg/m³ are recommended to prevent any measurable decrease in plasma cholinesterase activities and provides a very wide margin of safety in preventing cholinergic symptoms or organic injury.


**References:**

1. Martin, H.: *Pesticides Manual*, 2nd ed., British Crop Protection Council (1971).
2. Spencer, E.Y.: *Guide to the Chemicals Used in Crop Protection*, Canada Dept. of Agriculture (1968).
3. *Merck Index*, 9th ed., p. 281, Merck & Co., Inc., Rahway, NJ (1976).
4. Gray, H.E.: *Down to Earth* 21.26 (1965). A Dow Chemical Co. Publication.
5. Gaines, T.B.: *Tox. Appl. Pharm.* 14.515 (1969).
6. Ludwig, P.O., Kilian, D.J., Dishburger, H.J., Edwards, H.N.: *Mosquito News* 30.346 (1970).
7. FAO/WHO Pesticide Residue Report, No. FAD/RES/72.6a (November 1972).
8. The Dow Chemical Company: Personal communication to TLV Committee, Midland, MI (1973).
9. Griffin, T.B. *et al. Soc. Tox. Abstract No. 32*, Atlanta, GA (March 1976).
10. Eliason, D.A., Cranmer, M.F., vonWindeguth, D.C., Kilpatrick, J.W., Sugs, J.E., Schoof, H.F.: *Mosquito News* 29.591 (1969).
11. The Dow Chemical Company: Communication to the TLV Committee of unpublished data (1972).


# CHROMIUM

Cr

*Metal and Inorganic Compounds as Cr*

**TLV, 0.5 mg/m³ — Metal**

**0.5 mg/m³ — Cr II Compounds**

**0.5 mg/m³ — Cr III Compounds**

**0.05 mg/m³ — Water Soluble Cr VI Compounds**

**0.05 mg/m³, Appendix A1a — Recognized Carcinogen — Certain Water Insoluble Cr VI Compounds**

*Chromium is a metallic element, atomic number 24, atomic weight 51.996, in Group VIB of the periodic table. It is a steel-gray, lustrous metal, with a specific gravity of 7.20. The melting point is 1900° C and boils at 2642° C. The metal reacts with dilute hydrochloric acid and sulfuric acid, but not with nitric acid.*

Chromium metal was first isolated in 1798. The chief uses of chromium and chromium compounds are in stainless and alloy steels, refractory products, tanning agents for leather, pigments, electroplating, catalyst and in corrosion resistant products. Chromium is obtained from chromite ores ($FeO \cdot Cr_2O_3$). Relatively large deposits of chromite ore were found near Baltimore in the United States but no mining has taken place there since 1961.

Chromium can have a valence of 2, 3 or 6, and a wide range of chromium alloys and inorganic chromium compounds are encountered in the workplace. These chromium compounds vary greatly in their toxic and carcinogenic effects. For this reason it is necessary to divide chromium and its inorganic compounds into a number of groupings — each with its specific TLV based on available toxicological and epidemiological evidence. These groupings are:

1. **Chromium metals and alloys**
   This grouping includes chromium metal, stainless steels and other chromium-containing alloys.
2. **Divalent chromium compounds ($Cr^{2+}$) (Chromous compounds)**
   This grouping includes chromous chloride ($CrCl_2$) and chromous sulfate ($CrSO_4$).
3. **Trivalent chromium compounds ($Cr^{3+}$) (Chromic compounds)**
   This grouping includes chromic oxide ($Cr_2O_3$), chromic sulfate ($Cr_2[SO_4]_3$), chromic chloride ($CrCl_3$), chromic potassium sulfate ($KCr[SO_4]_2$) and chromite ore ($FeO \cdot Cr_2O_3$).
4. **Hexavalent chromium compounds ($Cr^{6+}$)**
   This grouping includes chromium trioxide ($CrO_3$) — the anhydride of chromic acid — chromates (e.g., $Na_2CrO_4$), dichromates (e.g., $Na_2Cr_2O_7$) and polychromates. Certain hexavalent chromium compounds have been demonstrated to be carcinogenic on the basis of epidemiological investigations on workers and experimental studies in animals. In general, these compounds tend to be of low solubility in water and thus may be subdivided into two subgroups:
   (a) **Water soluble hexavalent chromium compounds**
   These include chromic acid and its anhydride, and the monochromates and dichromates of sodium, potassium, ammonium, lithium, cesium and rubidium.
   (b) **Water insoluble hexavalent chromium compounds**
   These include zinc chromate, calcium chromate, lead chromate, barium chromate, strontium chromate and sintered chromium trioxide.

### Hexavalent Chromium

The first cases of occupational health effects from hexavalent chromium were reported in 1827[12] by Cumin, who observed cases of skin ulceration and dermatitis in dye workers handling potassium dichromate. Mackenzie[13] in



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1884 reported that perforation of the nasal septum occurred in workers exposed to potassium bichromate. DaCosta *et al*[4] in 1916 described chrome ulcers in tanners and dryers. Parkhurst[5] in 1925 reported chrome dermatitis in blueprint workers exposed to potassium dichromate. Bloomfield and Blum[6] reported on their study of electroplaters exposed to acidic mist of hexavalent chromium compounds. They noted that 20 or 23 workers examined showed evidence of perforated or ulcerated nasal septa and skin ulcers (*chrome holes*). The Factory Inspectorate in Great Britain[7] reported in 1930 on the results of medical examinations of 223 persons engaged in chromium plating. 42.6% had dermatitis or skin ulcers and 52% had perforated or ulcerated nasal septa.

The occupational health literature affords abundant evidence that hexavalent chromium compounds may cause irritant and allergic contact dermatitis, skin ulcers, and nasal irritation varying from rhinitis to perforation of the nasal septum. Dermatitis from exposure to soluble hexavalent chromium has been reported in lithographers[8,9] diesel repair shop workers[10] and leather workers.[11] Soluble chromates in cement have been stated to be the cause of cement dermatitis in some workers.[12]

Attempts have been made to correlate the airborne levels of hexavalent chromium with irritation of the nasal mucosa. In the study by Bloomfield and Blum,[6] electroplaters were exposed to estimated exposures ranging from 0.06 to 2.8 mg/m³ (as $Cr^{6+}$). Levels of $Cr^{6+}$ in the form of chromium trioxide, were capable of giving rise to nasal irritation at concentrations as low as 0.06 mg/m³. It is difficult to rule out the importance of personal hygiene in the production of nasal symptoms from direct transfer of chromium ($Cr^{6+}$) to the nasal mucosa. Nasal irritation is produced from exposure to soluble chromate and bichromate salts as well as to chromic acid mist.[12,13] The study by the U.S. Public Health Service[14] noted that the mean concentration of water-soluble chromium in plants where nasal irritation was encountered was 0.068 mg/m³ as $Cr^{6+}$.

Epidemiological studies showing an increased incidence of lung cancer among workers involved in the manufacture of chrome pigments have been reported from Germany,[15] Norway[16] and United States.[17] Machle and Gregorius[13] first reported increased incidence of lung cancer in the United States chromate industry. Baetjer[18] carried out a case control study and confirmed the increased risk of lung cancer among the U.S. chromate workers. Mancuso and Hueper[19] attempted to estimate the airborne exposures to chromium in those who developed lung cancer. They found that these workers were exposed to 0.01 to 0.15 mg/m³ of water soluble chromium and 0.1 to 0.58 mg/m³ of water insoluble chromium. The insoluble fraction was denoted as $Cr^{3+}$ and the soluble as $Cr^{6+}$ but it is impossible to assign $Cr^{6+}$ or $Cr^{3+}$ exclusively to either fraction.

The chromate workers in the preceding studies were exposed to various $Cr^{3+}$ and $Cr^{6+}$ compounds as well as to other substances. In general, the evidence does not suggest that chromite ore, a water insoluble $Cr^{3+}$ substance, is a carcinogen. While the evidence is incomplete it does appear that certain $Cr^{6+}$ compounds, mainly water insoluble, were involved in increased risk of lung cancer. The experimental data from animals supports the view that water insoluble $Cr^{6+}$ compounds, e.g., chromic and zinc chromates, are carcinogenic, whereas the soluble forms are not.[20] Royle,[21] however, has reported an increase in lung and other cancers in chrome platers in England.

Hexavalent chromium compounds have been said to also cause kidney damage in workers[22,23] where absorption through damaged skin has occurred.

The TLVs for hexavalent chromium compounds are recommended as follows:

(a) Water soluble hexavalent chromium compounds (see examples noted above). A TLV of 0.05 mg/m³ as water soluble $Cr^{6+}$ is considered adequate to protect against irritation of the respiratory tract and possible kidney and liver damage. NIOSH in the criteria document on chromic acid[24] recommended that occupational exposures be controlled to prevent exposures above 0.05 mg/m³ TWA. In a later criteria document on hexavalent chromium[25] NIOSH recommended a permissible exposure limit of 0.025 mg/m³.

(b) Certain water insoluble hexavalent chromium compounds (see examples noted above). A TLV of 0.05 mg/m³ as water insoluble $Cr^{6+}$ and insertion in appendix A1a is recommended. There is, unfortunately, little previous environmental data from those exposures associated with increased respiratory cancer risk. With the data available, however, this TLV provides an adequate margin of safety. NIOSH recommended a permissible exposure limit of 0.001 mg/m³ for certain insoluble hexavalent chromium compounds.[25]

(c) Mixed exposure to soluble and insoluble hexavalent chromium compounds. A TLV of 0.05 mg/m³ as $Cr^{6+}$ is recommended.

(d) Chromite ore processing
Chromate pigment manufacture
It may be advisable to list these process TLVs both as 0.05 mg/m³ as Cr and include them in appendix A1a. This TLV will serve to draw attention to those processes where increased risk of cancer has been associated with chromium compounds.

**Chromium Metal**

**Divalent chromium compounds**
(see examples listed earlier)

**Trivalent chromium compounds**
(see examples listed earlier)

Early studies indicated that trivalent chromium and divalent chromium compounds have a low order of toxicity.[26] Dermatitis has been reported in workers handling trivalent chromium compounds.[27,28]

Chest X-rays carried out in workers exposed to chromite dust have been reported to show "exaggerated pulmonary markings"[29] and Princiel *et al*[30] have reported pulmonary disease in workers exposed to ferrochrome alloys with chromium levels in air of 0.27 mg/m³ reported. Other dusts and fumes were present, however, in this plant. Exposure to chromium metal does not give rise to pulmonary fibrosis or pneumoconiosis.



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Because of the low toxicity of the metal and its divalent and trivalent compounds, a TLV of 0.5 mg/m³ as Cr is recommended. This TLV should be adequate to prevent pulmonary disease or other toxic effect.

Other recommendations. Chromic acid and chromates, as Cr, Sweden (1978) 0.02 mg/m³, Czechoslovakia (1969) 0.05 mg/m³, USSR (1976) 0.005 mg/m³. Lower valence chromium, Sweden 0.5 mg/m³ for metal and compounds, as Cr; USSR, chromic oxide 1 mg/m³, chrome alum 0.02 mg/m³ and chromium trichloride 0.01 mg/m³, all as Cr.

**References:**


1. *Chromium*, Committee on Biological Effects of Atmospheric Pollutants, National Academy of Sciences, Washington, DC (1974).
2. Cumin, W.: *Edinburg Med Sug J* 28 295-312 (1827)
3. Mackenzie, J.N.: *JAMA* 3 601-603 (1884)
4. DaCosta, J.C. Jones, J.P.X., Rosenberger, R.C.: *Ann Surg* 63 155-166 (1916).
5. Parkhurst, H.J.: *Arch Dermatol Syphilol* 12 253-256 (1925)
6. Bloomfield, J.J., Blum, W.: *Pub Health Rep* 43 2330-2347 (1928)
7. Medical Inspectorate of Factories: *J Ind Hyg* 12 314-315 (1930)
8. McCord, C.P. Higginbottom, H.C., McGuire, J.C.: *JAMA* 94 1 043-1044 (1930)
9. Levin, H.M. Brunner, M.J. and Rattner, H.: *JAMA* 169 566-569 (1959)
10. Winston, J.R., Walsh, E.M.: *JAMA* 147 1133-1134 (1951)
11. Morris, G.E.: *Arch Ind Health* 11 368 371 (1955)
12. Englebrigtsen, J.K.: *Acta Derm Venereol* 32 462-468 (1952)
13. Machle, W., Gregorius, F.: *Pub Health Rep* 63 1114-1127 (1948)
14. Federal Security Agency: *Health of Workers in Chromate Producing Industry — A Study*, US Pub Health Serv., Div of Occupational Health (1953).
15. Gross, E., Kosch, F.: *Arch. Gewerbepath Gewerbehyg* 12 164-170, Germany (1943).
16. Langard, S. and Norseth, T.: *Brit. J. Ind Med* 32 62-65 (1975)
17. Equitable Environmental Health, Inc.: *An Epidemiological Study of Workers in Lead Chromate Plants*, final report to The Dry Color Manufacturers Assoc, Arlington, VA (June 25, 1976)
18. Baetjer, A.M.: *Arch Ind. Hyg & Occup Med* 2 505-516 (1950)
19. Mancuso, R.F., Hueper, W.C.: *Ind Med Sug* 20 358-363 (1951)
20. Laskin, S., Kuschner, M., Drew, R.T.: Studies in Pulmonary Carcinogenesis, *Inhalation Carcinogenesis*, M.G Hanna P Nettesheim & J R. Gilbert, Eds., pp. 321-351, US Atomic Energy Commission, Oak Ridge, TN (1969)
21. Royle, H.: *Env Res* 10 39-53 (1975)
22. Major, R.H.: *Johns Hopkins Hosp Bull* 33 56-61 (1922)
23. Hunter, W.C., Roberts, J.M.: *Am J. Pathol* 9 133-147 (1933)
24. NIOSH: *Criteria for a Recommended Standard — Occupational Exposure to Chromic Acid* (1973)
25. NIOSH: *Criteria for a Recommended Standard — Occupational Exposure to Chromium (VI)* (1975)
26. Akatsuka, K., Fairhall, L.T.: *J Ind Hyg* 16 1 (1934)
27. Morris, G.E.: *Arch Derm* 78 612 (1958)
28. Fregert, S., Rorsman, H.: *Arch Derm* 90 4 (1964), abstracted in *J Occ Med* 7 49 (1965)
29. Government of India: *Report No* 1, p 24, Ministry of Labour (1953)
30. Princi, F. Miller, L.H. Davis, A. Cholak, J.: *J Occup Med* 4 301 (1962)


## CHROMYL CHLORIDE

**Chromium dioxychloride**

$CrO_2Cl_2$

**TLV, 0.025 ppm ( ≈ 0.15 mg/m³)**

*A dark red, fuming liquid, chromyl chloride has a molecular weight of 154.92 and a specific gravity of 1.91 at 25° C. The freezing and boiling points are −96.5° C and 116° C, respectively. It is miscible with carbon tetrachloride and carbon disulfide; with water it reacts vigorously to form $CrO_3$, HCl, $CrCl_3$ and $Cl_2$*

Chromyl chloride is used in organic oxidations and chlorinations, as a solvent for $CrO_3$ and in making chromium complexes and dyes.

NIOSH has classified this compound as an inferred carcinogen, with an occupational exposure standard, calculated as Cr, of 1 μg/m³.[1] The subcutaneous $LD_{50}$ in mice has been reported to be 5.45 mg/kg.[2]

The physical and chemical properties of chromyl chloride suggest that it would belong in the group of soluble dichromates, $CrO_3$, etc., which are considered (by NIOSH) to be non-carcinogenic, rather than the sparingly soluble chromates that appear to have been responsible for most chromate worker cancers.

The propsed TLV of 0.025 ppm corresponds to 0.05 mg/m³ of Cr, the same as the limit for other forms of hexavalent chromium, and twice the NIOSH recommendation for non-carcinogenic chromium. It would be lower than the TLV's for most oxidizing and acidic gases.

**References:**


1. NIOSH: *Criteria for a Recommended Standard — Occupational Exposure to Chromium(VI)* HEW Pub No (NIOSH) 76-129 (1975).
2. NIOSH: *Toxic Substances List*, p. 145, HEW Pub. No. (NIOSH) 74-134 (1974).




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sacrifice of the highest dosed group were elevated, although no histologic changes were evident.

Inhalation exposure of five rats to DBAE six hours daily, five days per week at 70 ppm for one week resulted in the death of one rat, a 57% average body weight loss for the group, a two-fold increase in liver and kidney-to-body-weight ratio, a 10-fold increase in total serum bilirubin, a slight increase in clotting time and an elevated hematocrit.[3] Inhalation exposure at 33 ppm for one week resulted in a 3% body weight loss, no significant changes in liver and kidney weights, slight increase in clotting time, but no changes in serum bilirubin or in hematocrit. Exposure for 27 weeks at 22 ppm DBAE resulted in no differences in the variables measured compared with controls.

DBAE, as well as DEA and other 2-aminoethanols inhibit acetylcholinesterase in vitro, the degree of inhibition being related to the number of carbon atoms attached to the nitrogen head of the molecule.[3] Thus, DBAE is a more potent inhibitor than DEA.

In view of the approximately 10-fold greater toxicity of DBAE than DEA, which has a TLV of 10 ppm based on irritation, and in view of the inhalation *no-health-effect* level of DBAE of 22 ppm, a TLV of 2 ppm for DBAE is recommended. This limit is believed to be sufficiently low to protect against systemic effects. Information is not available from which to judge whether 2 ppm will cause irritation. A STEL of 4 ppm is also recommended.

**References:**


1. **Hartung, R., Cornish, H.H.:** *Tox. Appl. Pharm.* 12:486 (1968)
2. **Smyth, H.F. Jr. et al.** *Arch. Ind. Hyg. & Occup. Med.* 10:61 (1954)
3. **Cornish, H.H., Dambrauskas, T., Beatty, L.D.:** *Am. Ind. Hyg. Assoc. J.* 30:46 (1969)

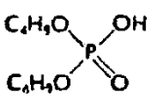

## DIBUTYL PHOSPHATE

**Di-n-butyl phosphate**

$(n\text{-}C_4H_9O)_2(OH)PO$

**TLV, 1 ppm ( ≈ 5 mg/m³)**

**STEL, 2 ppm ( ≈ 10 mg/m³)**



*Dibutyl phosphate is a pale amber liquid with a molecular weight of 210.21. It decomposes at temperatures above 100° C and has a vapor pressure of ≤ 1 mm Hg at 20° C. It is insoluble in water and is a moderately strong monobasic acid.*[1]

It is encountered in industrial operations as an organic catalyst and an antifoaming agent.

Although no published reports have appeared on the effects of exposure to this chemical, some workers exposed to it have complained of repiratory tract irritation and headache at relatively low levels.[2]

A TLV of 1 ppm and a STEL of 2 ppm are recommended, but it is possible that this limit is not sufficiently low to prevent sensory effects.

**References:**


1. **Albright and Wilson (Mfg.) Limited:** Brochure, *Organo Phosphorus Compounds*, London, England (November 1960)
2. **Mastromattee, E.:** Personal communication to TLV Committee (1964)

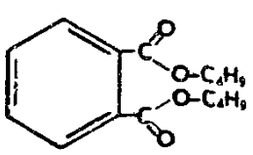

## DIBUTYL PHTHALATE

**n-Butyl phthalate; DBP**

$C_6H_4(CO_2C_4H_9)_2$

**TLV, 5 mg/m³**

**STEL, 10 mg/m³**



*Dibutyl phthalate is a colorless, odorless, very stable, oily liquid with a molecular weight of 278.34 and a specific gravity at 20° C of 1.0484. It has a distillation range between 227 and 235° C, a freezing point of −35° C and a vapor pressure of ≤ 0.1 mm Hg at 20° C. The closed cup flash point is 315° F, autoignition temperature is approximately 750° F and is combustible. It is miscible with common organic solvents, but insoluble in water.*

It is used as an insect repellant for the impregnation of clothing.[1]

The acute oral $LD_{50}$ in the rat is 8-16 g/kg. When rats were dosed twice weekly with dibutyl phthalate (1 mL/kg of body weight of a solution in oil) for a period of 6 weeks, no adverse effects were reported. Another group of rats were maintained on this regimen for 1.5 years without any adverse effects on the parameters studied which included hematology, pathology of organ tissues, and organ weights.[2] Smith[3] reported the maximal concentration that did not inhibit growth of rats in a chronic one-year finding study was 0.25% of the diet. In vitro studies with



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pancreatic lipase indicated that dibutyl phthalate is metabolized similarly to fat in the diet, however, rats given dibutyl phthalate orally excreted the monobutyl ester as the principal metabolite in the urine with phthalic acid as the secondary metabolite.[4]

Soviet experimenters found[5] that a 2-hour exposure of mice to an aerosol of dibutyl phthalate resulted in irritation of the eyes and upper respiratory tract mucous membranes at exposure levels around 250 mg/m³. At the higher levels, labored breathing, ataxia, paresis, convulsions, and death from paralysis of the respiratory system. The $LC_{50}$ (exposure time not stated) was given as 25,000 mg/m³, and the threshold for more sensitive responses as 4 mg/m³, including changes in the numbers of the formed elements of the blood. Similar findings from acute exposures of animals, either by inhalation or topically, were made by another Soviet investigator;[6] dibutyl, diethyl, dimethyl and dioctyl phthalates were considered nontoxic and nonirritant (levels not stated in abstract).

Cagianot[7] reported that a chemical operator who swallowed by accident 10 g (ca. 140 mg/kg) dibutyl phthalate became nauseated and dizzy, experienced photophobia, lacrimation and conjunctivitis, but made a prompt and uneventful recovery.

In a preliminary study of exposure of 150 to 250 workers to vapors in air mixtures of diethyl phthalate, dibutyl phthalate, and di-2-ethyl hexyl phthalate, 19 personal air samples (collected in breathing zone of employees), 4 hours duration each, were taken over 8 different days at a number of locations in the vicinity of the operations. The results of the air analysis ranged from 1-6 ppm, (8-15 mg/m³). In a diagnositc multiphasic testing operation, no phthalates in blood were found before and after the phthalate exposure and no peripheral polyneuritis was observed in the population.[6]

From the standpoint of hazard by inhalation, dibutyl phthalate should present little problem because of low vapor pressure, inhalation of significant amounts would occur only by spray or mist exposures. Its wide use as an insect repellent for man during World War II resulted in no report of toxic symptoms.

A TLV of 5 and a STEL of 10 mg/m³ are recommended for dibutyl phthalate based on its low order to toxicity. There are no reports that this level will cause either irritation or systemic effects in workers.

**References:**


1. *Merck Index*, 9th ed., p. 202, Merck & Co., Inc., Rahway, NJ (1976)
2. **Bommann, G.** *et al.* Behavior of the Organism as Influenced by Various Plasticizers. *Z. Lebens.-Unters. Forsch.* 103 413 (1956)
3. **Smith, C.C.**: *Arch. Ind. Hyg. & Occup. Med.* 7 310 (1953)
4. **Chambon, P.** *et al.* Etude du Metabisme des Phthalates de Dibutyle et de Diethyle Chez le Rat. *C.R. Acad. Sci. (D) (Paris)* 273 2165 (1971)
5. **Varonin, A.P.**: *Zh. Khim. Abstr. No.* 91523 (1973)
6. **Timofievskaya, L.A.**: Abstract Trans. from *Toksikol. Gig. Prod. Neftekhim. Neftekhim. Proizvod.* 2nd Publ., p. 206 (1972)
7. **Cagianot, B.**: *Schweiz. Med. Wochschr.* 84 1243 (1954)
8. **Raleigh, Robert, Dr.**: Personal communication to TLV Committee from Eastman Kodak Co., Rochester, NY.


## DICHLOROACETYLENE

**ClC≡CCl**

**CEILING LIMIT, 0.1 ppm ( ≈ 0.4 mg/m³)**

*Dichloroacetylene has a molecular weight of 94.93. It has a melting range between –66 and –64.2° C and explodes upon boiling. It is soluble in alcohol, ether and acetone.*

Dichloroacetylene may be generated by thermal decomposition of trichloroethylene, as in the faulty operation of catalytic burners at below optimal operating temperatures (450° F). Similarly, in closed circuit anesthesia, using trichloroethylene, sufficient heat and moisture may be produced from the soda-lime absorption of carbon dioxide to develop fatal quantities of dichloroacetylene in conjunction with phosgene and carbon monoxide.[1] Or dichloroacetylene can be synthesized by passing trichloroethylene over any one of several alkaline materials at a temperature of 70° C.[2]

Very preliminary exposures of guinea pigs indicated a four-hour $LC_{50}$ at approximately 20 ppm, death occurring two or three days later from pulmonary edema. A similar exposure of rats indicated an $LC_{50}$ of 55 ppm dichloroacetylene in the presence of 330 ppm trichloroethylene.[3]

When mixed with 9 parts of ether, the 4-hour rat $LC_{50}$ was 219 ppm, that for guinea pigs, 52 ppm.[6] With 7 parts trichloroethylene the 4-hour $LC_{50}$ for rats was 55 ppm, while with 10 parts trichloroethylene the 4-hour $LC_{50}$ for guinea pigs was 15 ppm.[6]

The signs and symptoms of dichloroacetylene response are characteristic: headache, loss of appetite, extreme nausea, vomiting, involvement of the trigeminal nerve and facial muscles and the "lighting up" of facial herpes.

Disabling nausea occurred among individuals exposed for prlonged periods at about 0.5 to 1 ppm of dichloroacetylene. Of those exposed, at least 85% were so affected.[2]

A number of fatalities attributed to dichloroacetylene have been reported by British physicians in the 1940's.[4,5] Humphrey and McClelland[4] reported on 13 cases of cranial nerve palsy, 9 with labial herpes following exposure to dichloroacetylene as a decomposition product of trichloroethylene. Other symptoms included extreme nausea, headache, intense pain in the jaw and vomiting. All cases showed a definite incubation period ranging from 24 hours to three days. One patient died on the third day and another on the sixteenth day with autopsies showing edema at the base of the brain.

Dichloroacetylene seems to have a different order of toxicity than most chlorinated hydrocarbons. A ceiling limit no higher than 0.1 ppm appears necessary to prevent disabling nausea and other more serious systemic effects. Whether this TLV is low enough to provide adequate protection against prolonged occupational exposure is uncertain.



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## ZINC CHLORIDE

$ZnCl_2$

*Fume*

**TLV, 1 mg/m³**

**STEL, 2 mg/m³**

*Zinc chloride may be in the form of a non-combustible, white powder or colorless crystals. Both are deliquescent and have a molecular weight of 136.29 and a specific gravity of 2.80 at 25° C. The fume of zinc chloride is white with an acrid odor. This compound boils at 732° C and melts at about 290° C. It is soluble in water, alcohol and ether.*

The chloride is the common inorganic salt of zinc, and is used in soldering fluxes, galvanizing iron, as a wood preservative, in textiles, adhesives, dentrifices, deodorants, embalming fluids, and in organic synthesis and petroleum refining. Zinc chloride is the main ingredient of some screening smokes.

Exposure to zinc chloride fume can cause damage to the mucous membranes of the nasopharynx and respiratory tract. Exposed persons have experienced a pale gray cyanosis. Zinc chloride is caustic and can cause ulceration of exposed surfaces of the skin.[1] Inhalation may produce a severe pneumonitis resulting from irritation of the respiratory tract.[2]

Hunter[3] reported 10 deaths and 25 cases of non-fatal injury among 70 persons in a tunnel when 79 smoke generators caught fire in a storage area. Most of the patients began to recover on the tenth day and were up and about six weeks after the incident. In two necropsies performed on the fatal cases, membranes lining the larynx, trachea and bronchi were red and edematous, with spots of necrosis. Milliken and associates[4] reported a case of fatal, acute interstitial fibrosis from inhaling $ZnCl_2$ smoke from a smoke generator. In 18 days the patient developed advanced pulmonary fibrosis, acute cor pulmonale and right ventricular hypertrophy, and ultimately died from acute respiratory insufficiency.

Hardy[5] comments that zinc chloride is caustic and because of the way it is used in industry causes trouble disproportionate to its harmful nature. She cites references suggesting that zinc compounds may have chronic effects. Ferry,[6] in investigating a borderline condition, found that levels between 0.07 and 0.4 mg/m³ of zinc chloride fume for 30 minutes did not result in sensory effects, but was corrosive to metals.

To prevent respiratory irritation and other effects, a TLV of 1 mg/m³ and a STEL of 2 mg/m³ are recommended.

Although insoluble zinc compounds such as the oxide and stearate (q.v.) appear less hazardous, there are not enough data to categorize the relative hazards from other soluble zinc salts, such as the nitrate and sulfate.

The Swedish limit (1978) for $ZnCl_2$ is also 1 mg/m³.

**References:**


1. Sax, N.I.: *Dangerous Properties of Industrial Materials*, p. 1268. Reinhold Pub. Corp., NY (1957)
2. Gafafer, W.M.: *Occupational Diseases*, Pub. Health Ser. Publ. #1097, U.S. Gov. Printing Office, Washington, DC (1964)
3. Hunter, D.: *The Diseases of Occupation*, pp. 367-377, Little, Brown & Co., Boston, MA (1955)
4. Milliken, J.A., Waugh, D., Kadish, M.E.: *Can. Med. Assoc. J.* 88:36 (1963)
5. Hamilton, A., Hardy, H.L.: *Industrial Toxicology*, 3rd ed., p. 187, Publishing Sciences Group, Acton (1974).
6. Ferry, J.: Communication to TLV Committee (1966)


## ZINC CHROMATES

$ZnCrO_4$; $ZnCr_2O_4$; $ZnCr_2O_7$

**TLV, 0.05 mg/m³, as Cr, Appendix A2 — Suspected Carcinogen**

The basic zinc chromate is yellow in color and exists in prism form; molecular weight 181.36, specific gravity 3.40. $ZnCr_2O_4$ has a molecular weight of 233.36 and a specific gravity of 5.30 at 15° C, and its cubes are dark green to black in color. The dichromate is an orange powder with a molecular weight of 281.35. All are soluble in acids, but sparingly soluble in water.

Although finding some use as colors, they are primarily employed in priming paints for metals, for which they provide resistance against corrosion. The pigment zinc yellow is potassium zinc chromate.

Because of their very slight solubility in water, zinc chromate is considered more likely to produce cancer of the respiratory passages, when inhaled, than are the water soluble chromates. While an increased incidence of lung cancer has reported among groups of pigment workers exposed to chromates,[1] including zinc chromate,[2] a classification of suspected, rather than actual human carcinogen seems appropriate at this time.

The TLV of 0.05 mg Cr/m³, the same as that of lead chromate, is retained for the present. A review would be in order, however, if the limit for the insoluble chromates was reduced.

For additional information, see the documentation for chromium and its compounds in this book.

**References:**


1. Equitable Environmental Health, Inc.: *An Epidemiological Study of Workers in Lean Chromate Plants*, final report submitted to The Dry Color Manufacturers Assoc. (June 25, 1976)
2. Langard, S., Norseth, T.: *Brit. J. Ind. Med.* 32:62-65 (1975)




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quired an 8 hour exposure at about 6000 ppm (35° C) to kill four of six rats. Signs of gross overexposure were varying degrees of ataxia, prostration, and respiratory distress followed by narcosis. Those that survived appeared to recover without significant signs of exposure.[1]

Shell Chemical Corporation[1] presents the following observations in respect to sensory responses reported by unconditioned personnel during or following 5-minute exposures to the vapor:

| | |
|---|---|
| Threshold, odor | 6 ppm |
| 50% Threshold, eye irritation | 50 ppm |
| 50% Threshold, nose irritation | 50 ppm |

No incidents of illness caused by industrial handling of EAK have been reported. Workers may complain of odor and transient eye irritation when handled in poorly ventilated areas when the concentration exceeds 25 ppm, but experience shows that transient responses do not lead to significant systemic effects.[1]

Accordingly, the TLV of 25 ppm is recommended as a comfort level for unconditioned workers.[2]

**References:**


1. *Industrial Hygiene Bulletin SC 57 59*. Shell Chemical Corporation, NY (March 1958).
2. Communication from O. M. Banks, Ind. Hygienist, Shell Chemical Corporation, (May 20, 1965).

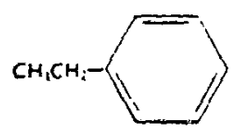

## ETHYL BENZENE

**Phenylethylene**

$C_6H_5C_2H_5$

**TLV, 100 ppm ( ≈ 435 mg/m³)**

**STEL, 125 ppm ( ≈ 545 mg/m³)**



*Ethyl benzene is a colorless, flammable liquid with an aromatic odor. It has a molecular weight of 106.16, a specific gravity of 0.86256 at 25° C and a vapor pressure of 7.1 mm Hg at 20° C. The vapor density is 3.7 times that of air. "Saturated" air with the vapor at 26° C and 760 mm is 7.32%. It boils at 136.2° C and freezes at -95.01° C. The closed cup flash point is 63° F, autoignition temperature is 810° F and is a fire risk.[1] Ethyl benzene is only slightly soluble in water at 15° C (14 mg/100 mL), but is miscible with alcohol and ether.*

This compound is employed as a solvent and as an intermediate in the production of styrene.

Ethyl benzene toxicity is characterized by its irritancy to the skin and less markedly, to the mucous membranes. Repeated application of the liquid to the skin of rabbits causes reddening and some exfoliation and blistering.[2] Oettel[3] characterized ethyl benzene as the most severe irritant of the benzene series.

On the eyes and nose, the vapor at 5000 ppm causes intolerable irritation, at 2000 ppm, eye irritation and lacrimation are immediate and severe, and are accompanied by moderate nasal irritation, decreasing somewhat in several minutes, at 1000 ppm, irritation and tearing, but tolerance develops rapidly, and at 200 ppm, the vapor has a transient irritant on human eyes.[1]

Like benzene, its acute toxicity is low, the dose fatal to guinea pigs in a few minutes was 10,000 ppm[4] and 5000 ppm dangerous to life in 30 to 60 minutes; animals dying from exposure had intense congestion and edema of the lungs, and generalized visceral hyperemia. The narcotic dose for animals was 10,000 ppm, reached in 18 minutes preceded by vertigo, unsteadiness and ataxia.

Chronic inhalation exposure of guinea pigs, monkeys, rabbits and rats at concentrations from 400 ppm to 2,200 ppm, seven to eight hours/day, five days/week for as long as six months, produced no effects in all species except the rat, which showed a slight increase in the weights of the kidneys and livers, on the average, for those exposed at 400 ppm for 18½ days. The investigators concluded that 400 ppm was the *beginning effect* level for chronic inhalation of the vapor.[4]

It is apparent that, as no systemic effects can be expected at levels producing distinctly disagreeable skin and eye irritation, the TLV must be based on the latter effects. For the prevention of disagreeable irritation, a TLV of 100 ppm and a STEL of 125 ppm are recommended.

Other recommendations: Czechoslovakia (1976) 45 ppm, Poland (1975) 25 ppm.

**References:**


1. Gerarde, H.W.: *Industrial Hygiene & Toxicology*, 2nd ed., Vol. II, p. 1231, Interscience, NY (1963).
2. Wolf, M.A. *et al*: *Arch. Ind. Health* 14:387 (1956).
3. Oettel, H.: *Arch. Exp. Path. Pharmak.* 183:641 (1936).
4. Yant, W.P., Schrenk, H.H., Waite, C.P., Patty, F.A.: *Pub. Health Rept.* 45:1241 (1930).

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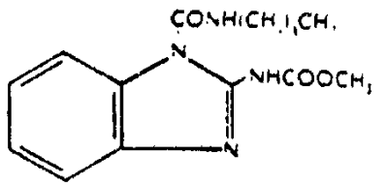
## BENOMYL

**Methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate; Benlate**

$C_{14}H_{18}N_4O_3$

**TLV, 10 mg/m³**

**STEL, 15 mg/m³**




*Benomyl is a white crystalline solid, which has a molecular weight of 290.32. It decomposes without melting and has a negligible vapor pressure, indicating exposure would be in particulate form. Very slightly soluble in water, it is soluble in xylene, acetone, dimethylformamide and chloroform.[1] Fluorometric and colorimetric[2] and liquid chromatographic[3] procedures for determining residues of benomyl have been published.*

Benomyl is the common name for this fungicide and ascaricide.

The acute oral $LD_{50}$ for the rate is $\geq$10,000 mg/kg. The acute skin absorption $LD_{50}$ for the rabbit is $\geq$10,000 mg/kg. Application to the shaved intact skin of ten male guinea pigs, at each level as aqueous suspensions containing 5, 12.5 and 25% benomyl as the active ingredient in a 50% wettable powder, resulted in negligible irritation. One of ten guinea pigs had mild erythema two days after application at the high rate. All guinea pigs at the two lower rates and in a control showed no irritation after two days.[4] Instillation into the eyes of rabbits of 10 mg of dry 50% powder or 0.1 mL of 10% suspension in mineral oil caused only temporary mild conjunctival irritation.[4] The acute inhalation $LC_{50}$ is $\geq$2000 mg/m³ ($\geq$ 2 mg/L) for rat[4] and is equivalent to $\geq$825 mg/m³ ($\geq$ 0.825 mg/L) for dog[4] for four-hour exposures. Histologically, there was reduction of spermatogenic activity in some animals. With regard to this activity, no-effect levels for benomyl for four-hour exposures are equivalent to $\geq$100 $\leq$410 mg/m³ ($\geq$ 0.1 $\leq$0.41 mg/L) for the rat and $\geq$325 $\leq$825 mg/m³ ($\geq$ 0.325 $\leq$0.825 mg/L) for the dog. Additionally, fifteen four-hour inhalation exposures at the equivalent of 100 mg/m³ (0.1 mg/L) of benomyl over a period of three weeks produced no clinical or histopathologic indication of accumulative effects in the rat.[4]

A low order of toxicity has been found in chronic studies. In two-year feeding studies no-effect levels in the diet are 2500 ppm (0.25%) for rats (highest level fed) and 500 ppm (0.05%) for dogs. Pesticide residue tolerances have been established in many food crops. They are as high as 15 ppm for stone fruits and food additive tolerances are as high as 50 ppm for raisins.[1] In a three-generation rat reproduction study, no compound-related reproduction or lactation differences were observed among control and test groups even at 2500 ppm (0.25%), the highest dietary level fed. In a teratogenic study in rat, neither the outcome of pregnancy nor embryonal development was affected even at 5000 ppm (0.50%), the highest dietary level fed.[5] In a dominant lethal mutagenic study in the rat, benomyl was not mutagenic at 2500 ppm (0.25%), the highest dietary level fed.[5]

Gardiner *et al.*[6] showed that rat and dog eliminated $\geq$99% of single, oral doses of 2-$^{14}$C benomyl via the urine and feces within 72 hours. The major metabolite was methyl 5-hydroxy-2-benzimidazole-carbamate, which was present in the urine as glucuronide and/or sulfate conjugates. Residue data on dog and rat tissues from two-year chronic feeding studies demonstrated that benomyl and its metabolites do not accumulate in animal tissues.

In view of the low order of acute and chronic toxicity, the TLV of 10 mg/m³ and the STEL of 15 mg/m³ appear appropriate.

**References:**


1. E.I. du Pont de Nemours & Co., Inc.: Technical data sheet (June 1974)
2. Pease, H.L., Holt, R.F.: *J. Assoc. Offic. Anal. Chem.* *54(6)* 1399-1402 (1971)
3. Kirkland, J.J., Holt, R.F., Pease, H.L.: *J. Agr. Food Chem.* *21(3)* 368-371 (1973)
4. E.I. du Pont de Nemours & Co., Inc.: Unpublished data
5. Sherman, H., Culik, R., Jackson, R.A.: *Tox. Appl. Pharm.* *32* 305-315 (1975)
6. Gardiner, J.A., Kirkland, J.J., Klopping, H.L.: *J. Agr. Food Chem.* *22(3)* 419-427 (1974)


## BENZENE

$C_6H_6$

**TLV, 10 ppm ( ≈ 30 mg/m³), Appendix A2 — Suspected Carcinogen**

**STEL, 25 ppm ( ≈ 75 mg/m³), Appendix A2**

*Benzene is a colorless, non-polar liquid, with an odor characteristic of aromatic hydrocarbons. It has a molecular weight of 78.11, a boiling point of 80.1° C, a melting point of 5.5° C, a vapor pressure of 75 mm Hg at 20° C and a specific gravity of 0.87865 at the same temperature. Benzene has a flash point of −11.1° C (closed cup, 12° F), making it a dangerous fire hazard. It was formerly derived almost exclusively by distillation of coal tar, but now comes primarily from petroleum, either by extraction or by dealkylation of toluene. Benzene is slightly soluble in water but soluble in all proportions in alcohol, acetone and ether.*

At one time benzene was an important solvent, especially for rubber, as a diluent in lacquers, and in paint removers. At present such uses are minimal, most benzene is consumed in the chemical industry, as a raw material for



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numerous organic chemicals. It is found in gasoline from trace amounts to as much as 30% concentration in some countries.

As an acute poison benzene produces narcotic effects comparable to those of toluene. It is a more potent narcotic than the alkanes or naphthenes of similar boiling points. But the effect of chronic exposure to this compound is by far the most serious disease caused by any of the common hydrocarbon solvents. Its action on the bone marrow may result in detectable alterations and, in some instances, aplastic anemia. The reported $LD_{50}$ orally in young adult rats is 3.8 mL/kg.[1]

It is unique among hydrocarbons as a myelotoxicant.[2] More than 140 fatal cases of benzene poisoning had been recorded prior to 1959.[3] Vigliani and Saita[4] listed 26 deaths from chronic benzene poisoning in two provinces in Italy between 1960 and 1963. Eleven of these were diagnosed as leukemia, which may develop several years after cessation of exposure to benzene.

Most deaths from benzene have resulted from exposures of the order of 200 ppm or more. In a few instances concentrations of 1000 or even 2000 ppm have been recorded in workplaces where deaths occurred. Some of these are: Legge,[5] 210 to 1050 ppm; Greenburg,[6] 70 to 1800 ppm, with over half above 200; Bowditch,[7] 100 to 200+ measured, one leukemia case described by Hunter[8] and Mallory[9] six years after exposure at over 200 ppm; Greenburg,[10] 25 to 1000 ppm in four rooms; Heimer,[11] 140 to 200 ppm after improvements; Savilahti,[12] 318, 433 and 470 ppm; Kozlova,[13] 47 to 310 ppm; Vigliani,[14] 190 to 660 ppm after four years death from leukemia; Juzwiak,[14] 31 to 156 ppm; Aksoy,[15] 150 to 650 ppm and 210 to 650 ppm;[16] 26 patients with acute leukemia or preleukemia; Ikeda,[17] 100 to 800 ppm, 7 deaths, all females, none from leukemia.

Winslow,[18] however, reported blood changes in workers where concentrations of benzene vapor below 100 ppm were found. Heimann and Ford[19] found one death and three cases with blood changes where air analysis for benzene showed a concentration of 105 ppm. Wilson[20] reported three fatal cases in a plant where the average concentration of benzene vapor was 100 ppm. In a fifth room, associated with benzene poisoning, Greenburg[10] found 11 to 57 ppm. So far as can be determined the lowest *measured* concentration of benzene vapor associated with a *fatal case* of benzene intoxication (due to aplastic anemia) was the 60 ppm reported by Hardy and Elkins in 1948[21] in a plant where repeated air analyses were made, and a number of other workers showed some blood abnormalities.

Blanev[22] found little evidence of benzene intoxication in a group of 90 workers regularly exposed to benzene for about 13 years. Concentrations were generally low, but urinary phenol measurements indicated some exposures of the order of 25 ppm.[23] A followup several years later showed no evidence of persisting blood dyscrasias. No cases of leukemia are known to have occurred in this group of workers. Pagnotto et al[24] found workers in rubber spreading operations involving naphtha with a relatively high benzene content exposed to benzene in concentrations which were for the most part between 6 and 25 ppm. A number of blood studies showed a few abnormalities but only two were serious to warrant special consideration. In one case the possibility of leukemia was raised, but on being removed from his job and given iron therapy the worker recovered. Because of several job changes his *benzene exposure could not be reliably estimated.*

The other worker was in a group studied intensively over a period of several years by Pagnotto.[25] He had a red count below four million, a hemoglobin below twelve grams and suffered from nose bleeds. His benzene exposure, as estimated from several urinary phenol determinations, was to about 40 ppm. After his exposure to benzene was terminated, his blood picture gradually returned to normal. The 38 workers in this plant were followed up for 15 years after the use of naphtha containing benzene was discontinued. None showed any signs of permanent blood abnormalities. There were three deaths, none being from leukemia. It was concluded that 25 ppm of benzene vapor is safe for most workers, but that since the margin of safety is small a TLV of 10 ppm was recommended.[26] Elkins,[27] in a summary of the findings in the rubber spreading industry, came to a similar conclusion.

These conclusions were consistent with those of Fuchs[27] in 1969, who found variations in the blood pictures of three workers but did not consider that the changes were proved to result from their benzene exposures of 19, 28 and 43 ppm respectively. He also stated that he could find no data in the literature on proved benzene poisoning in concentrations below 16 ppm, nor could he find any Soviet report which cited reasons for decreasing the Russian MAC to 5 ppm.

Two investigators have studied the effects on rats of exposures at relatively low levels of benzene vapor extended periods. Deichmann *et al*[28] found that after 5 to 8 weeks of 5 hours/day, 5 days/week exposure at 44 and 47 ppm, rats developed a moderate degree of leukopenia, but that none resulted from 15 to 31 ppm. Nau *et al*[29] found a decrease in the white blood cell counts of rats following 756 hours of exposure at 50 ppm of benzene on a schedule of 8 hours/day, 5 days/week. Reduced amounts of DNA in the white cells, a depression in myelocytic activity, and an increase in the relative numbers of red cell precursors in the bone marrow were also observed.

There have been numerous reviews of the literature of benzene intoxication. Noteworthy are those of the National Academy of Sciences in 1976[30] and the NIOSH criteria document on benzene, published in 1974.[31] As a result of this extremely thorough review, NIOSH recommended a workplace time weighted average standard of 10 ppm, with a ceiling of 25 ppm.

In 1976, however, NIOSH issued a revised recommendation for an occupational exposure standard for benzene.[32] The key to this recommendation is the statement in the introduction that *"Because it is not at present possible to establish a safe exposure level for a carcinogen, the NIOSH recommendation is to restrict exposure to very low levels which can still be reliably measured in the workplace."* A *number of references are given, primarily to support* the characterization of benzene as a carcinogen (leukemogen). Thus most relate to leukemia cases associated with heavy benzene exposures, either measured or inferred from association with numerous cases of aplastic anemia or other blood dyscrasias. Others are epidemiologic studies on cancer in which no evidence of the degree, or even fact, of benzene exposure is cited. Thus in at least two of these papers,[33,34] the word "benzene" does not appear. In these and other papers the incidence of various types of cancer,



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including leukemia was found to be higher than in the general population among certain groups of rubber workers. Monson and Nakano[35] found 55 cases of leukemia vs. 43 expected among rubber workers. It was noted that benzene has been used extensively in the rubber industry, but is no longer employed, although it is a contaminant of extensively used naphtha solvents. The degree of exposure to benzene in the rubber industry during the first half of the 1940-1950 decade may well have been excessive. Wilson[36] has noted deaths and blood abnormalities among workers in the rubber industry during the war years who were exposed, on the average, to concentrations of benzene vapor of 100 ppm. Neither Monson-Nakano or other authors of similar papers quoted in the NIOSH update mention whether or not aplastic anemia or other blood dyscrasias, apart from leukemia, occurred in the groups of workers that were studied.

Nevertheless OSHA, in 1977, issued an Emergency Temporary Standard (ETS)[16] establishing a TWA limit of 1 ppm for benzene vapor. (Enforcement of this standard was voided by the courts.) Much of the evidence substantiating this action was the same as that quoted in the NIOSH update. However, one additional paper was cited by Infante *et al.*[37] in which nine leukemia deaths were reported from two rubber film casting plants where benzene vapor concentrations allegedly ranged from 0 to 15 ppm. This report was critically examined in OSHA hearings on a permanent standard, with essentially the same provisions as the ETS, which were held during the summer of 1977. The data on benzene exposure in the two plants in question, especially during the first part of the ten year employment period (1940 to 1950) covered by the study, were found to be incomplete, unreliable and contradictory. Even in 1976 a NIOSH report of one of the plants involved, or its successor, showed concentrations in excess of 15 ppm at several locations.[38] A study by Harris *et al.*[39] in 1973 and 1974 revealed similar findings, although the overall average of all sample results was slightly above 1 ppm. During the period 1940 to 1945 or so, when many of the involved workers were employed, the permissible concentration for benzene exposure (ASA standard) was 100 ppm. In common with the papers cited by the NIOSH update, no information on other blood abnormalities was given in the Infante report.

Epidemiologic studies of workers exposed to measured low concentrations of benzene vapor have yielded negative or inconclusive results. Thorpe[40] after studying the occurrence of leukemia in a population of 38,000 workers in a variety of European petroleum and petrochemical operations, some of whom were exposed at levels of benzene that occasionally reached 20 ppm, over a period of ten years, found that deaths from leukemia "were not abnormal" for the countries involved (18 vs. 23.23 expected).

Retrospective studies of employees of a large chemical company, exposed for many years to benzene, mostly at low levels, revealed no excess mortality.[41,42] A cohort of 594 workmen were divided into four exposure groups: very low exposures, less than 2 ppm as time weighted average (TWA); low exposures, 2-9 ppm; moderate exposures, 9-24 ppm; and high exposures, above 25 ppm. In many areas there was exposure to other chemicals as well as to benzene. The duration of exposure was also divided into four groups, with 186 workers having in excess of 20 years.

Of 102 deaths, two were due to anemia, two to leukemia, and one had leukemia as a complication. Of these five cases, only one, an autopsy-confirmed pernicious anemia, involved a previous exposure to benzene of significance, 5520 ppm months. The other anemia death, diagnosed as being of the aplastic type, was of a worker with 453 ppm months of benzene exposure. Two of the leukemia cases involved exposures of 545 and 305 ppm months, respectively, while the third was of a worker with only 18 ppm months benzene exposure.

To put these exposure data in perspective, three of the deceased workers had had exposures to benzene equivalent to 40 years' employment in concentrations slightly above or below 1 ppm; the exposure of the fourth, if spread over 30 years, would have been at a concentration of 0.05 ppm.

The predicted deaths from anemia and leukemia were 0.2 and 1 respectively. The fact that, apart from the pernicious anemia death, there appeared to have been no dose response relationship, apparently led to the conclusion of the authors that *"no mortality findings directly attributable to benzene exposure were observed"*.

The NIOSH update mentions the consistent observations of chromosomal aberrations associated with benzene exposure, but further comments that the implications of these findings with respect to benzene leukemia are still not clear. The possibility of a chromosomal instability acting as a stimulus for a latent leukemogenic virus has been speculated upon.[43] This question was discussed at some length at the International Workshop on the Toxicology of Benzene, held in Paris in November 1976. Tough[44] had previously reported that marked aberrations were found only in plants where concentrations of benzene vapor were believed to be between 25 and 250 ppm, and that no significant changes were observed at 12 ppm. Forni[45] however, stated that there had been a few positive, as well as negative, reports at levels between 5 and 25 ppm. The consensus of opinion was that the significance of the finding of increased chromosome aberrations for the occurrence of benzene leukemia was still not clear. Maugeri and Pollini[46] reported that among Italian shoe workers *"almost all the cases of haemopathy due to benzol which lead to death show features of terminal leukemia ... and (the leukemias) were always preceded by aplastic conditions"*.

Opinions of the workshop participants relative to the appropriate TLV for benzene were varied. The final recommendation was to retain 10 ppm as a permissible TWA which must not be exceeded, but it was also specified that benzene should not be employed when substitute materials were available.

DeGowin's report[47] of a case of leukemia following an apparent benzene-induced aplastic anemia contains a discussion which implies that there is evidence that aplastic anemia per se may lead to leukemia, and that delayed cases of this disease are not confined to aplastic anemia due to benzene.

It is the opinion of the Committee that the characterization of benzene as a leukemogen, by NIOSH, is, in essence, valid, although benzene may be what Truhaut has described as a "secondary carcinogen".[48] An A2 notation should be applied to benzene in the TLV listings.

On the other hand, the Committee does not agree with the NIOSH recommendation of 1 ppm as an occupational



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exposure standard insofar as the TLV can be defined as such a standard. There is little evidence that exposure to benzene at concentrations below 25 ppm causes blood dyscrasias of any kind. Setting the TLV at 10 ppm as a time-weighted average, provides an added margin of safety.

If the standard is to be set at the lowest practicable detectable limit, it is the opinion of some members of the Committee that a value lower than 1 ppm should be selected. In the absence of interfering substances benzene vapor can be measured with reasonable accuracy in concentrations at least as low as 0.1 ppm. In the presence of certain interferences, it may be difficult to achieve the prescribed accuracy and reliability even at concentrations somewhat above 1 ppm.

Because the effects the TLV is designed to prevent are chronic in nature, a ceiling designation is not appropriate and a STEL of 25 ppm is recommended.

Other recommendations: ANSI (1969) 10 ppm. Czechoslovakia (1969) 16 ppm. USSR (1972) 1.6 ppm. DDR (1973) 16 ppm. Sweden (1975) 10 ppm. BRD (1974) 0 ppm (treats as carcinogen).

## References:


1. *Merck Index*, 9th ed., p. 138. Merck & Co. Inc., Rahway, NJ (1976).
2. Cerande, H.W.: *Toxicology & Biochemistry of Aromatic Hydrocarbons*. Elsevier Publishing Co. NY (1960).
3. Elkins, H.B.: *Chemistry of Industrial Toxicology*, p. 103. Wiley & Sons, NY (1959).
4. Vigliani, E.C. Saita, G.: *New Eng. J. Med.* 271 872 (1964).
5. Legge, T.M.: *J. Ind. Hyg.* 1 539 (1920).
6. Greenburg, L.: *U.S. Public Health Reports* 41 1357 (1926).
7. Bowditch, M., Elkins, H.: *J. Ind. Hyg. & Tox.* 21 321 (1939).
8. Hunter, F.T.: *Ibid.*, p. 331.
9. Mallory T.B. *et al. Ibid.*, p. 355.
10. Greenburg, L. *et al. Ibid.*, p. 395.
11. Helmer, K.J.: *Acta Med. Scand.* 118 354 (1944).
12. Savilahti, M.: *Arch. Gewerbepath. u. Gewerbehyg.* 15 147 (1956).
13. Koslova, T.A., Volkova, A.P.: *Gig. Sanit.* 25 29 (1960). Cited by NIOSH in ref. 31.
14. Juzwiak, I.: *Med. Przemyslowa* 20 67 (1969). *Ibid.*
15. Aksoy, M. *et al. Brit. J. Ind. Med.* 29 56 (1972).
16. Aksoy, M. *et al. Blood* 44 837 (1974).
17. Ikeda, M.: Poisoning Due to Benzene and its Substitutes in Japan. *International Workshop on the Toxicology of Benzene*. Paris (1976).
18. Winslow, C.E.A.: *J. Ind. Hyg.* 9 69 (1927).
19. Heimann, H., Ford, C.B.: *NY Ind. Hyg. Bull.* p. 224 (November 1940).
20. Wilson, R.H.: *J. Lab. Clin. Med.* 27 1517 (1942).
21. Hardy, H.L., Elkins, H.B.: *J. Ind. Hyg. & Tox.* 30 196 (1948).
22. Blanev, E.: *Ind. Med. & Surg.* 19 227 (1950).
23. Walkley, J.E. *et al. Am. Ind. Hyg. Assoc. J.* 22 362 (1961).
24. Pagnotto, L.D. *et al. Ibid.* p. 417.
25. Pagnotto, L.D. *et al.* Benzene Exposure in the Rubber Coating Industry, a Followup. Presented at the *American Industrial Hygiene Conference*. New Orleans (May 1977).
26. Elkins, H.B.: Significance of Benzene Exposure Among Workers in Rubber Spreading Operations. Presented at the *International Workshop on the Toxicology of Benzene*. Paris (1976).
27. Fuchs, A.: in *Documentation of the MAC in Czechoslovakia*. Prague (1969).
28. Deichmann, W.B. *et al. Tox. Appl. Pharm.* 5 201 (1963).
29. Nau, C.A. *et al. Arch. Env. Health* 12 382 (1966).
30. National Academy of Sciences: *Health Effects of Benzene*, a review (1976).
31. NIOSH: *Criteria for a Recommended Standard for Occupational Exposure to Benzene* (1974).
32. NIOSH: *Revised Recommendation for an Occupational Exposure Standard for Benzene* (August 1976).
33. McMichael, A.J. *et al. J. Occup. Med.* 16 458 (1974).
34. Andjelkovic, D. *et al. Ibid.* 18 387 (1976).
35. Monson, R.R., Nakano, K.K.: *Am. J. Epidem.* 103 284 (1976).
36. OSHA: Emergency Temporary Standard for Occupational Exposure to Benzene. *Federal Register* 42 22516 (May 3, 1977).
37. Infante, P.F. *et al. Leukemia Among Workers Exposed to Benzene*. A manuscript (1977).
38. Young, R. *et al. Walk Through Survey of Goodyear Tire & Rubber Co.*, St. Marys, OH. A manuscript (1977).
39. Harris, R.L. Jr.: Testimony before OSHA hearings on the proposed standards for occupational exposure to benzene. Washington, DC (August 1977).
40. Thorpe, J.J.: *J. Occup. Med.* 16 375 (1974).
41. Ott, M.G. *et al. Mortality Among Individuals Occupationally Exposed to Benzene*. A manuscript (1976).
42. Fishbeck, W.A.: Testimony before OSHA hearings on the proposed standards for occupational exposure to benzene. Washington, DC (August 1977).
43. Todaro, G.J., Huebner, R.J.: *Proc. Nat. Acad. Sci.* 69 1009 (1972). Cited by NIOSH in ref. 31.
44. Tough, I.M. *et al. Eur. J. Cancer* 6 49 (1970).
45. Forni, A.: Report in the *Proceedings of International Workshop on the Toxicology of Benzene*. Paris (1976).
46. Maugeri, S., Pollini, G.: Benzene Haemopatv, Cellular Damage and Chromosome Changes. Personal Researches. *Ibid.*
47. DeGowin, R.L.: *J.A.M.A.* 185 748 (1963).
48. Truhaut, R.: *Proceedings of the XI International Cancer Congress*. Florence, Italy (1974).




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4. Ayer, H.E., Fitzpatrick, M.S., Scheel, L.D.: Rept. of Survey of Air-borne Diisocyanate during Spray Application of Polyurethane Foam. Div. of Occup. Health (NIOSH), Cincinnati, OH (March 1963).

5. Konzen, R.B., Craft, B.F., Scheel, L.D., Gorski, C.H.: Am. Ind. Hyg. Assoc. J. 27:121 (1966).

6. Bruckner, H.C., Avery, S.B., Stetson, D.M., Dodson, V.N., Rohayne, J.J.: Arch. Env. Health 16:619 (1968).

# METHYLENE CHLORIDE

**Dichloromethane**

$CH_2Cl_2$

**TLV, 100 ppm ( ≈ 360 mg/m³)**

**STEL, 500 ppm ( ≈ 1700 mg/m³)**

*Methylene chloride is a colorless volatile liquid, soluble in water to only 1% by weight, but completely miscible with most organic solvents. It has a sweetish odor, like most chlorinated hydrocarbons. The molecular weight is 84.94, a specific gravity is 1.335, boiling point is 40° C and it solidifies at −95° C. With its high vapor pressure (315 mm Hg at room temperature, 23.5° C) sustantial concentrations of vapor are readily achieved whenever methylene chloride is spilled or spread out over a large surface, even in a space that is not closely confined. It is non-flammable by standard tests, but will burn in extreme conditions.*

Methylene chloride is widely used in paint removers, as a solvent for plastics, as a degreasing agent, in propellant mixtures for aerosol sprays and as a blowing agent in foams. The odor is not a good indication of exposure since concentrations of 100 ppm reportedly are not highly perceptible.

Liquid methylene chloride is painful and irritating if splashed in the eyes or if confined on the skin by gloves, clothing or paint remover formulations. A burn can result if it is not promptly removed from the eyes and skin. The acute oral $LD_{50}$ for rats is about 2000 mg/kg.

According to Lehmann and Flury,[1] slight narcosis occurs at 4000 to 6100 ppm in several species of animals. The fatal concentration for seven hours' exposure is given by many authorities as about 15,000 ppm. [illegible] Rats exposed 75 days (8 hours a day) at 1000 ppm showed slight liver changes which were not found at 50 days. [illegible] Cats exposed four to eight days at 7200 ppm for four weeks were found to have kidney and liver changes. Heppel and associates[illegible] found that daily seven-hour exposures at 5000 ppm for six months had no discernible effect on dogs and rabbits and only reduction in the rate of growth of guinea pigs. At 10,000 ppm, four hours a day, for seven and one-half weeks dogs and guinea pigs, but not monkeys, rabbits or rats developed liver injury. Moskowitz and Shapiro[illegible] reported four cases of poisoning with one fatality, apparently due to narcotic action. Collier[illegible] reported two cases of poisoning in painters who suffered from headache, giddiness, stupor, irritability, numbness and tingling in the limbs. Kuzelova and Vlasak[illegible] noted complaints of headache, fatigue and irritation of the eyes and respiratory passages by workers exposed at concentrations up to 5000 ppm. Neurasthenic disorders were found in 50%, and digestive disturbances in 30% of the persons exposed. Three acute poisonings, one involving loss of consciousness, were recorded without serious after-effects.

Weiss[illegible] stated that a chemist after a year's exposure developed toxic encephalosis with acoustical and optical delusions and hallucinations. Concentrations frequently exceeded 500 ppm, values of 660 ppm, 800 ppm and near the floor, 3600 ppm were noted.

Golubovski and Kamchatnova[illegible] found liver disease in workers exposed to methylene chloride and methanol which they attributed to the former. Exposure concentrations were not reported.

In the early 1940's methylene chloride was considered the least toxic of the chlorinated hydrocarbon solvents when a safe industrial air limit of 500 ppm was proposed by Heppel et al.[illegible] and later adopted by the TLV Committee as protective enough to prevent any significant narcotic effects or liver injury.

Subsequently, Stewart et al.[illegible] reported that significant quantities of carbon monoxide and carboxyhemoglobin were produced in humans receiving single exposures at 500-1000 ppm of methylene chloride. The carboxyhemoglobin concentrations reported by Stewart approximated those considered objectionable if due to inhalation of carbon monoxide.

More extensive examination of CO production from methylene chloride was later reported by the same investigators. [illegible] Human volunteers exposed to methylene chloride at 1000 ppm for two hours (2000 ppm-hours, one half of the Cl permitted for an 8-hour exposure at 500 ppm) resulted in carboxyhemoglobin levels in excess of those permitted in industry from exposure to CO alone.

This finding of the body's capacity to metabolize methylene chloride to CO was confirmed by Ratney, Wegman and Elkins[illegible] in a small group of workers exposed to 180 to 200 ppm methylene chloride. Such daily, repeated exposures resulted in equilibrium blood concentrations of carboxyhemoglobin of [illegible] that decreased to half that value by next day's start of work. The differential increment in percent carboxyhemoglobin of 4.5% from a day's exposure at 180 to 200 ppm of methylene chloride is approximately the same as that developed from a daily exposure to CO at its TLV of 50 ppm.

DiVincenzo[illegible] found that humans exposed to 100 ppm methylene chloride for 8 hours had a carboxyhemoglobin (COHb) value of 3.22% ± 0.22%, whereas an 8-hour exposure at 150 ppm produced 5.39% ± 0.06% level and an 8-hour exposure at 200 ppm resulted in COHb level of 6.8% ± 0.65%.

In an extensive study several healthy adults of both sexes were exposed from 2-10 times to methylene chloride vapor concentrations of 0.50, 100, 250 or 500 ppm for periods of 1, 3 and 7.5 hours in a controlled environment chamber. These studies were designed to simulate the type of exposures encountered in the industrial setting and consisted of both steady, non-fluctuating vapor concentrations. Exposure resulted in a prompt elevation of carboxyhemoglobin. The elevation persisted longer than COHb from CO alone since metabolism of the absorbed methy-



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lene chloride continued after exposure ceased. This solvent-induced COHb is apparently added to the body burden of carbon monoxide derived from other sources.

This study corroborated previous single exposure studies in that no deleterious effects upon the health or performance of healthy adults could be detected when they were repeatedly exposed to 250 ppm or less for 7.5 hours per day, five days per week for 2 weeks, or in the case of the male subjects, to 500 ppm on two consecutive days.[14] Among the parameters studied were complete blood count, clinical chemistry (SMA 12), EKG, serum triglycerides, blood pressure, subjective signs and symptoms, urinalysis (Combistrip), urinary urobilinogen, neurological tests, EEG, visual evoked response, pulmonary function and cognative awareness, time estimation, coordination, arithmetic and inspection tests.

The increase in COHb was related to the magnitude of the vapor exposure. Both duration of exposure and vapor concentration were factors. Seven and one-half hour exposures to concentrations as low as 100 ppm for 5 days resulted in COHb elevations about 5 percent in nonsmokers. The odor was not objectionable at 250 ppm and many subjects could not detect it at 50 or 100 ppm.

Since the toxic effects of methylene chloride are due in part to its conversion to carbon monoxide, they would presumably be augmented by the presence of carbon monoxide in the air. Foder et al. found the effects of CO and the COHb from methylene chloride to be additive in 5-hour exposure tests in rats. Therefore, whenever there is a combined exposure to the vapors of methylene chloride and carbon monoxide, the additive equation for mixtures should be used in determining whether or not the exposure is acceptable.

A time-weighted average TLV of 100 ppm is recommended for methylene chloride in the absence of occupational exposure to carbon monoxide. This recommendation is based upon experimental data obtained from nonsmoking males at rest, and should keep COHb levels well below 5 percent. A STEL of 500 ppm is recommended since data indicate that neither undesirable CNS responses nor COHb values are likely to occur with such exposures to methylene chloride alone. Concurrent exposure to other sources of carbon monoxide or physical activity will require assessment of the overall exposure and adjustment for the combined effect.

Other recommendations: NIOSH (1976) 75 ppm; West Germany (1979) and Elkins (1959) 200 ppm; ANSI (1969) 500 ppm; USSR (1970) 15 ppm; East Germany (1973), Romania (1975), Yugoslavia (1971) and Czechoslovakia (1976) 100 ppm; Sweden (1974) 100 ppm; others 200 or 250 ppm.

**References:**


1. Lehmann, K.B., Flury, F.: *Toxicology & Hygiene of Industrial Solvents*, pp. 13-138. Williams & Wilkins, Baltimore, MD (1943).
2. von Oettingen, W.F.: Halogenated Hydrocarbons: Toxicity & Potential Dangers. *Pub. Health Service Publication* #434, pp. 35-41 (1955).
3. Svirbely, J.L., Highman, B., Alford, W.C., von Oettingen, W.F.: *J. Ind. Hyg. & Tox.* 29:382 (1947).
4. Heppel, L.A., Neal, P.A., Perrin, T.L., Orr, N.L., Porterfield, V.T.: *Ibid.* 26:8 (1944).
5. Moskowitz, S., Shapiro, M.: *Arch. Ind. Hyg. & Occup. Med.* 6:116 (1952).
6. Collier, H.: *Lancet* 1:594 (1936).
7. Kuzelova, M., Vlasak, R.: *Pracovní Lékařství* 18:[illegible] (1966); abstr. in *Scientific Reports on Industrial Hygiene and Occupational Diseases in Czechoslovakia*, p. 64, Prague (1966).
8. Weiss, G.: *Zentralblatt Arbeitsmed. u. Arbeitsschutz* 17:282 (1967).
9. Golubovskii, I.E., Kamchatnova, V.P.: *Hygiene & Sanitation* 29:145, USSR (1964).
10. Stewart, R.D., Fisher, T.N., Hosko, J.J., Peterson, J.E., Baretta, E.D., Dodd, H.C.: *Science* 176:295 (1972).
11. Stewart, R.D., Fisher, T.N., Hosko, M.J., Peterson, J.E., Baretta, E.D., Dodd, H.C.: *Arch. Env. Health* 25:342 (1972).
12. Ratney, R.S., Wegman, D.H., Elkins, H.B.: *Ibid.* 28:223 (1974).
13. Raleigh, Robert L., M.D.: Letter report from Director, Health & Safety Laboratory, Eastman Kodak Company, Rochester (April 3, 1975).
14. Stewart, R.D., Hake, C.L., Forster, H.V., Lebrun, A.J., Peterson, J.E., Wu, A.: *Methylene Chloride: Development of a Biologic Standard for the Industrial Worker by Breath Analysis*.
15. Foder, G.G., Prasnar, D., Schlipkoter, H.W.: Endogenous CO Formation by Incorporated Halogenated Hydrocarbons of the Methane Series. *Staub-Reinhalt Luft* 33:260-261 (1973).
16. NIOSH: *Criteria for a Recommended Standard—Occupational Exposure to Methylene Chloride*. U.S. HEW Publication No. (NIOSH) 76-138 (March 1976).
17. Stewart, R.D., Forster, H.W., Hake, C.L., Lebrun, A.J., Peterson, J.E.: *Human Responses to Controlled Exposures of Methylene Chloride Vapor*. Report No. NIOSH-MCOW-ENVM-MC-[illegible]. The Medical College of Wisconsin, Dept. of Environmental Medicine, Milwaukee, WI (December 1973).
18. Winneke, G.: *Behavioral Effects of Methylene Chloride and Carbon Monoxide as Assessed by Sensory and Psychomotor Performance*. C. Xintaras, B.L. Johnson, I. de Groot, Eds. *Behavioral Toxicology — Early Detection of Occupational Hazards*. HEW Pub. No. (NIOSH) 74-126, pp. 110-144. U.S. DHEW, Center for Disease Control, NIOSH (1974).
19. Hake, C.L., Stewart, R.D., Forster, H.V., Lebrun, A.J., Peterson, J.E., Wu, A.: *Results of Controlled Exposure of Human Females to Vapor of Methylene Chloride*. Report No. NIOSH-MCOW-ENVM-MC-[illegible]. The Medical College of Wisconsin, Dept. of Environmental Medicine, Milwaukee, WI (March 1974).
20. Gamborale, F., Annwall, B.A., Hultengren, M.: Exposure to Methylene Chloride — II. Psychological Functions. *Scand. J. Work. Env. Health* 1:95-103 (1975).




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3. Grandjean, E. et al: Arch. Ind. Health 114:426-441 (1956)
4. Dale, K.: Scand. J. Resp. Dis. 54(3):168-184 (1973)
5. National Cancer Institute: Bioassay of Titanium Dioxide for Possible Carcinogenicity. DHEW Pub. No. (NIH) 78-1346. Bethesda, MD (1978)

# TOLUENE

**Toluol**

$C_6H_5CH_3$

**Skin**

**TLV, 100 ppm ( ≈ 375 mg/m³)**

**STEL, 150 ppm ( ≈ 560 mg/m³)**

*Toluene is a colorless liquid with a typical aromatic hydrocarbon odor. Its molecular weight and specific gravity are 92.13 and 0.866, respectively. The boiling point is 110.6° C and solidifies at -95° C. At 25° C, the vapor pressure is 28 mm Hg. The closed cup flash point is 40° F. It is insoluble in water but miscible with most organic solvents.*

Formerly derived solely from coal tar, toluene is now obtained chiefly from petroleum, and is present in gasoline and many petroleum solvents. It is used as a solvent in paints and coatings, for rubber, oils, resins, etc., as a raw material for the manufacture of benzene and a host of other chemicals, including TNT, TDI, and ingredients of detergents, dyes and drugs.

Because of its wide industrial use and chemical similarity to benzene, the literature of industrial toxicology and industrial medicine, particularly the latter, record numerous investigations of the toxic effects of toluene. According to Patty[1] the concentrations of toluene and benzene required to cause prostration of mice are apparently 3000 ppm and 4700 ppm, respectively. Death from acute poisoning results from 10,000 ppm toluene compared with 14,000 ppm of benzene. Several incidents of workers being overcome by toluene vapor, usually in confined spaces, have been reported. Longley and co-workers[2] describe such an event aboard ship where 26 men were overcome. There were no deaths or serious aftereffects. No irritation of eyes or respiratory passages was observed.

From the standpoint of chronic poisoning, toluene does not cause the severe injury to the bone marrow characteristic of benzene poisoning. Gerarde[3] stated that the myelotoxicity of benzene was completely absent in toluene and other alkyl derivatives of benzene. Von Oettingen *et al*[4] found that exposure of rats at 2500 to 5000 ppm of toluene caused a temporary decrease in the white-cell count, but no evidence of injury to blood-forming organs or liver. Greenburg and co-workers[5] studied a group of painters exposed to toluene in concentrations ranging from 100 to 1100 ppm. Their findings included enlargement of the liver, macrocytosis, moderate decrease in erythocyte count and absolute lymphocytosis, but no leukopenia.

Wilson[6] found that among workers exposed at less than 200 ppm of toluene there were some complaints of headache, lassitude and nausea, but physical findings were essentially negative. At concentrations between 200 and 500 ppm impairment of coordination, momentary loss of memory and anorexia were also present. Between 500 and 1500 ppm palpitation, extreme weakness, pronounced loss of coordination and impairment of reaction time were noted. The red cell count fell in many instances, and there were two cases of aplastic anemia, in which recovery followed intensive hospital treatment. A later comment by Wilson[7] however, suggests that he did not rule out the possibility that some of the above effects were due to a benzene impurity in the toluene used.

According to Fairhall,[8] severe exposure to toluene may result in a pronounced drop in the red count and partial destruction of the blood-forming elements of the bone marrow. However, Gerarde[9] stated that extensive animal studies clearly indicate that toluene is not a bone marrow poison. While there have been occasional reports of aplastic anemia attributed to toluene,[7] in some instances the presence of benzene was not precluded, and there have been no "epidemics" of this disease among toluene workers comparable to those which have resulted from benzene. Powars[10] reported six cases of aplastic anemia, one of them fatal, among glue sniffers. Although toluene was the solvent chiefly used, no analysis was given of the glue involved in the fatal case. Exposures in these cases are much greater than would normally arise from occupational use of toluene. Thus Knox and Nelson[11] described an instance of permanent encephalopathy involving a man who inhaled toluene regularly for over 14 years.

Von Oettingen and co-workers[4] found that human subjects exposed at 200 ppm suffered slight but definite changes in muscular coordination. They concluded that such concentrations were unlikely to have any discernible untoward effects on health. Gerarde[9] however, believed that von Oettingen's work did not justify the 200 ppm limit. Ogata *et al*[12] found that experimental human subjects exposed at 200 ppm for seven hours showed prolongation of reaction time, decrease in pulse rate and in systolic blood pressure. They consider 200 ppm too high as the MAC. Takeuchi[13] exposed rats at 200 ppm and higher concentrations of toluene for 32 weeks and then to benzene for 39 days. On the basis of differences found between the toluene-exposed animals and controls, e.g. changes in weight of adrenal glands, he suggested that the MAC of 200 ppm for toluene should be reconsidered.

Smyth *et al* reported an oral $LD_{50}$ administered to rats to be 7.53 mL/kg.[14]

On the basis of the above data, a reduction in the TLV for toluene from 200 ppm to 100 ppm is recommended with a STEL of 150 ppm.

Other recommendations: Cook (1945) 200 ppm, Smyth (1956) comments that this limit may permit early signs of narcosis, Elkins (1959) 200 ppm, ANSI (1967) 200 ppm, USSR (1967) 14 ppm, Czechoslovakia (1969) 50 ppm, West Germany (1974) 200 ppm, Sweden (1975) 100 ppm, East Germany (1973) 50 ppm, NIOSH (1973) 100 ppm.

**References:**

1. Patty, F.S.: *Industrial Hygiene & Toxicology*, 2nd ed., Vol. II, p. 1226, Interscience, NY (1963)
2. Longley, E.O., Jone, A.T., Lomaev, O.: *Arch. Env. Health* 14:481 (1967)

## NAPHTHA

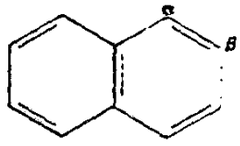
See. RUBBER SOLVENT

## NAPHTHALENE

$C_{10}H_8$

**TLV, 10 ppm ( ≈ 50 mg/m³)**

**STEL, 15 ppm ( ≈ 75 mg/m³)**




Naphthalene occurs commonly as white, crystalline flakes which have a strong coal tar odor. It has a molecular weight of 128.16 and a specific gravity of 1.145. It melts at 80.2° C, boils at 217.96° C and has a vapor pressure at 25° C of approximately 0.087 mm Hg. The open cup flash point is 176° F and closed cup is 190° F. Insoluble in water, it dissolves in most organic solvents.

Crystalline naphthalene finds household use as a moth repellent, scientific use in scintillation counters. It is an important raw material for the manufacture of phthalic anhydride, naphthol, hydrogenated naphthalenes and halogenated naphthalenes. It or its derivatives are employed in dyes, explosives, lubricants, tanning agents and emulsion breakers.

According to Flury and Zernik[1] and Patty[2] the inhalation of naphthalene vapor may cause headache, loss of appetite and nausea. Optical neuritis and injuries to the cornea and, in addition, kidney damage have also been reported. Ghetti and Mariani[3] reported opacities of the lens in 8 of 21 workers who had been exposed to naphthalene for about five years. Ingestion of naphthalene in relatively large amounts has reportedly caused severe hemolytic anemia and hemoglobinuria.[4] A hypersusceptibility, probably genetically based, is recognized.[5]

The oral $LD_{50}$ for rats is 1760 mg/kg.[6] It was used as an antihelmintic for many years at dose levels, for adults, of 0.1 to 0.5 gram three times a day,[7] several times higher than the lowest reported lethal dose for man of 50 mg/kg.[8] An incident in which blankets containing naphthalene caused acute hemolytic effects in infants, in some cases fatal, has been described.[8]

Patty suggested 25 ppm as a tentative limit for naphthalene vapor in air. He noted that this corresponds to a saturation pressure of approximately 25% at 25° C. This value has been used at the Los Alamos Laboratories, according to Hyatt and Milligan.[9] Robbins[10] however reported that concentrations in excess of about 15 ppm resulted noticeable irritation of the eyes.

Gerarde[11] also suggested 25 ppm as a tentative limit, noting that it represents 25% of the concentration of naphthalene vapor in air saturated at 25° C.

In view of the fact that irritation is experienced at 15 ppm and that continued exposure may result in early serious eye effects, a limit lower than 25 ppm would seem in order. The value of 10 ppm TLV and 15 ppm STEL are recommended to prevent ocular effects, but possibly not blood changes in hypersusceptibles.

Other recommendations: West Germany, 10 ppm; East Germany and USSR, 4 ppm.

**References:**


1. **Flury, F., Zernik, F.:** *Schadliche Case* p. 290 ; Springer Berlin (1931)
2. **Patty, F.A.:** *Industrial Hygiene & Toxicology* Vol. II, p. 770 Interscience, NY (1949)
3. **Ghetti, G., Mariani, L.:** *Med. d. Lavoro* 47 533 (1956)
4. **Zuelzer, W.W., Apt, L.:** *J.A.M.A.* 141 185 (1949)
5. **Stokinger, H.E., Mountain, I.T.:** *Arch. Env. Health* 6 495 (1963)
6. **NIOSH:** *Registry of Toxic Effects of Chemical Substance* (1977)
7. **Am. Ind. Hyg. Assoc.:** *Hygienic Guide Series-Naphthalen* (1967)
8. **Valoes, T., Doxiadis, S.A., Fassas, P.:** *J. Ped.* 63 904 (1963) Cited in ref. 7
9. **Hyatt, E.C., Milligan, M.F.:** *Am. Ind. Hyg. Assoc. Q.* 14 28 (1953)
10. **Robbins, M.C.:** *Arch. Ind. Hyg. & Occup. Med.* 4 85 (1951)
11. **Gerarde, H.W.:** *Toxicology & Biochemistry of Aromatic Hydrocarbons*, p. 230, Elsevier Pub. Co., NY (1960)

The TLV of 0.5 mg/m³ is believed low enough to minimize the incidence of chloracne and prevent serious injury to the liver. However, in view of the fact that hepatic changes in rats resulted from 143 eight-hour exposures at 1.44 mg/m³ of a mixture of penta- and hexachloronaphthalenes,[5] the margin of safety of the 0.5 mg/m³ limit for pentachloronaphthalene may be rather small. At this time, a STEL of 2 mg/m³ is suggested.

**References:**


1. von Oettingen, W.F.: *The Halogenated Hydrocarbons. Their Toxicity & Potential Dangers.* Public Health Service Pub. #414, p. 313 (1955).
2. Cotter, L.H.: *J.A.M.A.* 125:273 (1944).
3. *Annual Report of the Chief Inspector of Factories for 1938*, p. 67. H.M.S.O., London (1939).
4. Drinker, C.K., Warren, M.F., Bennett, G.A.: *J. Ind. Hyg. & Tox.* 19:283 (1937).
5. Bennett, G.A., Drinker, C.K., Warren, M.F.: *Ibid.* 20:97 (1938).
6. Drinker, C.K.: *Ibid.* 2:155 (1939).
7. Bell, W.B.: *Vet. Med.* 48:135 (1953).


## PENTACHLOROPHENOL

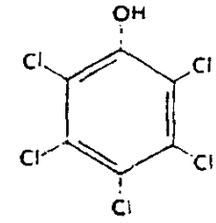
**PCP; Chem-Tol; Permacide; Penta; Santophen 20; Dowicide 7**

$C_6HCl_5O$

*Skin*

**TLV, 0.5 mg/m³**

**STEL, 1.5 mg/m³**

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*Pentachlorophenol is a colorless, noncombustible solid with a phenolic odor and a pungent taste. The molecular weight is 266.35, specific gravity is 1.978 at 20° C and, at the same temperature, the reported vapor pressure of 0.00017 mm Hg. It is volatile with steam and noncorrosive to metals. Its melting point is 190° C with a boiling point of 310° C. The compound is soluble in water to the extent of 14 ppm at 20° C. Its solubility in organic solvents depends greatly on the nature of the solvent. Barely soluble in alkanes, pentachlorophenol is most soluble in methyl alcohol.*

It is a contact herbicide, fungicide, wood preservative and molluscicide.

The most important effect of PCP inhalation is acute poisoning centering in the circulatory system with accompanying heart failure. Kehoe *et al.*[1] found no evidence of chronic poisoning in rabbits. The smallest lethal intravenous dose was 22 mg/kg. The compound penetrates the skin readily. Physiologic injury is mainly vascular with heart failure. Industrial hygiene experience shows that PCP and its sodium salt are capable of inducing discomfort and local as well as systemic effects. Dusts are particularly irritating to the eyes and nose in concentrations greater than 1 mg/m³.[2] Some irritation of the nose may occur at 0.3 mg/m³.[3] Hardened workers can tolerate up to 2.4 mg/m³.[2] PCP is highly poisonous with a wide range of acute action but no pronounced cumulative properties. It has been demonstrated[3] that dermal penetration is the most dangerous pathway of PCP exposure. The acute gastric $LD_{50}$'s for mice and rats are 130 and 184 mg/kg, respectively.[3] The dermal $LD_{50}$ in rats is 96 mg/kg. The inhalation $LD_{50}$ for rats is 335 mg/m³ and for mice 225 mg/m³.[3] The rat embryo was shown to be most susceptible to the toxic effects of PCP during the early phases of organogenesis.[4] The world literature reveals about 51 cases of PCP poisoning from its use as a herbicide, molluscicide or wood preservative of which 30 out of 51 resulted in death.[5] The survivors of PCP intoxication suffer with impairments in autonomic function, circulation, visual damage and an acute type of scotoma.[6] Other damage included acute inflammation of the conjunctiva and characteristically shaped corneal opacity, corneal numbness and slight mydriasis.[6] Other symptoms involve excessive sweating, tachycardia, tachypnea, respiratory distress, hepatic enlargement and metabolic acidosis.

The 0.5 mg/m³ TLV and the STEL of 1.5 mg/m³ are derived by analogy with other compounds of similar action and toxicity in addition to the specific available information. They are believed low enough to prevent vascular injury.

**References:**


1. Kehoe, R.A., Deichmann-Gruebler, W., Kitzmiller, K.V.: *J. Ind. Hyg. & Tox.* 21:160 (1939).
2. Patty, F.A.: *Industrial Hygiene & Toxicology*, 2nd ed., Vol. II, p. 1401. Interscience, NY (1963).
3. Demidenko, N.M.: *Gigiena Truda i Prof. Zabolevaniya* 13(9):58 (1969).
4. Schwetz, B.A., Gehring, P.J.: *Tox. Appl. Pharm.* 24(3):455 (1973).
5. Anonymous: *Calif. Health* 27(12):13 (1970).
6. Imaizum, K.: *Atsumi, K. Gankai* 3(7):71[illegible] (197[illegible]).




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**References**

1. NIOSH: *Toxic Substances List*. HEW Pub. No. (NIOSH) 74-134 (1974)
2. Dow Chemical Company: Communication to TLV Committee (1977)

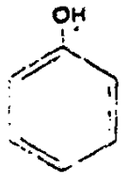
# PHENOL

## $C_6H_5OH$

**Skin**

**TLV, 5 ppm ( ≈ 19 mg/m³)**

**STEL, 10 ppm ( ≈ 38 mg/m³)**




*Pure phenol is a solid at room temperature and is liquified by mixing with about 8% water. The molecular weight is 94.11 and the specific gravity is 1.071. It is white but often has a pinkish hue resulting from impurities or exposure to light and has a characteristic sweet, tarry odor. The solid has a boiling point of 182° C and, when free from water and cresols, it congeals at 41° C and melts at 43° C. At 25° C it has a vapor pressure of 0.35 mm Hg. It is soluble in water and most organic solvents and is combustible having a closed cup flash point of 172° F.*

Its chief use is as a starting point in the manufacture of phenolic resins, bis-phenol-A, caprolactam and many other chemicals and drugs. It is employed as a disinfectant in germicidal paints and as a slimicide.

Deichmann[1] reported results of animal experimentation in which guinea pigs were severely injured by inhalation for 20 days of phenol vapor at concentrations of from 25 to 50 ppm. Post mortem evidence of acute toxicity to the lungs, heart, liver and kidney was found.

Intermittent industrial exposure[2] (five to ten minutes per hour) inside a conditioning room for phenol-impregnated asbestos resulted in marked irritation of the nose, throat and eyes. The average phenol concentration in the room was 48 ppm, although formaldehyde (8 ppm) also was found. Urine sulfate ratios were 79.4 and 86.7 percent. Workers at the same plant, continuously exposed during winding operations, experienced no respiratory irritation, although the odor of phenol was noticeable. The average concentration found was 4 ppm. Urine sulfate ratios averaged 74 percent.

Due in part to its low volatility, phenol does not frequently constitute a serious respiratory hazard in industry.[3] Formerly its use as an antiseptic in surgery resulted in numerous cases of sub-acute or chronic poisoning among surgeons and their assistants.[4] Urinary excretions of 2 grams per day, by patients, have been reported.[4] Absorption of 2 grams of phenol could result from eight hours inhalation at about 50 ppm.

According to Thomas and Back[5] the TLV of 5 ppm provides a sufficiently large factor of safety to prevent systemic poisoning if skin absorption is avoided.

In 1976 NIOSH published a criteria document in which the toxicology of phenol was reviewed.[6] The serious local and systemic effects of contact of the skin with phenol and its concentrated solutions were properly emphasized. Relatively little additional information on the effects of inhalation, bearing on the TLV, however, turned up. A report by Petrov[7] of poisonings among workers in Russia who quenched coke with waste water containing 0.3 to 0.8 mg of phenol per liter is discussed. Air samples indicated phenol vapor concentrations of the order of 2 to 3 ppm and the author believed that phenol might have been implicated in the intoxications which were not described.

The NIOSH recommendation of 20 mg/m³ as a time-weighted average standard is essentially the same as the TLV of 5 ppm established in 1952. The NIOSH [illegible] mg/m³ for any 15 minute period is higher than the STEL of 10 ppm ( 38 mg/m³).

Except for the USSR, which has set an MAC of 5 ppm, most of the published hygienic standards (East and West Germany, Sweden, Czechoslovakia) are either 19 or 20 mg/m³ or, for practical purposes, 5 ppm.

**References:**

1. Deichmann, W.B., Kitzmiller, K.V., Witherup, S.: Am. J. Clin. Path. 14:273 (1944)
2. Connecticut Bur. of Ind. Hygiene: Unpublished data
3. Elkins, H.B.: *The Chemistry of Industrial Toxicology*, 2nd ed., p. 116, Wiley & Sons, NY (1959)
4. Patty, F.A.: *Industrial Hygiene & Toxicology*, 2nd ed., vol. 2, p. 1370, Interscience, NY (1963)
5. Thomas, A.A., Back, K.C.: *A Symposium on Toxicity in the Closed Ecologic System*, p. 135, Hohma & Crosby Ed., Lockheed Missiles & Space Co., Palo Alto, CA (1964)
6. NIOSH: *Criteria for a Recommended Standard-Occupational Exposure to Phenol*. HEW Publication No. (NIOSH) 76-196 (1976)
7. Petrov, V.I.: Cases of Phenol Vapor Poisoning During Coke Slaking with Phenol Water, in Levine, B.S. (trans): *USSR Literature on Air Pollution and Related Occupational Diseases-A Survey*. U.S. Dept. of Commerce, National Technical Information Service 8:219 (1963) (NTIS 63-11570), Springfield, VA. Cited by NIOSH in ref. 6



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| | |
|---|---|
| Common Name | Liquid — Yellow to black — Tarry odor |

**Fire**

Combustible

**Exposure**

LIQUID

**Water Pollution**

## 1 RESPONSE TO DISCHARGE

Issue warning — water contaminated
Mark shoreline for evidence
Should be removed
Chemical and physical treatment

## 2 LABELS

No Label required — Code of Federal Regulations

## 3 CHEMICAL DESIGNATIONS

3.1 Synonyms: Creosote oil, Dead oil
3.2 Coast Guard Compatibility Classification: Crude
3.3 Chemical Formula: Mixture
3.4 NIOSH/OSHA Basic Numerical Designation: 9/3622

## 4 OBSERVABLE CHARACTERISTICS

4.1 Physical State (at shipping): Liquid
4.2 Color: Yellow to brown to black
4.3 Odor: (Pungent or tarry aromatic

## 5 HEALTH HAZARDS

5.1 Personal Protective Equipment: Allowable respirator mask, rubber gloves, chemical safety goggles and or face shield, overall or a disposable apron, barrier creams
5.2 Symptoms Following Exposure: Vapors cause moderate irritation of nose and throat. Liquid causes burns of eyes and reddening and itching of skin. Prolonged contact and skin absorption form lesions which are cancerous. Inhalation causing headaches, dizziness, nausea, loss of appetite, difficult breathing, chronic bronchitis, chronic pulmonary congestion, chronic conjunctivitis
5.3 Treatment for Exposure: INHALATION: remove victim to fresh air. If breathing is difficult give oxygen. Call physician. EYES: flush immediately with plenty of water for at least 15 min. and call a physician. SKIN: wash with soap and water. INGESTION: Give victim some water to drink. do NOT induce vomiting
5.4 Toxicity by Inhalation (Threshold Limit Value): Data not available
5.5 Short-Term Inhalation Limits: Data not available
5.6 Toxicity by Ingestion: Grade 2. $LD_{50}$ 0.5 to 5.0 g/kg
5.7 Late Toxicity: Prolonged exposure may cause cancer of skin
5.8 Vapor (Gas) Irritant Characteristics: Vapors cause moderate irritation with that permanent and high concentration, irritation. The eyes are affected
5.9 Liquid or Solid Irritant Characteristics: Liquid causes skin irritation. May cause burns and ulcerated degree burns after a few minutes contact
5.10 Odor Threshold: Data not available

## 6 FIRE HAZARDS

6.1 Flash Point: > 150°F C.C.
6.2 Flammable Limits in Air: Not pertinent
6.3 Fire Extinguishing Agents: Dry chemical, carbon dioxide or foam
6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective
6.5 Special Hazards of Combustion Products: Data not available
6.6 Behavior in Fire: Heavy smoking black smoke is formed
6.7 Ignition Temperature: 650°F
6.8 Electrical Hazard: Not pertinent
6.9 Burning Rate: Data not available

## 7 CHEMICAL REACTIVITY

7.1 Reactivity with Water: No reaction
7.2 Reactivity with Common Materials: No reaction
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: Not pertinent
7.6 Inhibitor of Polymerization: Not pertinent

## 8 WATER POLLUTION

8.1 Aquatic Toxicity: Data not available
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): Data not available
8.4 Food Chain Concentration Potential: None

## 9 SELECTED MANUFACTURERS

1 Koppers Chemical Corporation
Pitch Division
3rd Park Avenue
New York, N.Y.
2 Koppers Company, Inc.
Organic Materials Division
Koppers Building
Pittsburgh, Pa.
3 Allied Chemical Corporation
Semet-Solvay Division
Ironton Tar Plant
3330 South Third Street
Ironton, Ohio

## 10 SHIPPING INFORMATION

10.1 Origin or Purpose: Water treatment or reclamation, depending on boiling point. A. Boiler water problems
10.2 Storage Temperature: Ambient
10.3 Inert Atmosphere: No requirement
10.4 Venting: Open-flame pressure

## 11 HAZARD ASSESSMENT CODE

A T U R Y

## 12 HAZARD CLASSIFICATIONS

12.1 Code of Federal Regulations Combustible Liquid
12.2 NAS Hazard Rating for Bulk Water Transportation

| Category | Rating |
|---|---|
| Fire | 1 |
| Health | |
| Vapor Irritant | 2 |
| Liquid or Solid Irritant | 3 |
| Poisons | 3 |
| Water Pollution | |
| Marine Toxicity | 2 |
| Aquatic Toxicity | 3 |
| Aquatic Effect | 4 |
| Reactivity | |
| Other Chemicals | 1 |
| Water | 0 |
| Self Reaction | 0 |

12.3 NFPA Hazard Classifications

| Category | Classification |
|---|---|
| Health Hazard (Blue) | 3 |
| Flammability (Red) | 2 |
| Reactivity (Yellow) | 0 |

## 13 PHYSICAL AND CHEMICAL PROPERTIES

13.1 Physical State at 15°C and 1 atm.: Liquid
13.2 Molecular Weight: Mixture
13.3 Boiling Point at 1 atm.: > 315°F = > 150°C = > 332°K
13.4 Freezing Point: Not pertinent
13.5 Critical Temperature: Not pertinent
13.6 Critical Pressure: Not pertinent
13.7 Specific Gravity: 1.05 (Range 1.15°C liquid)
13.8 Liquid Surface Tension (mn): 15 dynes/cm = 0.015 N/m at 20°C
13.9 Liquid Water Interfacial Tension (mn): 30 dynes/cm = 0.030 N/m at 20°C
13.10 Vapor (Gas) Specific Gravity: Not pertinent
13.11 Ratio of Specific Heats of Vapor (Gas): Not pertinent
13.12 Latent Heat of Vaporization: Not pertinent
13.13 Heat of Combustion: (range 14,000 to 17,000 Btu/lb) = (8,000 to 10,000 kg)
13.14 Heat of Decomposition: Not pertinent
13.15 Heat of Solution: Not pertinent
13.16 Heat of Polymerization: Not pertinent

(Continued on next page)

NOTES

| CRS | CRESOLS |
|---|---|

| | |
|---|---|
| [illegible] | Water liquid or solid miscible. Colorless or tinted. Sweet tarry odor. Soluble in water. |
| [illegible] | [illegible] |
| Fire | Combustible. POISONOUS GASES MAY BE PRODUCED IN FIRE. [illegible] |
| Exposure | [illegible] MEDICAL AID. LIQUID. [illegible] DO NOT INDUCE VOMITING. |
| Water Pollution | HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS. [illegible] |

## 1. RESPONSE TO DISCHARGE

[illegible]

## 2. LABEL

## 3. CHEMICAL DESIGNATIONS

3.1 Synonyms
- Cresylic acid
- Hydroxytoluene
- Methylphenol
- Cresylic acid
- Tar acid

3.2 Coast Guard Compatibility Classification: Class

3.3 Chemical Formula: $CH_3C_6H_4OH$

3.4 NFPA Hazard Rating: [illegible]

Designation: [illegible]

## 4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Liquid or solid

4.2 Color: Colorless to dark yellow

4.3 Odor: Sweet, tarry

## 5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Organic vapor cartridge and (U.S.B.M. Type B) respirator in U.S. Bureau of Mines Rubber gloves, chemical safety goggles, face shield. Long sleeve shirt or rubber apron, rubber shoes or boots.

5.2 Symptoms Following Exposure: Vapor causes irritation of eyes, nose and throat. Contact with skin causes burns (acid) burns. Chemical is rapidly absorbed through skin.

5.3 Treatment for Exposure: Call physician. INHALATION: Immediately remove to fresh air. INGESTION: Give water or milk, do NOT induce vomiting. SKIN OR EYES: Flush with plenty of water for at least 15 min. Remove contaminated clothing immediately and wash before reuse. Discard contaminated shoes.

5.4 Toxicity by Inhalation (Threshold Limit Value): 5 ppm

5.5 Short-Term Inhalation Limits: Data not available

5.6 Toxicity by Ingestion: Grade 2 (LD50 0.5 to 5.0 g/kg rat, rabbit)

5.7 Late Toxicity: Data not available

5.8 Vapor (Gas) Irritant Characteristics: Vapor causes irritation of eyes, nose and throat. Contact with skin causes burns (acid) burns. The vapor is irritating.

5.9 Liquid or Solid Irritant Characteristics: Fatal when swallowed, may cause burns and severe gastrointestinal irritation.

5.10 Odor Threshold: 5 ppm

## 6. FIRE HAZARDS

6.1 Flash Point: [illegible] F (C.C.)

6.2 Flammable Limits in Air: LEL [illegible] (basis of data)

6.3 Fire Extinguishing Agents: Water, dry chemical, carbon dioxide and foam.

6.4 Fire Extinguishing Agents Not to Be Used: Not applicable.

6.5 Special Hazards of Combustion Products: Highly toxic and corrosive gas of cresol.

6.6 Behavior in Fire: Sealed closed containers may burst due to pressure of decomposition gases.

6.7 Ignition Temperature: [illegible] F (Autoignition temperature)

6.8 Electrical Hazard: Data not available

6.9 Burning Rate: Data not available

## 7. CHEMICAL REACTIVITY

7.1 Reactivity with Water: Not reactive

7.2 Reactivity with Common Materials: Corrosive

7.3 Stability During Transport: Stable

7.4 Neutralizing Agents for Acids and Caustics: Not pertinent

7.5 Polymerization: Not pertinent

7.6 Inhibitor of Polymerization: Not pertinent

## 8. WATER POLLUTION

8.1 Aquatic Toxicity: [illegible]

8.2 Waterfowl Toxicity: Data not available

8.3 Biological Oxygen Demand (BOD): [illegible]

8.4 Food Chain Concentration Potential: None

## 9. SELECTED MANUFACTURERS

1. Allied Chemical Corp., Plastics Division, Morristown, N.J. 07960
2. Commercial Oil Co., Petrochemical Chemicals Division, Paramus, N.J. [illegible]
3. [illegible] Co. Inc., Chemical Materials Division, Pittsburgh, Pa. [illegible]

## 10. SHIPPING INFORMATION

10.1 Grades of Purity: [illegible]

## 11. HAZARD ASSESSMENT CODE

A-0-0 1-0-0-Y

## 12. HAZARD CLASSIFICATIONS

12.1 Code of Federal Regulations: Poison B liquid or solid, Class B

12.2 NFPA Hazard Rating for Bulk Water Transportation:

| Category | Rating |
|---|---|
| Fire | 1 |
| Health | |
| Water Hazard | 2 |
| Liquid or Solid Hazard | 3 |
| Poisons | 2 |
| Water Pollution | |
| Marine Toxicity | 1 |
| Aquatic Toxicity | 3 |
| Aquatic Effect | 4 |
| Reactivity | |
| Other Chemicals | 2 |
| Water | 0 |
| Self-Reaction | 0 |

12.3 NFPA Hazard Classification:

| Category | Classification (Water and Dry Bulk) | |
|---|---|---|
| Health Hazard (Blue) | 3 | 3 |
| Flammability (Red) | 2 | 1 |
| Reactivity (Yellow) | 0 | 0 |

## 13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 Physical State at 15°C and 1 atm: Liquid

13.2 Molecular Weight: 108.13

13.3 Boiling Point at 1 atm: [illegible] °F = [illegible] °C = [illegible] °K

13.4 Freezing Point: Not pertinent

13.5 Critical Temperature: Not pertinent

13.6 Critical Pressure: Not pertinent

13.7 Specific Gravity: 1.03 at 20°C (liquid)

13.8 Liquid Surface Tension: [illegible] N/m at 20°C

13.9 Liquid-Water Interfacial Tension: Data not available

13.10 Vapor (Gas) Specific Gravity: Not pertinent

13.11 Ratio of Specific Heats of Vapor (Gas): 1.07

13.12 Latent Heat of Vaporization: [illegible]

13.13 Heat of Combustion: [illegible]

13.14 Heat of Decomposition: Not pertinent

13.15 Heat of Solution: Not pertinent

13.16 Heat of Polymerization: Not pertinent

## 14. SHIPPING INFORMATION (Cont'd.)

14.1 Special Handling Precautions: [illegible]

14.2 Storage Temperature: Ambient

14.3 Inert Atmosphere: No requirement

14.4 Venting: Open

REVISED 1978

# Occupational Health Guideline for Phenol

## INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

## SUBSTANCE IDENTIFICATION

- Formula: $C_6H_5OH$
- Synonyms: Carbolic acid, monohydroxybenzene
- Appearance and odor: Colorless to pink solid or thick liquid with a characteristic, sweet, tarry odor

## PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for phenol is 5 parts of phenol per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 19 milligrams of phenol per cubic meter of air (mg/m³). NIOSH has recommended that the permissible exposure limit be changed to 20 mg/m³ averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling of 60 mg/m³ averaged over a 15-minute period. The NIOSH Criteria Document for Phenol should be consulted for more detailed information.

## HEALTH HAZARD INFORMATION

- **Routes of exposure**

Phenol can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed. It may enter the body through the skin.

- **Effects of overexposure**

*1. Short-term Exposure:* Phenol has a marked corrosive effect on any tissue. When it comes in contact with the eyes, it may cause severe damage and blindness. On contact with the skin, it does not cause pain but causes a whitening of the exposed area. If the chemical is not removed promptly, it may cause a severe burn or systemic poisoning. Systemic effects may occur from any route of exposure, especially after skin contact.

*2. Long-term Exposure:* Repeated or prolonged exposure to phenol may cause chronic phenol poisoning. The symptoms of chronic poisoning include vomiting, difficulty in swallowing, diarrhea, lack of appetite, headache, fainting, dizziness, dark urine, mental disturbances, and possibly a skin rash. Liver damage and discoloration of the skin may occur.

*3. Reporting Signs and Symptoms:* A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to phenol.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to phenol at potentially hazardous levels:

*1. Initial Medical Examination:*

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Persons with a history of convulsive disorders or abnormalities of the skin, respiratory tract, liver, or kidneys would be expected to be at increased risk from exposure. Examination of the liver, kidneys, and respiratory tract should be stressed. The skin should be examined for evidence of chronic disorders.

—Urinalysis: Darkening of the urine has occurred in persons exposed to phenol after accidental ingestion or skin contact. A urinalysis should be performed, including at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment. Urinary phenol is useful if good individual background levels are available.

—Liver function tests: Since liver damage has been observed in humans exposed to phenol, a profile of liver function should be performed by using a medically acceptable array of biochemical tests.

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These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration



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2. *Periodic Medical Examination:* The aforementioned medical examinations should be repeated on an annual basis.

• **Summary of toxicology**

Phenol in the vapor form or in solution is an irritant to the eyes, mucous membranes, and skin; systemic absorption causes central nervous system effects as well as liver and kidney damage. Sudden collapse is characteristic of gross overexposure. In animals, prolonged inhalation of the vapor at 30 to 60 ppm induced respiratory difficulty, lung damage, and paralysis. Systemic absorption by animals caused muscle twitching and severe convulsions. There are no reports of human fatalities from inhalation of the vapor, although one case of severe poisoning has been reported. Ingestion of lethal amounts (as little as 1 g) cause severe burns of the mouth and throat, marked abdominal pain, cyanosis, muscular weakness, collapse, coma, and death; tremors, convulsions, or muscle twitching were occasionally observed but were not severe. A laboratory technician repeatedly exposed to unknown vapor concentrations and liquid spilled on the skin developed anorexia, weight loss, weakness, muscle aches and pain, and dark urine; during several months of nonexposure there was gradual improvement in his condition, but after brief reexposure he suffered an immediate worsening of symptoms with prompt darkening of the urine and tender enlargement of the liver. Brief intermittent industrial exposures to vapor concentrations of 48 ppm of phenol (accompanied by 8 ppm of formaldehyde) caused marked irritation of eyes, nose, and throat. Concentrated phenol solutions are severely irritating to the human eye and cause conjunctival swelling; the cornea becomes white and hypesthetic; loss of vision has occurred in some cases. Solutions of phenol have a marked corrosive action on any tissue on contact; on skin, there is local anesthesia and a white discoloration, and the area may subsequently become gangrenous; severe dermatitis will result from contact with dilute solutions, and prolonged exposure may result in ochronosis. In workers making phenol-formaldehyde plastic, the urinary level of total phenol, free plus conjugated, was proportional to the air concentration of phenol up to 12.5 mg/m³ of workroom air. Mice were treated twice weekly for 72 weeks by application of 1 drop of a 10% solution of phenol in benzene to the shaved dorsal skin; after 52 weeks of treatment there were papillomas in 5 of 14 mice, and 1 fibrosarcoma appeared at 58 weeks.

## CHEMICAL AND PHYSICAL PROPERTIES

• **Physical data**

1. Molecular weight: 94.11
2. Boiling point (760 mm Hg): 182 C (359 F)
3. Specific gravity (water = 1): 107 (solid); 1.05 (liquid)
4. Vapor density (air = 1 at boiling point of phenol): 3.24
5. Melting point: 41 C (106 F)
6. Vapor pressure at 20 C (68 F): 0.36 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 8.4
8. Evaporation rate (butyl acetate = 1): Less than 0.01

• **Reactivity**

1. Conditions contributing to instability: Heat
2. Incompatibilities: Contact with strong oxidizers (especially calcium hypochlorite) may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving phenol.
4. Special precautions: Liquid phenol will attack some forms of plastics, rubber, and coatings. Hot liquid phenol will attack aluminum, magnesium, lead, and zinc metals.

• **Flammability**

1. Flash point: 79 C (174 F) (closed cup)
2. Autoignition temperature: 715 C (1319 F)
3. Flammable limits in air, % by volume: Lower: 1.7; Upper: 8.6
4. Extinguishant: Alcohol foam, carbon dioxide, dry chemical

• **Warning properties**

1. Odor Threshold: Summer reports that the odor threshold of phenol is 3 ppm; the Manufacturing Chemists Association reports 0.3 ppm; Thienes and Haley report 5 ppm.
2. Irritation Levels: The *Documentation of TLV's* reports that intermittent exposures to 48 ppm phenol have been observed to produce eye, nose, and throat irritation. Formaldehyde was also present in this atmosphere at a concentration of 8 ppm. The Respirator Review Committee considers the source of the eye irritation to be the 8 ppm formaldehyde rather than the phenol.
3. Evaluation of Warning Properties: Since the odor threshold of phenol is at or below the permissible exposure limit, phenol is treated as a material with good warning properties.

## MONITORING AND MEASUREMENT PROCEDURES

• **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of phenol. Each measurement



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should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• **Method**

Sampling and analyses may be performed by collection of phenol in a bubbler containing sodium hydroxide, followed by treatment with sulfuric acid, and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure phenol may be used. An analytical method for phenol is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 6, 1980, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00369-6).

## RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

## PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with solid or liquid phenol or liquids containing phenol.

• If employees' clothing has had any possibility of being contaminated with solid or liquid phenol or liquids containing phenol, employees should change into uncontaminated clothing before leaving the work premises.

• Clothing which has had any possibility of being contaminated with solid or liquid phenol or liquids containing phenol should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of phenol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the phenol, the person performing the operation should be informed of phenol's hazardous properties.

• Where there is any possibility of exposure of an employee's body to solid or liquid phenol or liquids containing phenol, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

• Non-impervious clothing which becomes contaminated with phenol should be removed immediately and not reworn until the phenol is removed from the clothing.

• Employees should be provided with and required to use dust- and splash-proof safety goggles where there is any possibility of solid or liquid phenol or liquids containing phenol contacting the eyes.

• Where there is any possibility that employees' eyes may be exposed to solid or liquid phenol or liquids containing phenol, an eye-wash fountain should be provided within the immediate work area for emergency use.

## SANITATION

• Skin that becomes contaminated with phenol should be immediately washed or showered with soap or mild detergent and water to remove any phenol.

• Any clothing which becomes wet with liquid phenol or liquids containing phenol should be removed immediately and not reworn until the phenol is removed from the clothing.

• Eating and smoking should not be permitted in areas where solid or liquid phenol or liquids containing phenol are handled, processed, or stored.

• Employees who handle solid or liquid phenol or liquids containing phenol should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

## COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to phenol may occur and control methods which may be effective in each case:

| Operation | Controls |
|---|---|
| Application and curing of bonding resin in plywood manufacture; application and curing of molding resins in manufacture of molded articles, such as | Process enclosure; local exhaust ventilation; personal protective equipment |



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| | |
|---|---|
| electrical appliances, automotive parts, foundry sand molds, and utensil handles; manufacture of friction materials, bonded abrasives, coated abrasives, wood particle board, and insulation materials | |
| Use in industrial coatings in drum and can linings, milk and beer-processing equipment, water tanks and air-conditioning equipment, decorative laminates, and textile coatings | Process enclosure; local exhaust ventilation; personal protective equipment |
| Use in synthesis of thermosetting phenolic resins, epoxy, polycarbonate, phenoxy, and polysulfone; synthesis of aprolactam for use in nylon 6 fibers, plastics, and films | Process enclosure; local exhaust ventilation, personal protective equipment |
| Use in synthesis of agricultural chemicals and intermediates; synthesis of pharmaceuticals, rubber and plastic plasticizers, antioxidants, curing agents, and intermediates | Process enclosure; local exhaust ventilation; personal protective equipment |
| Use in synthesis of stabilizers and preservatives for dyes, perfumes, and fungicides | Process enclosure; local exhaust ventilation; personal protective equipment |
| Use during solvent refining of lubrication oil and wax; use in synthesis of additives for gasoline and lubricating fluids and intermediates | Process enclosure; local exhaust ventilation; personal protective equipment |
| Use in synthesis of intermediates in polyester production; production of corrosion-resistant polyester and polyester polyols; use in synthesis of dye intermediates | Process enclosure, local exhaust ventilation; personal protective equipment |
| Use in synthesis of surface-active agents and detergent intermediates; in synthesis of explosives | Process enclosure, local exhaust ventilation; personal protective equipment |
| Use in manufacture of disinfectant agents and products for industrial and household use | Process enclosure; local exhaust ventilation; personal protective equipment |
| Use in synthesis of synthetic cresols and xylenols | Process enclosure; local exhaust ventilation, personal protective equipment |

## EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If solid or liquid phenol or liquids containing phenol get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If solid or liquid phenol or liquids containing phenol get on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If solid or liquid phenol or liquids containing phenol penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. Get medical attention immediately.

- **Breathing**

If a person breathes in large amounts of phenol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- **Swallowing**

When solid or liquid phenol or liquids containing phenol have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately



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• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

## SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If phenol is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill.
2. If in the solid form, for small quantities, sweep onto paper or other suitable material, place in an appropriate container and burn in a safe place (such as a fume hood). Large quantities may be reclaimed, however, if this is not practical, dissolve in a flammable solvent (such as alcohol) and atomize in a suitable combustion chamber.
3. If in the liquid form, for small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber.

• Waste disposal methods:

Phenol may be disposed of:

1. If in the solid form, by making packages of phenol in paper or other flammable material and burning in a suitable combustion chamber, or by dissolving phenol in a flammable solvent (such as alcohol) and atomizing in a suitable combustion chamber.
2. If in the liquid form, by absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill, or by atomizing the liquid in a suitable combustion chamber.

## REFERENCES


• American Conference of Governmental Industrial Hygienists: "Phenol," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.

• American Industrial Hygiene Association: "Phenol," *Hygienic Guide Series*, Detroit, Michigan, 1957.

• Baskin, A. D. (ed.): *Handling Guide for Potentially Hazardous Commodities*, Railway Systems and Management Association, Chicago, 1972.

• Boutwell, R. K., and Bosch, D. K.: "The Tumor-promoting Action of Phenol and Related Compounds for Mouse Skin," *Cancer Research*, 19:413-424, 1959.

• Christiensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.

• Community Air Quality Guides: "Phenol and Cresol," *American Industrial Hygiene Association Journal*, 30:425-428, 1969.

• Deichmann, W. B., and Witherup, S.: "Phenol Studies VI: The Acute and Comparative Toxicity of Phenol and o-, m-, and p-Cresols for Experimental Animals," *Journal of Pharmacolology and Experimental Therapy*, 80, 233, 1944.

• Fairhall, L. T.: *Industrial Toxicology* (2nd ed.), Williams and Wilkins, Baltimore, 1957.

• Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969.

• Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.

• *Hygienic Information Guide No. 40 – Phenol*, Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Occupational Health, 1968.

• Jacobs, M.: *The Analytical Chemistry of Industrial Poisons, Hazards, and Solvents*, Interscience, New York, 1956.

• Manufacturing Chemists Association, Inc.: *Chemical Safety Data Sheet SD-4, Phenol*, Washington, D.C., 1964.

• Merliss, R. R.: "Phenol Marasmus," *Journal of Occupational Medicine*, 14:55-56, 1972.

• National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard . . . . Occupational Exposure to Phenol*, HEW Publication No. (NIOSH) 76-196, GPO No. 017-033-00184-7, U.S. Government Printing Office, Washington, D.C., 1976.

• Ohtsuji, H., and Ikeda, M.: "Quantitative Relationship between Atmospheric Phenol Vapour and Phenol in the Urine of Workers in Bakelite Factories," *British Journal of Industrial Medicine*, 29:70-73, 1972.

• Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.

• Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.

• Spector, W. S. (Vols. I, II), Negherbon, W. O. (Vol. III), Grebe, R. M. (Vol. IV), and Dittmer, D. S. (Vol. V) (eds.): *Handbook of Toxicology*, Saunders, Philadelphia, 1956-1959.

• Summer, W.: *Odor Pollution of Air: Causes and Control*, L. Hill, London, 1975.

• Thienes, C. H., and Haley, T. J.: *Clinical Toxicology* (5th ed.), Lea and Febiger, Philadelphia, 1972.

• Union Carbide Corporation, Industrial Medicine and Toxicology Department: *Toxicology Studies – Phenol*, New York, 1966.




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## RESPIRATORY PROTECTION FOR PHENOL

| Condition | Minimum Respiratory Protection* Required Above 5 ppm |
|---|---|
| Vapor or Particulate Concentration | |
| 50 ppm or less | Any chemical cartridge respirator with an organic vapor cartridge(s) and dust and mist filter(s).<br>Any supplied-air respirator.<br>Any self-contained breathing apparatus. |
| 100 ppm or less | A chemical cartridge respirator with a full facepiece, organic vapor cartridge(s), and dust and mist filter(s).<br>A gas mask with a chin-style or a front- or back-mounted organic vapor canister and dust and mist filter.<br>Any supplied-air respirator with a full facepiece, helmet, or hood.<br>Any self-contained breathing apparatus with a full facepiece. |
| Greater than 100 ppm** or entry and escape from unknown concentrations | Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.<br>A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode. |
| Fire Fighting | Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. |
| Escape | Any gas mask providing protection against organic vapors and particulates.<br>Any escape self-contained breathing apparatus. |

*Only NIOSH-approved or MSHA-approved equipment should be used.

**Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of phenol; however, this equipment should be selected, used, and maintained under the immediate supervision of trained personnel. Where supplied-air suits are used above a concentration of 100 ppm, an auxiliary self-contained breathing apparatus operated in positive pressure mode should also be worn.

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# Occupational Health Guideline for Pentachlorophenol

## INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

## SUBSTANCE IDENTIFICATION

- Formula: $C_6Cl_5OH$
- Synonyms: PCP; penta
- Appearance and odor: Light brown solid with a pungent odor when hot.

## PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for pentachlorophenol is 0.5 milligram of pentachlorophenol per cubic meter of air (mg/m³) averaged over an eight-hour work shift.

## HEALTH HAZARD INFORMATION

- **Routes of exposure**

Pentachlorophenol can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may enter the body through the skin.

- **Effects of overexposure**

Exposure to pentachlorophenol may cause irritation of the eyes and respiratory tract. Bronchitis has been reported to occur. Systemic effects from either a large exposure or repeated smaller exposures include weakness, loss of appetite, nausea, vomiting, shortness of breath, chest pain, excessive sweating, headache, and dizziness. In fatal cases the temperature is often very high and death may occur as early as three hours after the onset of symptoms. The risk of serious intoxication is greater in hot weather. Persons with decreased liver or kidney functions are more susceptible to poisoning from this chemical. Repeated exposure to pentachlorophenol may cause an acne-like skin rash and liver damage. Commercial pentachlorophenol may be contaminated with dioxin compounds which are much more toxic than pentachlorophenol.

- **Reporting signs and symptoms:**

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to pentachlorophenol.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to pentachlorophenol at potentially hazardous levels:

*1. Initial Medical Examination:*

—A complete history and physical examination. The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the cardiovascular system, eyes, upper respiratory tract, liver, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders. Analysis of the urine for pentachlorophenol may be helpful in estimating the extent of absorption.

*2. Periodic Medical Examination:* The aforementioned medical examinations should be repeated on an annual basis.

- **Summary of toxicology**

Pentachlorophenol dust and mist cause irritation of the eyes and upper respiratory tract, absorption results in an increase in metabolic rate and hyperpyrexia, prolonged skin exposure causes an acneform dermatitis. Human exposure to dust or mist concentrations greater than 1 mg/m³ causes pain in the nose and throat, violent sneezing, and cough; 0.3 mg/m³ may cause some nose irritation, persons acclimated to pentachlorophenol can tolerate concentrations up to 2.4 mg/m³. Pentachlorophenol readily penetrates the skin; systemic intoxication is cumulative and has been fatal. Intoxication is characterized by weakness, anorexia, weight loss, and profuse sweating; there also may be headache, dizziness, nausea, vomiting, dyspnea, and chest pain. In fatal cases, the body temperature is frequently extremely high and

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

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death has occurred as early as 3 hours after the onset of symptoms. The risk of serious intoxication is increased during hot weather; persons with impaired liver or kidney function are more susceptible to the effects of pentachlorophenol. The dust, mist, and vapor cause eye irritation. Prolonged exposure of workers has caused an acneform dermatitis; 10 workers engaged in production of pentachlorophenol for 5 to 10 months developed a widely disseminated skin eruption characterized by small and large furuncles, brown pigmentation, and some cicatrization; 7 workers also developed severe bronchitis; all but 1 worker still showed signs of extensive acne more than a year after cessation of exposure, and 4 still complained of bronchitis. On the skin, solutions of pentachlorophenol as dilute as 1% may cause irritation if contact is repeated or prolonged.

## CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
  1. Molecular weight: 266.3
  2. Boiling point (760 mm Hg): 311 C (592 F) (decomposes)
  3. Specific gravity (water = 1): 2.0
  4. Vapor density (air = 1 at boiling point of pentachlorophenol): Not applicable
  5. Melting point: 182 – 190 C (360 – 374 F)
  6. Vapor pressure at 20 C (68 F): 0.00017 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): 0.002
  8. Evaporation rate (butyl acetate = 1): Not applicable
- **Reactivity**
  1. Conditions contributing to instability: None.
  2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
  3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, chlorinated phenols, and carbon monoxide) may be released when pentachlorophenol decomposes.
  4. Special precautions: None.
- **Flammability**
  1. Not combustible
- **Warning properties**
  1. Odor Threshold: The AIHA *Hygienic Guide* states that pentachlorophenol has a characteristic odor. No quantitative information is available, however, concerning the odor threshold of this substance.
  2. Irritation Levels: The *Documentation of TLV's* states that "dusts are particularly irritating to the eyes and nose, in concentrations appreciably greater than 1 mg/m³, but some irritation of the nose may occur at 0.3 mg/m³. Hardened workers can tolerate up to 2.4 mg/m³."
  3. Evaluation of Warning Properties: Through its irritant effects, pentachlorophenol can be detected within three times of the permissible exposure limit. For the purposes of this guideline, therefore, pentachlorophenol is treated as a material with good warning properties.

## MONITORING AND MEASUREMENT PROCEDURES

- **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Method**

An analytical method for pentachlorophenol is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 4, 1978, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00317-3).

- Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969.

## RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

## PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with pentachlorophenol or liquids containing pentachlorophenol.
- If employees' clothing has had any possibility of being contaminated with pentachlorophenol or liquids containing pentachlorophenol, employees should change into uncontaminated clothing before leaving the work premises.

• Clothing which has had any possibility of being contaminated with pentachlorophenol should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of pentachlorophenol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the pentachlorophenol, the person performing the operation should be informed of pentachlorophenol's hazardous properties.

• Where there is any possibility of exposure of an employee's body to pentachlorophenol or liquids containing pentachlorophenol, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

• Non-impervious clothing which becomes contaminated with pentachlorophenol should be removed immediately and not reworn until the pentachlorophenol is removed from the clothing.

• Employees should be provided with and required to use dust- and splash-proof safety goggles where there is any possibility of pentachlorophenol or liquids containing pentachlorophenol contacting the eyes.

• Where there is any possibility that employees' eyes may be exposed to pentachlorophenol or liquids containing pentachlorophenol, an eye-wash fountain should be provided within the immediate work area for emergency use.

## SANITATION

• Skin that becomes contaminated with pentachlorophenol should be immediately washed or showered with soap or mild detergent and water to remove any pentachlorophenol.

• Workers subject to skin contact with pentachlorophenol or liquids containing pentachlorophenol should wash with soap or mild detergent and water any areas of the body which may have contacted pentachlorophenol at the end of each work day.

• Eating and smoking should not be permitted in areas where pentachlorophenol or liquids containing pentachlorophenol are handled, processed, or stored.

• Employees who handle pentachlorophenol or liquids containing pentachlorophenol should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

## COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to pentachlorophenol may occur and control methods which may be effective in each case:

| Operation | Controls |
|---|---|
| Formulation of preservatives, pesticides, and fungicides | Process enclosure; local exhaust ventilation, personal protective equipment |
| Application as a preservative for wood, starch, paint, adhesives, leather, latex, and oils; use in slime-algae control; use as a pesticide, herbicide, and snail control agent | Personal protective equipment |
| Manufacture of pentachlorophenol | Process enclosure; local exhaust ventilation; personal protective equipment |

## EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If pentachlorophenol or liquids containing pentachlorophenol get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If pentachlorophenol or liquids containing pentachlorophenol get on the skin, immediately wash the contaminated skin using soap or mild detergent and water. If pentachlorophenol or liquids containing pentachlorophenol penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation is present after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of pentachlorophenol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When pentachlorophenol or liquids containing pentachlorophenol have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency



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rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

## SPILL AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills until cleanup has been completed.

• If pentachlorophenol is spilled, the following steps should be taken:

1. Ventilate area of spill.
2. Collect spilled material in the most convenient and safe manner and depost in sealed containers for reclamation or for disposal in a secured sanitary landfill. Liquid containing pentachlorophenol should be absorbed in vermiculite, dry sand, earth, or a similar material.

• Waste disposal method:

Pentachlorophenol may be disposed of in sealed containers in a secured sanitary landfill.

## REFERENCES


• American Conference of Governmental Industrial Hygienists: "Pentachlorophenol," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.

• American Industrial Hygiene Association: "Pentachlorophenol and Sodium Pentachlorophenate," *Hygienic GuideSeries*, Detroit, Michigan, 1970.

• Baader, E. W., and Bauer, H. J.: "Industrial Intoxication Due to Pentachlorophenol," *Industrial Medicine and Surgery*, 20 286-290, 1951.

• Bergner, H., et al.: "Industrial Pentachlorophenol Poisoning in Winnipeg," *Canadian Medical Association Journal*, 92:448-451, 1965.

• Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.

• Fairhall, L. T.: *Industrial Toxicology* (2nd ed.), Williams and Wilkins, Baltimore, 1957

• Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969

*1969.*

• Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.

• Hayes, W. J., Jr.: *Clinical Handbook on Economic Poisons, Emergency Information for Treating Poisoning*, U.S. Public Health Service Publication No. 476, U.S. Government Printing Office, Washington, D.C., 1963.

• Hunter, D.: *Diseases of Occupations* (4th ed.), Little, Brown, Boston, 1969.

• International Labour Office: *Encyclopedia of Occupational Health and Safety*, McGraw-Hill, New York, 1971.

• Johnstone, R. T., and Miller, S. E.: *Occupational Disease and Industrial Medicine*, Saunders, Philadelphia, 1960.

• Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.

• Spector, W. S. (Vols. I, II), Negherbon, W. O. (Vol. III), Grebe, R. M. (Vol. IV), and Dittmer, D. S. (Vol. V) (eds.): *Handbook of Toxicology*, Saunders, Philadelphia, 1956-1959.

• Thienes, C. H., and Haley, T. J.: *Clinical Toxicology* (5th ed.), Lea and Febiger, Philadelphia, 1972.

## RESPIRATORY PROTECTION FOR PENTACHLOROPHENOL

| Condition | Minimum Respiratory Protection* Required Above 0.5 mg/m³ |
|---|---|
| Particulate or Vapor Concentration | |
| 2.5 mg/m³ or less | Any chemical cartridge respirator with an organic vapor cartridge(s) and dust, fume, and mist filter(s), including pesticide respirators which meet the requirements of this class.**<br>Any supplied-air respirator.**<br>Any self-contained breathing apparatus.** |
| 25 mg/m³ or less | Any chemical cartridge respirator with a full facepiece, an organic vapor cartridge(s), and dust, fume, and mist filter(s), including pesticide respirators which meet the requirements of this class.<br>A gas mask with a chin-style or a front- or back-mounted organic vapor canister and dust, fume, and mist filter, including pesticide respirators which meet the requirements of this class.<br>Any supplied-air respirator with a full facepiece, helmet, or hood.<br>Any self-contained breathing apparatus with a full facepiece. |
| 150 mg/m³ or less | |

**If eye irritation occurs, full-facepiece respiratory protective equipment should be used.



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## 7.3 Sampling and Analytical Procedures

The procedures identified are specified for the following field activities associated with the South Cavalcade site:

1) Air Sampling
2) Monitoring Well Installation
3) Falling Head Permeability Testing
4) Groundwater Sampling
5) Surface Water Sampling
6) Surface Sediment Sampling
7) Subsurface Soil Sampling

## 7.4 Air Sampling

Upwind and downwind air samples will be taken to characterize any airborne hazard that may be present at the site.

## 7.5 Monitoring Well Installation

A series of groundwater monitored wells will be installed in and around the South Cavalcade Site. The intent of this activity is to determine aquifer characteristics.

## 7.6 Falling Head Permeability

The intent of the falling head permeability aquifer testing is to measure permeability of the geologic strata in the proximity of selected monitoring wells. The testing results will provide site specific data on geologic strata, groundwater and aquifer characteristics.

## 7.7 Groundwater Sampling

Shallow and deep groundwater samples will be collected from the monitoring wells to determine the groundwater quality. Samples collected will be analyzed for both priority pollutants and trace heavy metals which may be present in the groundwater. Results from the analysis will be utilized in conjunction with data obtained from the monitoring well and falling head permeability testing activities. The following information should be recorded in the field log book. Groundwater sampling should proceed in accordance with the REM II SOP for the above. A copy of which is included in the appendix of this report.

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| Well No. | Total depth of casing | Groundwater elevation | Evacuated volume | Conductivity & Temperature | pH |
|---|---|---|---|---|---|

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7.8 Surface Water Sampling

Surface water samples will be collected at various ponded areas and in drainage paths around the site. The results will determine the presence of contamination on the surface of the site and determine if contaminants are escaping off site through surfac drainage paths.

7.9 Sediment Sampling

Sediment samples will be collected in drainage pathways around the site to determine if contaminants are migrating off site through surface drainage paths.

7.10 Subsurface Soil Sampling

Subsurface soils in various locations on the site have suspected contamination. Sample will be collected at identified locations to quantify the vertical extent of contamination. The soil sample program will consist of using a power auger to sample soil to a depth of 5 feet below the suspected level of contamination based on OVA and HNU readings.

7. SAMPLING PROTOCOL/
FIELD INVESTIGATIONS

7.11 Air Sample

7.11.1 Objective: To characterize any airborne hazards that may be present at the site.

7.11.2 Sample Type, Sample Method Method, and Sample Code:

Sample Type: Air
Sample Method: Composite
Sample Code: AR

7.11.3 Preparatory Activities: Check predominant wind direction for each day of sampling.

7.11.4 Field Equipment:

Equipment to be utilized in this activity specified by PRP's contractor.

7.11.5 Personal Protection: Level D personal protective equipment will be used during this activity with the contingency to upgrade to Level C. Specific Personnel Protective Equipment utilized in this activity is specified on page 4A of the Personnel Protection and Safety Evaluation Form.

7.11.6 Responsibilities: The On-Site Coordinator will be responsible to inspect all sample collection tubes to assure their adequacy.

7.11.7 Procedures: See Method No. 3816016 of REM II Site Investigations Procedures Appendix V.

7.11.8 Sample Containers and Preservatives:

| Specified Analysis | Container | Volume | Preservative |
|---|---|---|---|
| (1) Voltatile Organics | Tennax Tubes | - | None |

(x) used to specify analysis, containers and preservatives required in the identified activities.

Prelabeled sampling and shipping containers will be supplied by:

To be specified

7.11.9 Sample Control: Each sampling location will be identified by the following code system:

SCK - AR - AA

South Cavalcade - Air Samples - Station Number

The actual samples will be numbered consecutively, utilizing a fourth group of characters. The sample numbers will be assigned, just prior to the sampling program, by the analytical coordinator. The general sampling coding method is described below:

SCK - AR - AAA - BB
SCK - Site Code
AR - Sample Code
AAA - Station Code
BBB - Sequence Number

A comprehensive listing of the proposed samples collected for each sampling round is contained on Table 7-1.

| | | |
|---|---|---|
| Total Samples: | Initial Soil Samples | 9 |
| | Duplicates | 9 |
| | Field Blanks | 2 |
| | | 20 |

7.11.10 Sample Traffic Control:

SEND ORGANIC SAMPLES (1)(3)

To be specifed

Case Number:

7.11.11 Health and Safety Guidelines:

The field investigation team members will be required to utilize Level D protective equipment while collecting air samples with the contingency to upgrade Level C as outlined below.

(1) Level D respiratory protection shall be used when HNu readings observed in the ambient atmosphere are 5 ppm or greater.

(2) When HNu readings observed in ambient atmosphere are below 5 ppm above background for a 15 minute time weighted average then downgrade to Level D protection with permission of the site safety officer.

(3) When HNu readings in the ambient atmosphere at the breathing zone exceed an sustained 50 ppm reading, the site shall be vacated and the Health and Safety Supervisor and the Site Manager notified.

7.11.12 Field Investigation Team: The sampling team will be composed of the following individuals and positions:

7. SAMPLING PROTOCOL/
FIELD INVESTIGATIONS

| | |
|---|---|
| On-Site Coordinator | To be designated |
| Health and Safety Officer | " |
| Field Technicians | " |
| Field Technicians | " |

7.11.13 Quality Assurance: The specific sampling procedures will be subject to the requirement of the program quality assurance plan. Specific quality control tasks are described below:

(1) Duplicate samples from the site for every sample collected.

7.11.14 Special instructions: None

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TABLE 7-1

AIR SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Upwind Day 1 | Same | AR-01 | 01 | - | - | (1) | |
| Upwind Day 2 | | AR-02 | 01 | - | - | (1) | |
| Upwind Day 3 | | AR-03 | 01 | - | - | (1) | |
| Downwind Day 1 | | AR-04 | 01 | - | - | (1) | |
| Downwind Day 1 | | AR-04 | 02 | - | - | (1) | |
| Downwind Day 2 | | AR-05 | 01 | - | - | (1) | |
| Downwind Day 2 | | AR-05 | 02 | - | - | (1) | |
| Downwind Day 3 | | AR-06 | 01 | - | - | (1) | |
| Downwind Day 3 | | AR-06 | 02 | - | - | (1) | |
| Upwind Day 1 Duplicate | | AR-01 | 02 | - | - | (1) | |
| Upwind Day 2 Duplicate | | AR-02 | 02 | - | - | (1) | |
| Upwind Day 3 Duplicate | | AR-03 | 02 | - | - | (1) | |
| Downwind Day 1 Duplicate | | AR-04 | 03 | - | - | (1) | |
| Downwind Day 1 Duplicate | | AR-04 | 04 | - | - | (1) | |
| Downwind Day 2 Duplicate | | AR-05 | 03 | - | - | (1) | |
| Downwind Day 2 Duplicate | | AR-05 | 04 | - | - | (1) | |
| Downwind Day 3 Duplicate | | AR-06 | 03 | - | - | (1) | |
| Downwind Day 3 Duplicate | | AR-06 | 04 | - | - | (1) | |

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## 7.12 Monitoring Well Installation

7.12.1 Objective: To install exploration wells at the site identified with well screens at depths approximately 5 feet below depth of contamination.

7.12.2 Sample Type Sample Method and Sample Code:
Sample Type: Monitoring Well
Sample Method: Installation
Sample Code: OW

7.12.3 Preparatory Activity: The senior geologist shall contact the well installation subcontractor prior to the initiation of site work to review the scope of work contained in the contract documents. Any potential conflicts identified shall be brought to the attention of the Project Manager for resolution prior to initiation of the field investigation activity.

The well installation subcontractor is:
(To Be Specified)

The senior geologist shall locate and stake monitoring well locations prior to the initiation of the drilling activities. Monitoring wells will be located by ground survey and placed on the site map.

7.12.4 Field Equipment: To be specified by PRP's Contractor.

7.12.5 Personal Protective Equipment: Level C specified personal protective equipment will be used during the installation of the exploration wells. Upgrade of personal protective equipment is to Level B for contingencies.

7.12.6 Responsibilities: It is the responsibility of the senior geologist to ensure that the monitoring well clusters are installed in the general locations shown on Figure 7-2. It is the responsibility of the senior geologist to ensure that the subcontractor performs consistent with the contract documents as well as performing the procedures listed below.

7.12.7 Procedures: Refer to Method No. 3816013 of Site Investigations Procedures. See Appendix V.

7.12.8 Sample Containers and Preservatives: Subsurface soil samples will be collected during well drilling.

| | Specified Analysis | Container | Volume | Preservative |
|---|---|---|---|---|
| (1) | Volatiles | 2 Vials | 40 ML. | |
| (2) | Priority Metals | Glass | 1L. | $HNO_3$ pH<2 |
| (3) | Cyanide | Glass | 1L. | NaOH |
| (4) | Total Petroleum Hydrocarbons | Glass | 1L. | Cool 4°C |

| | | | | |
|---|---|---|---|---|
| (5) | Acid/Base Neutral | Glass Amber | 1 Gal. | Hexane Rinse, Baked |

(x) Used to specify analysis, container and preservatives required in the identified activities.

7.12.9 Sample Control: Each of the sampling locations will be identified using the site map. Each sampling location will be identified by the following code system:

SCK - SL - AA

South Cavalcade - Subsurface Soils - Station Number

The actual samples will be numbered consecutively, utilizing a fourth group of characters. The sample numbers will be assigned, just prior to the sampling program, by the analytical coordinator. The general sampling coding method is described below:

SCK - SL - AAA - BB
SCK - Site Code
SL - Sample Code
AAA - Station Code
BBB - Sequence Number

A comprehensive listing of the proposed samples collected for each sampling round is contained on Table 7-2.

| | | |
|---|---|---|
| Total Samples: | Initial Soil Samples | 72 |
| | Duplicates | 4 |
| | Field Blanks | 9 |
| | Total | 85 |

7.12.10 Sample Traffic Control:

To be specified

7. SAMPLING PROTOCOL/
FIELD INVESTIGATIONS

FIGURE 7-2

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TABLE 7-2

MONITORING WELL INSTALLATION SCHEDULE AND

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Refer to Figure 7-2 | | | | | | | |
| Shallow Well | Same | SCK-SL-15A | 01 | - | - | (1-6) | |
| " | | -15A | 02 | - | - | " | |
| " | | -15A | 03 | - | - | " | |
| " | | -15A | 04 | - | - | " | |
| " | | -16A | 01 | - | - | " | |
| " | | -16A | 02 | - | - | " | |
| " | | -16A | 03 | - | - | " | |
| " | | -16A | 04 | - | - | " | |
| " | | -17A | 01 | - | - | " | |
| " | | -17A | 02 | - | - | " | |
| " | | -17A | 03 | - | - | " | |
| " | | -17A | 04 | - | - | " | |
| " | | -18A | 01 | - | - | " | |
| " | | -18A | 02 | - | - | " | |
| " | | -18A | 03 | - | - | " | |
| " | | -18A | 04 | - | - | " | |

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TABLE 7-2

MONITORING WELL INSTALLATION SCHEDULE AND

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Refer to Figure 7-2 | | | | | | | |
| Shallow Well | Same | SCK-SL-19A | 01 | - | - | (1-6) | |
| " | | -19A | 02 | - | - | " | |
| " | | -19A | 03 | - | - | " | |
| " | | -19A | 04 | | | | |
| " | | -20A | 01 | - | - | " | |
| " | | -20A | 02 | - | - | " | |
| " | | -20A | 03 | - | - | " | |
| " | | -20A | 04 | - | - | " | |
| " | | -21A | 01 | - | - | " | |
| " | | -21A | 02 | - | - | " | |
| " | | -21A | 03 | - | - | " | |
| " | | -21A | 04 | - | - | " | |
| " | | -22A | 01 | - | - | " | |
| " | | -22A | 02 | - | - | " | |
| " | | -22A | 03 | - | - | " | |
| " | | -22A | 04 | - | - | " | |

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TABLE 7-2

MONITORING WELL INSTALLATION SCHEDULE AND

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| " | | -23A | 01 | - | - | " | |
| " | | -23A | 02 | - | - | " | |
| " | | -23A | 03 | - | - | " | |
| " | | -23A | 04 | - | - | " | |
| " | | -24A | 01 | - | - | " | |
| " | | -24A | 02 | - | - | " | |
| " | | -24A | 03 | - | - | " | |
| " | | -24A | 04 | - | - | " | |
| " | | -25A | 01 | - | - | " | |
| " | | -25A | 02 | - | - | " | |
| " | | -25A | 03 | - | - | " | |
| " | | -25A | 04 | - | - | " | |
| Refer to Figure 7-2 | | | | | | | |
| Shallow Well | Same | SCK-SL-26A | 01 | - | - | (1-6) | |
| " | | -26A | 02 | - | - | " | |
| " | | -26A | 03 | - | - | " | |
| " | | -26A | 04 | - | - | " | |

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TABLE 7-2

MONITORING WELL INSTALLATION SCHEDULE AND

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Refer to Figure 7-2 | | | | | | | |
| Shallow Well | | SCK-SL-27A | 01 | - | - | " | |
| " | | -27A | 02 | - | - | " | |
| " | | -27A | 03 | - | - | " | |
| " | | -27A | 04 | - | - | " | |
| Refer to Figure 7-2 | | | | | | | |
| Deep Well | | SCK-SL-28A | 01 | - | - | " | |
| " | | -28A | 02 | - | - | " | |
| " | | -28A | 03 | - | - | " | |
| " | | -28A | 04 | - | - | " | |
| Refer to Figure 7-2 | | | | | | | |
| Deep Well | | SCK-SL-29A | 01 | - | - | " | |
| " | | -29A | 02 | - | - | " | |
| " | | -29A | 03 | - | - | " | |
| " | | -29A | 04 | - | - | " | |



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TABLE 7-2

MONITORING WELL INSTALLATION SCHEDULE AND

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Duplicate | | SCK-SL-30A | 01 | - | - | " | |
| " | | -31A | 01 | - | - | " | |
| " | | -32A | 01 | - | - | " | |
| Field Blank Day 1 | | -33A | 01 | - | - | " | |
| Field Blank Day 2 | | -34A | 01 | - | - | " | |



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| | |
|---|---|
| On-Site Coordinator | To be designated |
| Health and Safety Officer | " |
| Senior Geologist | " |
| Field Technician | " |

7.14.13 Quality Assurance: The specific sampling procedures will be subject to the requirements of the program quality assurance plan. Specific quality control tasks are described below:

(1) Duplicate for every twenty (20) samples collected for the specified media.

(2) Complete set of field blanks for each sampling day.

7.12.14 Special Instructions: None.

TABLE 7-3

GROUNDWATER SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Existing Well | | | | | | | |
| Refer to Figure 7-3 | Same | CAV-OW-01 | 01 | - | - | (1-7) | |
| Existing Well | | CAV-OW-01 | 02 | - | - | " | |
| " | | CAV-OW-02 | 01 | - | - | " | |
| " | | CAV-OW-02 | 02 | - | - | " | |
| " | | CAV-OW-07 | 01 | - | - | " | |
| " | | CAV-OW-07 | 02 | - | - | " | |
| " | | CAV-OW-08 | 01 | - | - | " | |
| " | | CAV-OW-08 | 02 | - | - | " | |
| " | | CAV-OW-09 | 01 | - | - | " | |
| " | | CAV-OW-09 | 02 | - | - | " | |
| " | | CAV-OW-10 | 01 | - | - | " | |
| " | | CAV-OW-10 | 02 | - | - | " | |
| " | | CAV-OW-11 | 01 | - | - | " | |
| " | | CAV-OW-11 | 02 | - | - | " | |
| " | | CAV-OW-13 | 01 | - | - | " | |
| " | | CAV-OW-13 | 02 | - | - | " | |



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TABLE 7-3

GROUNDWATER SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Existing Well | | | | | | | |
| Refer to Figure 7-3 | Same | CAV-OW-14 | 01 | - | - | (1-7) | |
| | | CAV-OW-14 | 02 | - | - | " | |
| New Shallow Well | | SCK-OW-15 | 01 | - | - | " | |
| " | | SCK-OW-15 | 02 | - | - | " | |
| " | | SCK-OW-16 | 01 | - | - | " | |
| " | | SCK-OW-16 | 02 | - | - | " | |
| " | | SCK-OW-17 | 01 | - | - | " | |
| " | | SCK-OW-17 | 02 | - | - | " | |
| " | | SCK-OW-18 | 01 | - | - | " | |
| " | | SCK-OW-18 | 02 | - | - | " | |
| " | | SCK-OW-19 | 01 | - | - | " | |
| " | | SCK-OW-19 | 02 | - | - | " | |
| " | | SCK-OW-20 | 01 | - | - | " | |
| " | | SCK-OW-20 | 02 | - | - | " | |
| " | | SCK-OW-21 | 01 | - | - | " | |
| " | | SCK-OW-21 | 02 | - | - | " | |

TABLE 7-3

GROUNDWATER SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Refer to Figure 7-3 | | | | | | | |
| New Shallow Well | Same | SCK-OW-22 | 01 | - | - | (1-7) | |
| " | | SCK-OW-22 | 02 | - | - | " | |
| " | | SCK-OW-23 | 01 | - | - | " | |
| " | | SCK-OW-23 | 02 | - | - | " | |
| " | | SCK-OW-24 | 01 | - | - | " | |
| " | | SCK-OW-24 | 02 | - | - | " | |
| " | | SCK-OW-25 | 01 | - | - | " | |
| " | | SCK-OW-25 | 02 | - | - | " | |
| " | | SCK-OW-26 | 01 | - | - | " | |
| " | | SCK-OW-26 | 02 | - | - | " | |
| " | | SCK-OW-27 | 01 | - | - | " | |
| " | | SCK-OW-27 | 02 | - | - | " | |
| New Deep Well | | SCK-OW-28 | 01 | - | - | " | |
| " | | SCK-OW-28 | 02 | - | - | " | |
| " | | SCK-OW-29 | 01 | - | - | " | |
| " | | SCK-OW-29 | 02 | - | - | " | |
| Duplicate | | SCK-OW-30 | 01 | - | - | " | |

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TABLE 7-3

GROUNDWATER SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Duplicate | Same | SCK-OW-31 | 01 | - | - | (1-7) | |
| Field Blank Day 1 | | SCK-OW-32 | 01 | - | - | " | |
| Field Blank Day 2 | | SCK-OW-33 | 01 | - | - | " | |



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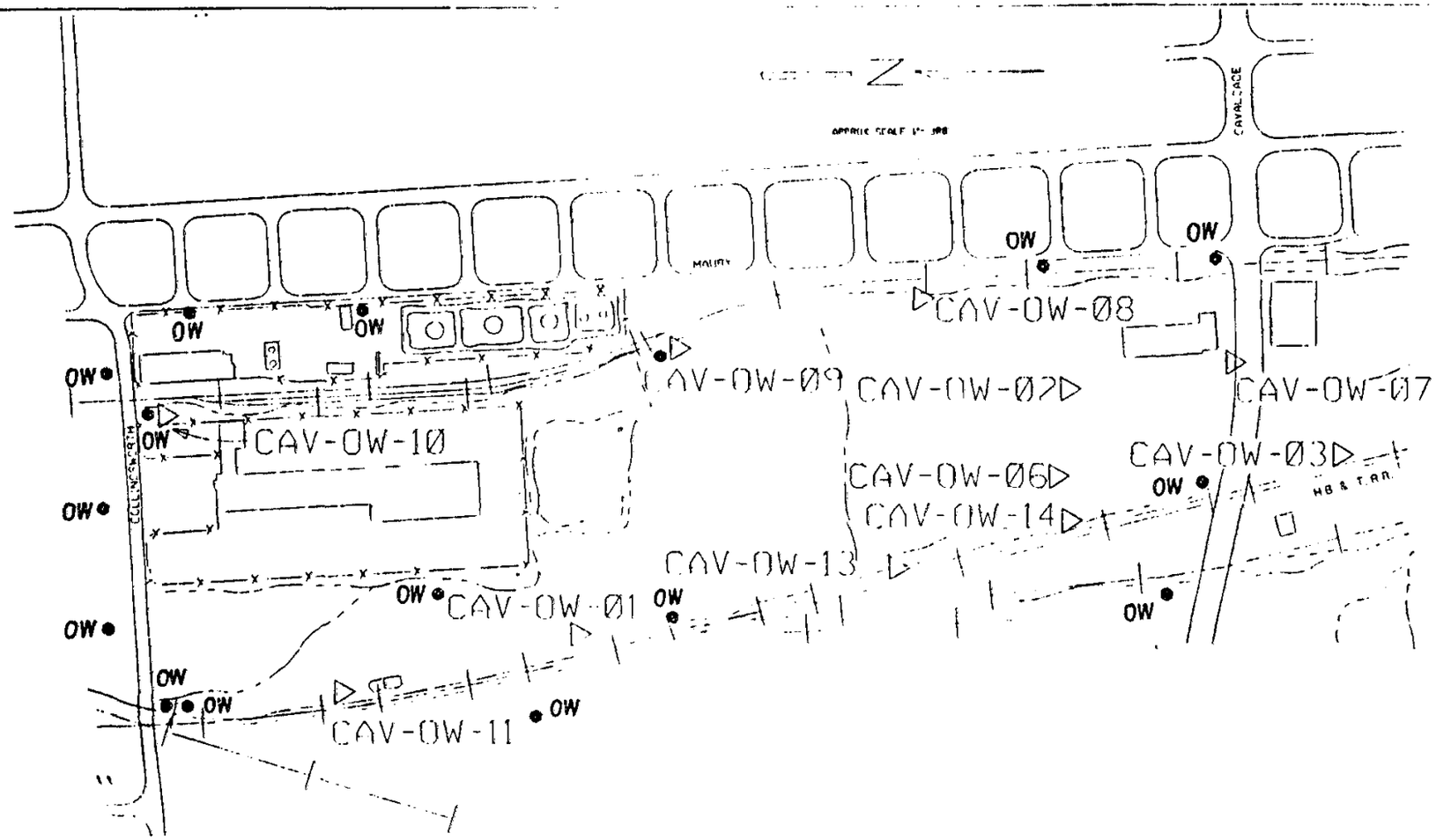


FIGURE 7-3

OBSERVATION WELL LOCATIONS

CAMP DRESSER & McKEE INC.

7.15 Subsurface Soil Sampling

7.15.1 Objective: To determine the vertical extent of contamination in the saturated zone in the area of the site known to have been used for wood treating operations and storage of timber. Representative samples of contaminated soils will be sent for the specified analysis.

7.15.2 Sample Type, Sample Method, and Sample Code:

Sample Type: Subsurface Soil
Sample Method: Composite
Sample Code: SL

7.15.3 Preparatory Activities: Onsite coordinator shall arrange to have laboratory's refrigerated truck retrieve samples from site.

7.15.4 Field Equipment: To be specified by PRP.

7.15.5 Personal Protection; Level D personal protection will be used during this activity with the contingency to upgrade to Level C as site conditions merit.

7.15.6 Responsibilities: The On-Site coordinator will be responsible to inspect all sample bottles to assure their adequacy.

7.15.7 Procedures: Refer to Method No. 3816031 of Site Investigations Procedure Manual.

7.15.8 Sample Containers and Preservatives:

| | Specified Analysis | Container | Volume | Preservative |
|---|---|---|---|---|
| (1) | Priority Metals | 2 Glass Widemouth | 16 oz. | Cool 4°C |
| (2) | Petroleum Hydrocarbon | Jars For All Tests | | |
| (3) | Volatile Organics | | | |
| (4) | Cyanide | | | |
| (5) | Acid Base Neutrals | | | |

(x) Used to specify analysis, containers and preservatives required in the identified activities.

Prelabeled sampling and shipping containers will be supplied by:

To be specified

7.15.9 Sample Control: Each of the sampling locations will be identified using stakes after the collection of the sample. Each sampling location will be identified

(3) When HNu readings in the ambient atmosphere at the breathing zone exceed a sustained 50 ppm reading, the site shall be vacated and the Regional Health and Safety Supervisor and Site Manager notified.

7.15.12 Field Investigation Team: The sampling team will be composed of the following individuals and positions:

| | |
|---|---|
| On-site Coordinator | To be designated |
| Health and Safety Officer | " |
| Field Technicians | " |

7.15.13 Quality Assurance: The specific sampling procedures will be subject to the requirement of the program quality assurance plan. Specific quality control tasks are described below:

(1) Duplicate samples from the site for every twenty (20) samples collected.

7.15.14 Special Instructions: Subsurface soil sampling locations will be permanently marked using stakes. Photographic evidence of the sampling locations will be required. All samples will undergo surrogate analysis chosen for lab analysis. Samples should be chosen ranging from uncontaminated to highly contaminated. 5 more highly contaminated samples will be lab analyzed.

TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 1 | | | | | | | |
| Refer to Figure 7-4 | Same | SL-01 | 01 | - | - | (1-6) | |
| Surrogate Analysis Only | | -01 | 02 | - | - | " | |
| " | | -01 | 03 | - | - | " | |
| " | | -01 | 04 | - | - | " | |
| " | | -02 | 01 | - | - | " | |
| " | | -02 | 02 | - | - | " | |
| " | | -02 | 03 | - | - | " | |
| " | | -02 | 04 | - | - | " | |
| " | | -03 | 01 | - | - | " | |
| " | | -03 | 02 | - | - | " | |
| " | | -03 | 03 | - | - | " | |
| " | | -03 | 04 | - | - | " | |
| " | | -04 | 01 | - | - | " | |
| " | | -04 | 02 | - | - | " | |
| " | | -04 | 03 | - | - | " | |
| " | | -04 | 04 | - | - | " | |



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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 1 | | | | | | | |
| Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-05 | 01 | - | - | (1-6) | |
| " | | -05 | 02 | - | - | " | |
| " | | -05 | 03 | - | - | " | |
| " | | -05 | 04 | - | - | " | |
| Area 2 | | -06 | 01 | - | - | " | |
| " | | -06 | 02 | - | - | " | |
| " | | -06 | 03 | - | - | " | |
| " | | -06 | 04 | - | - | " | |
| " | | -07 | 01 | - | - | " | |
| " | | -07 | 02 | - | - | " | |
| " | | -07 | 03 | - | - | " | |
| " | | -07 | 04 | - | - | " | |
| " | | -08 | 01 | - | - | " | |
| " | | -08 | 02 | - | - | " | |
| " | | -08 | 03 | - | - | " | |
| " | | -08 | 04 | - | - | " | |

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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 2 | | | | | | | |
| Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-13 | 01 | - | - | (1-6) | |
| " | | -13 | 02 | - | - | " | |
| " | | -13 | 03 | - | - | " | |
| " | | -13 | 04 | - | - | " | |
| " | | -14 | 01 | - | - | " | |
| " | | -14 | 02 | - | - | " | |
| " | | -14 | 03 | - | - | " | |
| " | | -14 | 04 | - | - | " | |
| " | | -15 | 01 | - | - | " | |
| " | | -15 | 02 | - | - | " | |
| " | | -15 | 03 | - | - | " | |
| " | | -15 | 04 | - | - | " | |
| " | | -16 | 01 | - | - | " | |
| " | | -16 | 02 | - | - | " | |
| " | | -16 | 03 | - | - | " | |
| " | | -16 | 04 | - | - | " | |

TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 4 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-17 | 01 | - | - | (1-6) | |
| " | | -17 | 02 | - | - | " | |
| " | | -17 | 03 | - | - | " | |
| " | | -17 | 04 | - | - | " | |
| " | | -18 | 01 | - | - | " | |
| " | | -18 | 02 | - | - | " | |
| " | | -18 | 03 | - | - | " | |
| " | | -18 | 04 | - | - | " | |
| Area 5 | | -19 | 01 | - | - | " | |
| " | | -19 | 02 | - | - | " | |
| " | | -19 | 03 | - | - | " | |
| " | | -19 | 04 | - | - | " | |
| " | | -20 | 01 | - | - | " | |
| " | | -20 | 02 | - | - | " | |
| " | | -20 | 03 | - | - | " | |
| " | | -20 | 04 | - | - | " | |



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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 5 | | | | | | | |
| Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-21 | 01 | - | - | (1-6) | |
| " | | -21 | 02 | - | - | " | |
| " | | -21 | 03 | - | - | " | |
| " | | -21 | 04 | - | - | " | |
| " | | -22 | 01 | - | - | " | |
| " | | -22 | 02 | - | - | " | |
| " | | -22 | 03 | - | - | " | |
| " | | -22 | 04 | - | - | " | |
| " | | -23 | 01 | - | - | " | |
| " | | -23 | 02 | - | - | " | |
| " | | -23 | 03 | - | - | " | |
| " | | -23 | 04 | - | - | " | |
| Area 6 | | -24 | 01 | - | - | " | |
| " | | -24 | 02 | - | - | " | |
| " | | -24 | 03 | - | - | " | |
| " | | -24 | 04 | - | - | " | |

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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 5 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-25 | 01 | - | - | (1-6) | |
| " | | -25 | 02 | - | - | " | |
| " | | -25 | 03 | - | - | " | |
| " | | -25 | 04 | - | - | " | |
| " | | -26 | 01 | - | - | " | |
| " | | -26 | 02 | - | - | " | |
| " | | -26 | 03 | - | - | " | |
| " | | -26 | 04 | - | - | " | |
| " | | -27 | 01 | - | - | " | |
| " | | -27 | 02 | - | - | " | |
| " | | -27 | 03 | - | - | " | |
| " | | -27 | 04 | - | - | " | |
| " | | -28 | 01 | - | - | " | |
| " | | -28 | 02 | - | - | " | |
| " | | -28 | 03 | - | - | " | |
| " | | -28 | 04 | - | - | " | |

TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 6 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-29 | 01 | - | - | (1-6) | |
| " | | -29 | 02 | - | - | " | |
| " | | -29 | 03 | - | - | " | |
| " | | -29 | 04 | - | - | " | |
| Area 7 | | -30 | 01 | - | - | " | |
| " | | -30 | 02 | - | - | " | |
| " | | -30 | 03 | - | - | " | |
| " | | -30 | 04 | - | - | " | |
| " | | -31 | 01 | - | - | " | |
| " | | -31 | 02 | - | - | " | |
| " | | -31 | 03 | - | - | " | |
| " | | -31 | 04 | - | - | " | |
| " | | -32 | 01 | - | - | " | |
| " | | -32 | 02 | - | - | " | |
| " | | -32 | 03 | - | - | " | |
| " | | -32 | 04 | - | - | " | |

TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 5 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-33 | 01 | - | - | (1-6) | |
| " | | -33 | 02 | - | - | " | |
| " | | -33 | 03 | - | - | " | |
| " | | -33 | 04 | - | - | " | |
| " | | -34 | 01 | - | - | " | |
| " | | -34 | 02 | - | - | " | |
| " | | -34 | 03 | - | - | " | |
| " | | -34 | 04 | - | - | " | |
| " | | -35 | 01 | - | - | " | |
| " | | -35 | 02 | - | - | " | |
| " | | -35 | 03 | - | - | " | |
| " | | -35 | 04 | - | - | " | |
| " | | -36 | 01 | - | - | " | |
| " | | -36 | 02 | - | - | " | |
| " | | -36 | 03 | - | - | " | |
| " | | -36 | 04 | - | - | " | |

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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 7 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-37 | 01 | - | - | (1-6) | |
| " | | -37 | 02 | - | - | " | |
| " | | -37 | 03 | - | - | " | |
| " | | -37 | 04 | - | - | " | |
| " | | -38 | 01 | - | - | " | |
| " | | -38 | 02 | - | - | " | |
| " | | -38 | 03 | - | - | " | |
| " | | -38 | 04 | - | - | " | |
| | | -39 | 01 | - | - | " | |
| " | | -39 | 02 | - | - | " | |
| " | | -39 | 03 | - | - | " | |
| " | | -39 | 04 | - | - | " | |
| Area 8 | | -40 | 01 | - | - | " | |
| " | | -40 | 02 | - | - | " | |
| " | | -40 | 03 | - | - | " | |
| " | | -40 | 04 | - | - | " | |

TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 8 Refer to Figure 7-4 | Same | SL-41 | 01 | - | - | (1-6) | |
| " | | -41 | 02 | - | - | " | |
| " | | -41 | 03 | - | - | " | |
| " | | -41 | 04 | - | - | " | |
| Area 9 | | -42 | 01 | - | - | " | |
| " | | -42 | 02 | - | - | " | |
| " | | -42 | 03 | - | - | " | |
| " | | -42 | 04 | - | - | " | |
| " | | -43 | 01 | - | - | " | |
| " | | -43 | 02 | - | - | " | |
| " | | -43 | 03 | | - | " | |
| " | | -43 | 04 | - | - | " | |
| " | | -44 | 01 | - | - | " | |
| " | | -44 | 02 | - | - | " | |
| " | | -44 | 03 | - | - | " | |
| " | | -44 | 04 | - | - | " | |



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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 9 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-45 | 01 | - | - | (1-6) | |
| " | | -45 | 02 | - | - | " | |
| " | | -45 | 03 | - | - | " | |
| " | | -45 | 04 | - | - | " | |
| " | | -46 | 01 | - | - | " | |
| " | | -46 | 02 | - | - | " | |
| " | | -46 | 03 | - | - | " | |
| " | | -46 | 04 | - | - | " | |
| " | | -47 | 01 | - | - | " | |
| " | | -47 | 02 | - | - | " | |
| " | | -47 | 03 | - | - | " | |
| " | | -47 | 04 | - | - | " | |
| Area 10 | | -48 | 01 | - | - | " | |
| " | | -48 | 02 | - | - | " | |
| " | | -48 | 03 | - | - | " | |
| " | | -48 | 04 | - | - | " | |



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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 10 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-49 | 01 | - | - | (1-6) | |
| " | | -49 | 02 | - | - | " | |
| " | | -49 | 03 | - | - | " | |
| " | | -49 | 04 | - | - | " | |
| " | | -50 | 01 | - | - | " | |
| " | | -50 | 02 | - | - | " | |
| " | | -50 | 03 | - | - | " | |
| " | | -50 | 04 | - | - | " | |
| " | | -51 | 01 | - | - | " | |
| " | | -51 | 02 | - | - | " | |
| " | | -51 | 03 | | - | " | |
| " | | -51 | 04 | - | - | " | |
| " | | -52 | 01 | - | - | " | |
| " | | -52 | 02 | - | - | " | |
| " | | -52 | 03 | - | - | " | |
| " | | -52 | 04 | - | - | " | |



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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 10 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-53 | 01 | - | - | (1-6) | |
| " | | -53 | 02 | - | - | " | |
| " | | -53 | 03 | - | - | " | |
| " | | -53 | 04 | - | - | " | |
| " | | -53 | 01 | - | - | " | |
| " | | -54 | 02 | - | - | " | |
| " | | -54 | 03 | - | - | " | |
| " | | -54 | 04 | - | - | " | |
| " | | -55 | 01 | - | - | " | |
| " | | -55 | 02 | - | - | " | |
| " | | -55 | 03 | - | - | " | |
| " | | -55 | 04 | - | - | " | |
| " | | -56 | 01 | - | - | " | |
| " | | -56 | 02 | - | - | " | |
| " | | -56 | 03 | - | - | " | |
| " | | -56 | 04 | - | - | " | |

TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 10 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-57 | 01 | - | - | (1-6) | |
| " | | -57 | 02 | - | - | " | |
| " | | -57 | 03 | - | - | " | |
| " | | -57 | 04 | - | - | " | |
| " | | -58 | 01 | - | - | " | |
| " | | -58 | 02 | - | - | " | |
| " | | -58 | 03 | - | - | " | |
| " | | -58 | 04 | - | - | " | |
| " | | -59 | 01 | - | - | " | |
| " | | -59 | 02 | - | - | " | |
| " | | -59 | 03 | - | - | " | |
| " | | -59 | 04 | - | - | " | |
| Area 10 | | -60 | 01 | - | - | " | |
| " | | -60 | 02 | - | - | " | |
| " | | -60 | 03 | - | - | " | |
| " | | -60 | 04 | - | - | " | |



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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 11 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-61 | 01 | - | - | (1-6) | |
| " | | -61 | 02 | - | - | " | |
| " | | -61 | 03 | - | - | " | |
| " | | -61 | 04 | - | - | " | |
| " | | -62 | 01 | - | - | " | |
| " | | -62 | 02 | - | - | " | |
| " | | -62 | 03 | - | - | " | |
| " | | -62 | 04 | - | - | " | |
| " | | -63 | 01 | - | - | " | |
| " | | -63 | 02 | - | - | " | |
| " | | -63 | 03 | - | - | " | |
| " | | -63 | 04 | - | - | " | |
| " | | -64 | 01 | - | - | " | |
| " | | -64 | 02 | - | - | " | |
| " | | -64 | 03 | - | - | " | |
| " | | -64 | 04 | - | - | " | |

TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| *Area 11 Refer to Figure 7-4* | | | | | | | |
| Surrogate Analysis Only | Same | SL-65 | 01 | - | - | (1-6) | |
| " | | -65 | 02 | - | - | " | |
| " | | -65 | 03 | - | - | " | |
| " | | -65 | 04 | - | - | " | |
| Area 12 | | -66 | 01 | - | - | " | |
| " | | -66 | 02 | - | - | " | |
| " | | -66 | 03 | - | - | " | |
| " | | -66 | 04 | - | - | " | |
| " | | -67 | 01 | - | - | " | |
| " | | -67 | 02 | - | - | " | |
| " | | -67 | 03 | - | - | " | |
| " | | -67 | 04 | - | - | " | |
| " | | -68 | 01 | - | - | " | |
| " | | -68 | 02 | - | - | " | |
| " | | -68 | 03 | - | - | " | |
| " | | -68 | 04 | - | - | " | |



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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Surrogate Analysis Only | Same | SL-69 | 01 | - | - | (1-6) | |
| " | | -69 | 02 | - | - | " | |
| " | | -69 | 03 | - | - | " | |
| " | | -69 | 04 | - | - | " | |
| " | | -70 | 01 | - | - | " | |
| " | | -70 | 02 | - | - | " | |
| " | | -70 | 03 | - | - | " | |
| " | | -70 | 04 | - | - | " | |
| " | | -71 | 01 | - | - | " | |
| " | | -71 | 02 | - | - | " | |
| " | | -71 | 03 | - | - | " | |
| " | | -71 | 04 | - | - | " | |
| " | | -72 | 01 | - | - | " | |
| " | | -72 | 02 | - | - | " | |
| " | | -72 | 03 | - | - | " | |
| " | | -72 | 04 | - | - | " | |



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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 14 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-73 | 01 | - | - | (1-6) | |
| " | | -73 | 02 | - | - | " | |
| " | | -73 | 03 | - | - | " | |
| " | | -73 | 04 | - | - | " | |
| " | | -74 | 01 | - | - | " | |
| " | | -74 | 02 | - | - | " | |
| " | | -74 | 03 | - | - | " | |
| " | | -74 | 04 | - | - | " | |
| " | | -75 | 01 | - | - | " | |
| " | | -75 | 02 | - | - | " | |
| " | | -75 | 03 | - | - | " | |
| " | | -75 | 04 | - | - | " | |
| " | | -76 | 01 | - | - | " | |
| " | | -76 | 02 | - | - | " | |
| " | | -76 | 03 | - | - | " | |
| " | | -76 | 04 | - | - | " | |

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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 15 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-77 | 01 | - | - | (1-6) | |
| " | | -77 | 02 | - | - | " | |
| " | | -77 | 03 | - | - | " | |
| " | | -77 | 04 | - | - | " | |
| " | | -78 | 01 | - | - | " | |
| " | | -78 | 02 | - | - | " | |
| " | | -78 | 03 | - | - | " | |
| " | | -78 | 04 | - | - | " | |
| " | | -79 | 01 | - | - | " | |
| " | | -79 | 02 | - | - | " | |
| " | | -79 | 03 | - | - | " | |
| " | | -79 | 04 | - | - | " | |
| " | | -80 | 01 | - | - | " | |
| " | | -80 | 02 | - | - | " | |
| " | | -80 | 03 | - | - | " | |
| " | | -80 | 04 | - | - | " | |

TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 13 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-71 | 01 | - | - | (1-6) | |
| " | | -71 | 02 | - | - | " | |
| " | | -71 | 03 | - | - | " | |
| " | | -71 | 04 | - | - | " | |
| " | | -72 | 01 | - | - | " | |
| " | | -72 | 02 | - | - | " | |
| " | | -72 | 03 | - | - | " | |
| " | | -72 | 04 | - | - | " | |



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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 14 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-73 | 01 | - | - | (1-6) | |
| " | | -73 | 02 | - | - | " | |
| " | | -73 | 03 | - | - | " | |
| " | | -73 | 04 | - | - | " | |
| " | | -74 | 01 | - | - | " | |
| " | | -74 | 02 | - | - | " | |
| " | | -74 | 03 | - | - | " | |
| " | | -74 | 04 | - | - | " | |
| " | | -75 | 01 | - | - | " | |
| " | | -75 | 02 | - | - | " | |
| " | | -75 | 03 | - | - | " | |
| " | | -75 | 04 | - | - | " | |
| " | | -76 | 01 | - | - | " | |
| " | | -76 | 02 | - | - | " | |
| " | | -76 | 03 | - | - | " | |
| " | | -76 | 04 | - | - | " | |



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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 15 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-77 | 01 | - | - | (1-6) | |
| " | | -77 | 02 | - | - | " | |
| " | | -77 | 03 | - | - | " | |
| " | | -77 | 04 | - | - | " | |
| " | | -78 | 01 | - | - | " | |
| " | | -78 | 02 | - | - | " | |
| " | | -78 | 03 | - | - | " | |
| " | | -78 | 04 | - | - | " | |
| " | | -79 | 01 | - | - | " | |
| " | | -79 | 02 | - | - | " | |
| " | | -79 | 03 | - | - | " | |
| " | | -79 | 04 | - | - | " | |
| " | | -80 | 01 | - | - | " | |
| " | | -80 | 02 | - | - | " | |
| " | | -80 | 03 | - | - | " | |
| " | | -80 | 04 | - | - | " | |

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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 16 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-81 | 01 | - | - | (1-6) | |
| " | | -81 | 02 | - | - | " | |
| " | | -81 | 03 | - | - | " | |
| " | | -81 | 04 | - | - | " | |
| " | | -82 | 01 | - | - | " | |
| " | | -82 | 02 | - | - | " | |
| " | | -82 | 03 | - | - | " | |
| " | | -82 | 04 | - | - | " | |
| " | | -83 | 01 | - | - | | " |
| " | | -83 | 02 | - | - | " | |
| " | | -83 | 03 | - | - | " | |
| " | | -83 | 04 | - | - | " | |
| " | | -84 | 01 | - | - | " | |
| " | | -84 | 02 | - | - | " | |
| " | | -84 | 03 | - | - | " | |
| " | | -84 | 04 | - | - | " | |



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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 16 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-85 | 01 | - | - | (1-6) | |
| " | | -85 | 02 | - | - | " | |
| " | | -85 | 03 | - | - | " | |
| " | | -85 | 04 | - | - | " | |
| " | | -86 | 01 | - | - | " | |
| " | | -86 | 02 | - | - | " | |
| " | | -86 | 03 | - | - | " | |
| " | | -86 | 04 | - | - | " | |
| " | | -87 | 01 | - | - | " | |
| " | | -87 | 02 | - | - | " | |
| " | | -87 | 03 | - | - | " | |
| " | | -87 | 04 | - | - | " | |
| " | | -88 | 01 | - | - | " | |
| " | | -88 | 02 | - | - | " | |
| " | | -88 | 03 | - | - | " | |
| " | | -88 | 04 | - | - | " | |

TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area 16 Refer to Figure 7-4 | | | | | | | |
| Surrogate Analysis Only | Same | SL-89 | 01 | - | - | (1-6) | |
| " | | -89 | 02 | - | - | " | |
| " | | -89 | 03 | - | - | " | |
| " | | -89 | 04 | - | - | " | |
| " | | -90 | 01 | - | - | " | |
| " | | -90 | 02 | - | - | " | |
| " | | -90 | 03 | - | - | " | |
| " | | -90 | 04 | - | - | " | |
| Location to be selected | | | | | | | |
| for full lab analysis | | -91 | 01 | - | - | " | |
| " | | -91 | 02 | - | - | " | |
| " | | -91 | 03 | - | - | " | |
| " | | -91 | 04 | - | - | " | |
| " | | -92 | 01 | - | - | " | |
| " | " | -93 | 01 | - | - | " | |
| " | | -94 | 01 | - | - | " | |
| " | | -95 | 01 | - | - | " | |
| " | | -96 | 01 | - | - | " | |

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TABLE

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Area to be selected for full analysis | Same | SL-97 | 01 | - | - | (1-6) | |
| " | | -98 | 01 | - | - | " | |
| " | | -99 | 01 | - | - | " | |
| " | | -100 | 01 | - | - | " | |
| " | | -101 | 01 | - | - | " | |
| " | | -102 | 01 | - | - | " | |
| " | | -103 | 01 | - | - | " | |
| " | | -104 | 01 | - | - | " | |
| " | | -105 | 01 | - | - | " | |
| " | | -106 | 01 | - | - | " | |
| " | | -107 | 01 | - | - | " | |
| " | | -108 | 01 | - | - | " | |
| " | | -109 | 01 | - | - | " | |
| " | | -100 | 01 | - | - | " | |
| " | | -110 | 01 | - | - | " | |
| " | | -110 | 01 | - | - | " | |
| " | | -111 | 01 | - | - | " | |
| " | | -112 | 01 | - | - | " | |
| " | | -113 | 01 | - | - | " | |

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TABLE 7-4

SUBSURFACE SOIL SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Location to be selected | | | | | | | |
| for full analysis | Same | SL-114 | 01 | - | - | (1-6) | |
| " | | -115 | 01 | - | - | " | |
| " | | -116 | 01 | - | - | " | |
| " | | -117 | 01 | - | - | " | |
| " | | -118 | 01 | - | - | " | |
| " | | -119 | 01 | - | - | " | |
| " | | -120 | 01 | - | - | " | |
| Highly Contaminated | | | | | | | |
| Sample Analysis | | -121 | 01 | - | - | " | |
| " | | -122 | 01 | - | - | " | |
| " | | -123 | 01 | - | - | " | |
| " | | -124 | 01 | - | - | " | |
| " | | -125 | 01 | - | - | " | |
| Duplicate | | -126 | 01 | - | - | " | |
| Duplicate | | -127 | 01 | - | - | " | |
| Field Blank | | -128 | 01 | - | - | " | |



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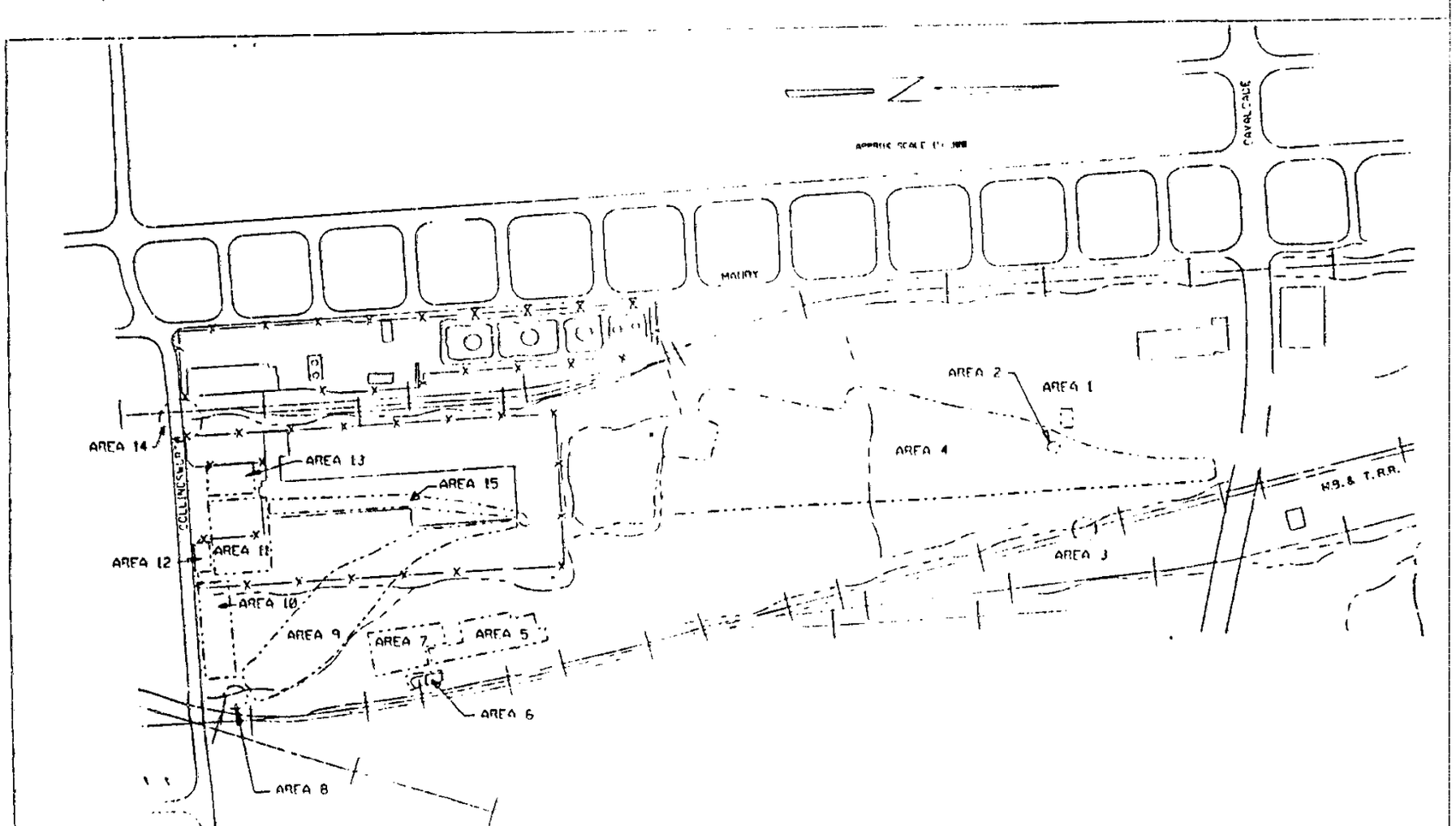


FIGURE 7-4
PROPOSED SUBSURFACE BORING AREAS

— CAMP DRESSER & McKEE INC.

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7.16.9 Sample Control: Each of the sampling locations will be identified using the following system:

SCK-SW-AA
South Cavalcade - Surface Water - Station Number

The actual samples will be numbered consecutively, utilizing a fourth group of characters. The sample numbers will be assigned just prior to the sampling program by the analytical coordinator. The general sampling coding is described below:

SCK-SW-AAA-BB
SCK-Site Code
SW-Sample Code
AAA-Station Code
BB-Sequence Number

A comprehensive listing of the proposed samples collected for each sampling round is contained on Table 7-5.

| | | |
|---|---|---|
| Total Samples: | Initial Water Samples: | 72 |
| | Duplicates | 4 |
| | Field Blanks | 2 |
| | Total | 78 |

7.16.10 Sample Traffic Control

SEND ORGANIC SAMPLES: (1)(3) SEND INORGANIC SAMPLES: (1)(2)

To be specified To be specifed

7.16.11 Health and Safety Guidelines

The field investigation team members will be required to utilize Level D protective equipment while collecting samples with the contingency to upgrade to Level C if HNu readings go above 5 ppm in the ambient atmosphere.

7.16.12 Field Investigation Team: The sampling team will be composed of the following individuals and positions:

| | |
|---|---|
| On site coordinator | To be designated |
| Health and Safety Officer | " |
| Field Technicians | " |

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7.16 Surface Water Sampling

7.16.1 Objective: To determine the extent of off site migration of contaminants in drainage pathways and determine amount of contamination in ponded areas on site through sampling suface water.

7.16.2 Sample Type, Sample Method, and Sample Code:

Sample Type: Surface Water
Sample Method: Grab
Sample Code: SW

7.16.3 Preparatory Activities: On site coordinator shall arrange to have laboratory's refrigerated truck retrieve samples from site.

7.16.4 Field Equipment: To be specified by PRP.

7.16.5 Personal Protection: Level D protection will be used during this activity with the contingency to upgrade to Level C as conditions merit.

7.16.6 Responsiblities: The on site coordinator will be responsible to collect and to 11 sample bottlesinspecture their adequacy.

res: Refer to Method 3816012 of the REM II Site Investigations Procedures. See Appendix V.

7.16.8 Sample Containers and Preservatives:

| Specified Analysis | Container | Volume | Preservative |
|---|---|---|---|
| (1) Volatiles | VOA Vial | 2x[illegible] ml. | Cool 4°C |
| (2) Acid Base Neutral | Glass Amber | 1 Gal. | Cool 4°C |
| (3) Priority Metals | Glass | 1 L. | $NHO_3$ to pH<2 |
| (4) Total Cyanide | Glass | 1 L. | NaOH |
| (5) Total Petroleum Hydrocarbons | Glass | 1 L. | Cool 4°C |
| (6) Nitrates | Glass Amber | 1 Gal. | Cool 4°C |

(x) Used to specify analysis, containers and preservatives required in the indentified activities.

Prelabeled sampling and shipping containers will be supplied by:

To be specified

7.12.11 Health and Safety Guidelines: The senior geologist and the well drilling subcontractor will utilize Level C personnel protective equipment with the option to upgrade to Level B when HNu or OVA readings in the atmosphere exceed 50 ppm. If ambient concentrations are less than 5 ppm for a 15 minute time weighted average, protection can be downgraded to Level D. A hard hat must be worn during all drilling activities. No loose clothing will be allowed to be worn in the vicinity of the operating drilling. Steel toe boots should be worn by personnel within immediate vicinity of the drilling. It is the responsibility of the senior geologist to ensure that these guidelines are adhered to.

7.12.12 Field Investigation Team: The sampling team will consist of the following individuals and positions:

| | |
|---|---|
| Senior Geologist | To be designated |
| Field Geologist | To be designated |
| Health and Safety Officer | To be designated |
| Field Technicians | Well Drilling Subcontractor (To Be Specified) |

7.12.13 Quality Assurance: No specific quality assurance/quality control measures will be implemented for in-field operations subject to this activity. Contract documents specifying activity procedures will be reviewed by appropriate personnel.

7.13 Falling Head Permeability

These tests will be performed by the drilling subcontractor under the guidance of the On-site Coordinator.

7.13.1 Objective:

To measure the local horizontal permeability of the geological strata in the proximity of selected monitoring wells.

7.13.2 Sample Type, Sample Method and Sample Code:

Sample Type: Falling Head Permeability Test
Sample Method: -
Sample Code: PT

7.13.3 Preparatory Activity: Obtain necessary maps and keys.

7.13.4 Field Equipment: To be specified by PRP's Contractor

7.13.5 Personnel Protective Equipment

Level D with contingency to upgrade to Level C respiratory protection.

7.13.6 Responsibilities: Are adequately defined.

7.13.7 Procedure:

The Falling Head in situ permeability procedure consists of either introducing water into the well riser or extracting water from the well and measuring the rate of dissapperance or re-appearance of water. All results and observations should be recorded on Falling Head Data Sheets and the field log notebook.

a. Record monitoring well number in log book and note location on site map.

b. Record time, weather conditions and ambient air NHu readings prior to opening well head.

c. Check the well for above ground damage.

d. Remove the well cap using a wrench if needed and vent caps.

e. Measure and record volatile organic level in well casing using HNu.

f. Measure and record the depth to water and the time of measurement.

g. Measure and record the total depth of the well from top of standpipe.

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h. Measure and record the height of standpipe from ground surface (stick-up).

i. Upon introduction of water into the well, the water is poured in and an initial elevation is noted immediately when the pouring ceases. Alternatively, when water is extracted using the bailer, the initial elevation is noted immediately upon removal of the bailer from the well. In each case the water level in the well is subsequently noted at the following times: 0.25, 0.5, 1.0, 2.0, 4.0, 8.0 16.0, and 32.0 minutes.

j. Repeat Step i until consistent results are obtained.

k. Replace vent caps, well head cap and lock.

l. Clean tape or water level records with distilled water rinse, acetone rinse and distilled water rinse prior to proceeding to recording next well location contamination.

7.13.8 Sample Containers and Preservatives: No samples will be collected during this activity.

7.13.9 Sample Control: No samples will be collected during this activity.

7.13.10 Sample Traffic Control: No samples will be collected during this activity.

7.13.11 Health and Safety Guidelines: The field investigation team members will be required to utilize Level D protective equipment while performing the water level measurements and contingency to upgrade as outlined below.

(1) When ambient HNu readings observed in the breathing zone of field personnel are >5 ppm above background for a 15 minute time weighted average period Level C respiratory protection shall be donned.

(2) When instantaneous HNu readings observed within well heads are >100 but <1000 ppm Level C respiratory protection shall be donned.

(3) When HNu readins in ambient atmosphere exceed 50 ppm or in well heads exceeds 1000 ppm the site shall be vacated and the Project Health and Safety Manager notified prior to continuation of work efforts.

7.13.12 Field Investigation Team: The field team will be composed of the following individuals and positions:

| | |
|---|---|
| Senior Geologist | To be designated |
| Health and Safety Officer | |
| Field Technicians | Well Drilling Subcontractor (To Be Specified) |

7.13.13 Quality Assurance: No specific quality assurance/quality control measures will be implemented for in-field operations subject to this activity.

7.13.14 Special Instructions: None.

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## 7.14 Groundwater Sampling (Shallow and Deep)

7.14.1 Objective: To collect representative groundwater samples.

Additional sampling may be performed based on the results of the initial sampling analysis.

7.14.2 Sample Type, Sample Method, and Sample Code:

Sample Type: Observation Well
Sample Method: Grab
Sample Code: OW

7.14.3 Preparatory Activities: The on-site coordinator shall contact the senio geologist to determine that the proper sample locations are identified.

7.14.4 Field Equipment: To be specified by PRP.

7.14.5 Personal Protective Equipment: Level C personal protective equipment will be used during this activity with contingency to upgrade. Specific personnel protective equipment utilized in this activity specified on page 4 of the Personnel Protection and Safety Evaluation Form.

7.14.6 Responsibilities: It is the responsibility of the senior geologist to coordinate with the well drilling subcontractor for operation of the pump for well evacuation purposes. The On-Site Coordinator will be responsible for inspection of all sample containers to determine if the containers are adequate for the specified analysis.

7.14.7 Procedures: Refer to Method NO. 3816013 of Site Investigations Procedures. See Appendix V.

7.14.8 Sample Container and Preservatives:

| | Specified Analysis | Container | Volume | Preservative |
|---|---|---|---|---|
| (1) | Volatile Organic Compounds | VOA Vial | 2x40ml | Cool 4°c |
| (2) | Acid/Base Neutral | Glass Amber | 1 Gal. | Cool 4°c |
| (3) | Priority Metals | Glass | 1 L. | $HNO_3$ to pH<2 |
| (4) | Cyanide | Glass | 1 L. | NaOH |
| (5) | Total Petroleum Hydrocarbons | Glass | 1 L. | Cool 4°c |
| (6) | Pesticides, PCB | Glass Amber | 1 Gal. Baked | Hexane Rinsed, |
| (7) | Nitrates | Glass Amber | 1 Gal. | Cool 4°c |

(x) used to specify analysis, containers and preservatives required in the identified activities.

Prelabeled sampling and shipping containers will be supplied:

To be specified

7.14.9 Sample Control: Each of the sampling locations will be identified with a permanent, easily visible label. The labels will contain the following coding

SCK - OW - AA

South Cavalcade - Observation Well - Station Number

The actual samples will be numbered consecutively, utilizing a fourth group of characters. The sample numbers will be assigned, just prior to the sampling program, by the analytical coordinator. The general sampling coding method is described below:

SCK - OW - AAA - BBB
SCK - Site Code
OW - Sample Code
AAA - Station Code
BBB Sequence Number

A comprehensive listing of the proposed samples collected for each sampling round is contained on Table 7-3.

| | | |
|---|---|---|
| Total Samples: | Initial Deep Well Samples | 6 |
| | Initial Shallow Well Samples | 44 |
| (Initial Round) | Field Blank | 2 |
| | Duplicate | 3 |
| | Total | 55 |

7.14.10 Sample Traffic Control:
SEND VOLATILE ORGANIC AND
INORGANIC SAMPLES (1) (2)

To be specified

Case Number:

7.14.11 Health and Safety Guidelines: The field investigation team will be required to utilize Level C protective equipment while collecting monitoring well groundwater samples with the option to upgrade to Level B if HNU ambient atmosphere readings exceed 50 ppm. A downgrade to Level D may occur if HNU ambient concentrations fall below 5 ppm for a 15 minute time weighted average.

7.14.12 Field Investigation Team: The sample team will be composed of the following individuals and positions.

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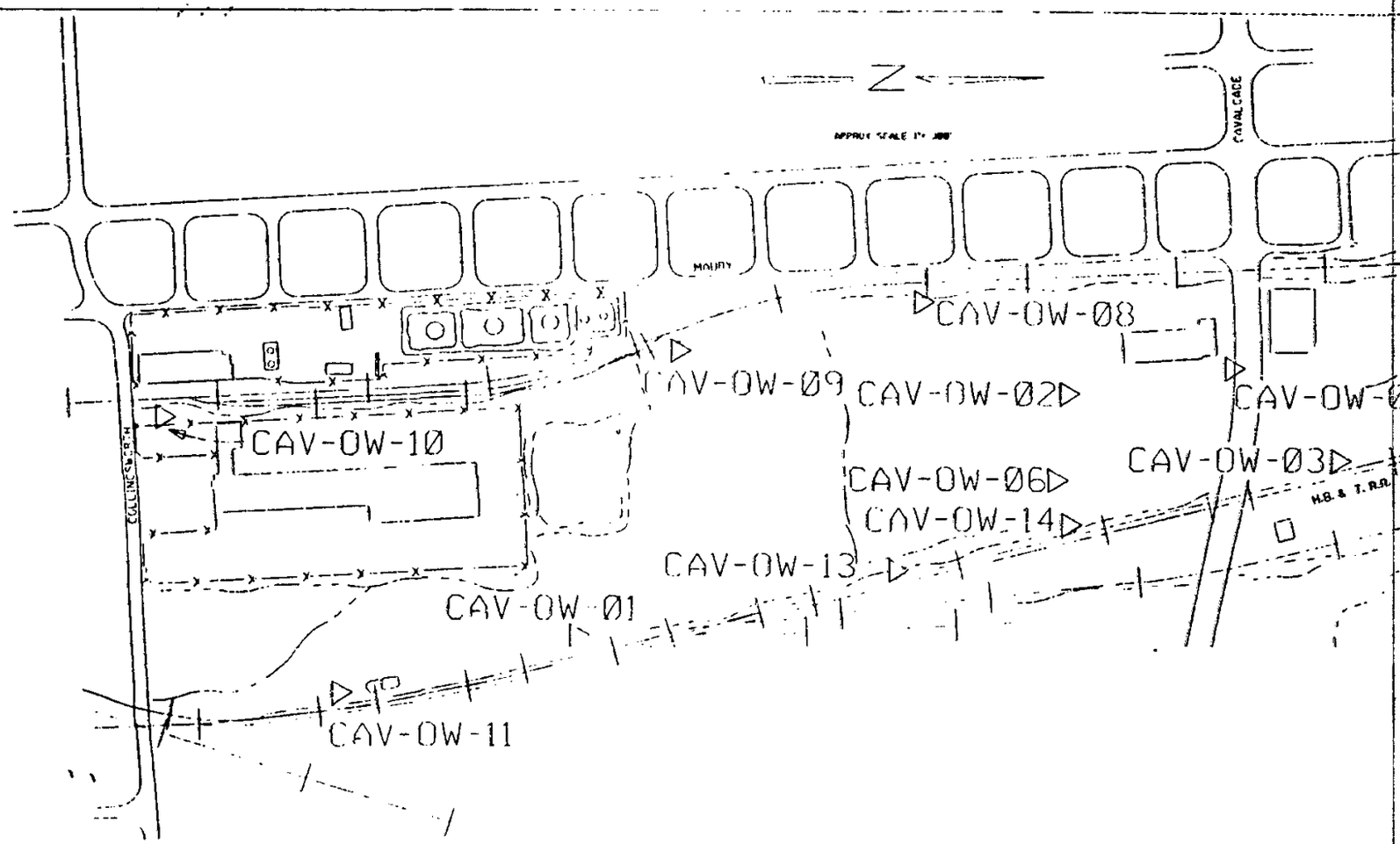


FIGURE 7-2
OBSERVATION WELL LOCATIONS

CAMP DRESSER & McKEE INC.

7.16.13 Quality Assurance: The specific sampling procedures will be subject to the requirement of the program quality assurance plan. Specific quality control tasks are described below:

(1) Duplicate samples from the site for every twenty (20) samples collected.

(2) 1 Field blank will be collected for each day of sampling.

7.16.14 Special Instructions: 90% of total number of samples must be collected for completion.

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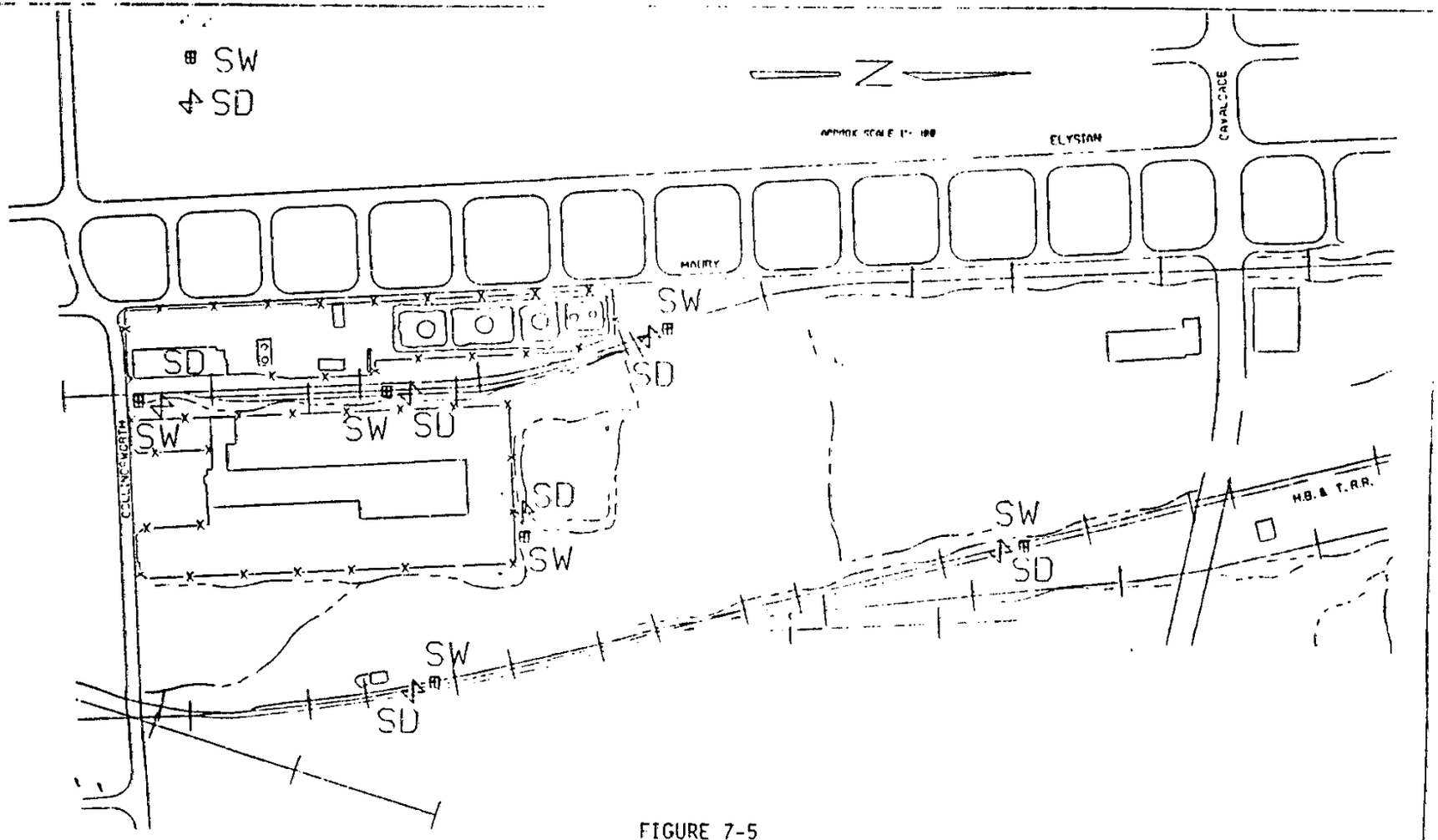


FIGURE 7-5
PROPOSED SEDIMENT AND
SURFACE WATER SAMPLING SITES

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TABLE 7-5

SURFACE WATER SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Refer to Figure 7-5 | Same | SW-01 | 01 | - | - | (1-6) | |
| " | | -01 | 02 | - | - | " | |
| " | | -01 | 03 | - | - | " | |
| " | | -01 | 04 | - | - | " | |
| " | | -01 | 05 | - | - | " | |
| " | | -01 | 06 | - | - | " | |
| " | | -01 | 07 | - | - | " | |
| " | | -01 | 08 | - | - | " | |
| " | | -02 | 01 | - | - | " | |
| " | | -02 | 02 | - | - | " | |
| " | | -02 | 03 | - | - | " | |
| " | | -02 | 04 | - | - | " | |
| " | | -02 | 05 | - | - | " | |
| " | | -02 | 06 | - | - | " | |
| " | | -02 | 07 | - | - | " | |
| " | | -02 | 08 | - | - | " | |

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TABLE 7-5

SURFACE WATER SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Refer to Figure 7-5 | Same | SW-03 | 01 | - | - | (1-6) | |
| " | | -03 | 02 | - | - | " | |
| " | | -03 | 03 | - | - | " | |
| " | | -03 | 04 | - | - | " | |
| " | | -03 | 05 | - | - | " | |
| " | | -03 | 06 | - | - | " | |
| " | | -03 | 07 | - | - | " | |
| " | | -03 | 08 | - | - | " | |
| " | | -04 | 01 | - | - | " | |
| " | | -04 | 02 | - | - | " | |
| " | | -04 | 03 | - | - | " | |
| " | | -04 | 04 | - | - | " | |
| " | | -04 | 05 | - | - | " | |
| " | | -04 | 06 | - | - | " | |
| " | | -04 | 07 | - | - | " | |
| " | | -04 | 08 | - | - | " | |

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TABLE 7-5

SURFACE WATER SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Refer to Figure 7-5 | Same | SW-05 | 01 | - | - | (1-6) | |
| " | | -05 | 02 | - | - | " | |
| " | | -05 | 03 | - | - | " | |
| " | | -05 | 04 | - | - | " | |
| " | | -05 | 05 | - | - | " | |
| " | | -05 | 06 | - | - | " | |
| " | | -05 | 07 | - | - | " | |
| " | | -05 | 08 | - | - | " | |
| " | | -06 | 01 | - | - | " | |
| " | | -06 | 02 | - | - | " | |
| " | | -06 | 03 | - | - | " | |
| " | | -06 | 04 | - | - | " | |
| " | | -06 | 05 | - | - | " | |
| " | | -06 | 06 | - | - | " | |
| " | | -06 | 07 | - | - | " | |
| " | | -06 | 08 | - | - | " | |

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TABLE 7-5

SURFACE WATER SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Refer to Figure 7-5 | Same | SW-07 | 01 | - | - | (1-6) | |
| " | | -07 | 02 | - | - | " | |
| " | | -07 | 03 | - | - | " | |
| " | | -07 | 04 | - | - | " | |
| " | | -07 | 05 | - | - | " | |
| " | | -07 | 06 | - | - | " | |
| " | | -07 | 07 | - | - | " | |
| " | | -07 | 08 | - | - | " | |
| " | | -08 | 01 | - | - | " | |
| " | | -08 | 02 | - | - | " | |
| " | | -08 | 03 | - | - | " | |
| " | | -08 | 04 | - | - | " | |
| " | | -08 | 05 | - | - | " | |
| " | | -08 | 06 | - | - | " | |
| " | | -08 | 07 | - | - | " | |
| " | | -08 | 08 | - | - | " | |

TABLE 7-5

SURFACE WATER SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Refer to Figure 7-5 | Same | SW-09 | 01 | - | - | (1-6) | |
| " | | -09 | 02 | - | - | " | |
| " | | -09 | 03 | - | - | " | |
| " | | -09 | 04 | - | - | " | |
| " | | -09 | 05 | - | - | " | |
| " | | -09 | 06 | - | - | " | |
| " | | -09 | 07 | - | - | " | |
| " | | -09 | 08 | - | - | " | |
| Duplicate | | SW-10 | 01 | - | - | " | |
| " | | -11 | 01 | - | - | " | |
| " | | -12 | 01 | - | - | " | |
| " | | -13 | 01 | - | - | " | |
| Field Blank | | -14 | 01 | - | - | " | |
| Field Blank | | -15 | 01 | - | - | " | |

7.17 Sediment Sampling

7.17.1 Objective: To determine the extent of off site migration of contaminants in drainage pathways through sediment sampling.

7.17.2 Sample Type, Sample Method and Sample Code:

Sample Type: Sediment
Sample Method: Grab
Sample Code: SD

7.17.3 Preparatory Activities: On site coordinator shall arrange to have laboratory's refrigerated truck retrieve samples from the site.

7.17.4 Field Equipment: To be specified by PRP.

7.17.5 Personal Protection: Level D protection will be used during this activity with the contingency to upgrade to Level C as conditions merit.

7.17.6 Responsibilities: The on site coordinator will be responsible to collect and to inspect all sample bottles to assure their adequacy.

7.17.7 Procedures: Refer to Method No. 3816011 of the REM II Site Investigations Procedures. See Appendix V.

7.17.8 Sample Containers and Preservatives:

| Specified Analysis | Container | Volume | Preservative |
|---|---|---|---|
| (1) Volatile Organics | 2 Glass Widemouth Jars for all tests | 16 oz. | 4°C cool |
| (2) Priority Metals | | | |
| (3) Cyanide | | | |
| (4) Total Petroleum Hydrocarbons | | | |
| (5) Acid Base Neutrals | | | |

(x) Used to specify analysis, containers and preservatives required in the identified activities.

Prelabeled sampling and shipping containers will be supplied by:

To be specified

7.17.9 Sample Control: Each of the sampling locations will be identified using the following system:

SCK-SD-AA
South Cavalcade - Sediment - Station Number

The actual samples will be numbered consecutively, utilizing a fourth group of characters. The sample numbers will be assigned just prior to the sampling program by the analytical coordinator. The general sampling coding is described below:

SCK-SD-AAA-BB
SCK-Site Code
SD-Sample Code
AAA-Station Code
BB-Sequence Number

A comprehensive listing of the proposed samples collected for each sampling round is contained on Table 7-6.

| | | |
|---|---|---|
| Total Samples: | Initial Water Samples: | 30 |
| | Duplicates | 2 |
| | Field Blanks | 2 |
| | Total | 34 |

7.17.10 Sample Traffic Control

SEND ORGANIC SAMPLES: (1)(3) SEND INORGANIC SAMPLES: (1)(2)

To be specified To be specified

7.17.11 Health and Safety Guidelines

The field investigation team members will be required to utilize Level D protective equipment while collecting samples with the contingency to upgrade to Level C if HNu readings go above 5 ppm in the ambient atmosphere.

7.17.12 Field Investigation Team: The sampling team will be composed of the following individuals and positions:

| | |
|---|---|
| On site coordinator | To be designated |
| Health and Safety Officer | " |
| Field Technicians | " |

7.17.13 Quality Assurance: The specific procedures will be subject to the requirement of the program quality assurance plan. Specific quality control tasks are described below:

(1) Duplicate samples from the site for every twenty (20) samples collected.

7.17.14 Special Instructions: 90% of total number of samples must be taken for completion.

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TABLE 7-6

SEDIMENT SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Refer to Figure 7-6 | Same | SD-01 | 01 | - | - | (1-5) | |
| " | | -01 | 02 | - | - | " | |
| " | | -02 | 01 | - | - | " | |
| " | | -02 | 02 | - | - | " | |
| " | | -03 | 01 | | | | |
| " | | -03 | 02 | - | - | " | |
| " | | -04 | 01 | - | - | " | |
| " | | -04 | 02 | - | - | " | |
| " | | -05 | 01 | | | | |
| " | | -05 | 02 | - | - | " | |
| " | | -06 | 01 | - | - | " | |
| " | | -06 | 02 | | | | |
| " | | -07 | 01 | - | - | " | |
| " | | -07 | 02 | - | - | " | |
| " | | -08 | 01 | | | | |
| " | | -08 | 02 | - | - | " | |

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TABLE 7-6

SEDIMENT SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Refer to Figure 7-6 | Same | SD-09 | 01 | - | - | (1-5) | |
| " | | -09 | 02 | - | - | " | |
| " | | -10 | 01 | | | | |
| " | | -10 | 02 | - | - | " | |
| " | | -11 | 01 | - | - | " | |
| " | | -11 | 02 | | | | |
| " | | -12 | 01 | - | - | " | |
| " | | -12 | 02 | - | - | " | |
| " | | -13 | 01 | | | | |
| " | | -13 | 02 | - | - | " | |
| " | | -14 | 01 | - | - | " | |
| " | | -14 | 02 | | | | |
| " | | -15 | 01 | - | - | " | |
| " | | -15 | 02 | - | - | " | |
| Duplicate | | -16 | 01 | | | | |
| Duplicate | | -17 | 01 | - | - | " | |



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TABLE 7-6

SEDIMENT SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS FOR SOUTH CAVALCADE (Cont'd)

| SAMPLING LOCATION DESCRIPTION | MAP REFERENCE | SAMPLE/SITE DESIGNATION | SEQUENCE NUMBER | SMO CONTROL NUMBER ORGANIC | SMO CONTROL NUMBER INORGANIC | SAMPLING CONTAINERS/ ANALYSIS | REMARKS |
|---|---|---|---|---|---|---|---|
| Field Blank | Same | SD-18 | 01 | - | - | (1-5) | |
| Field Blank | | SD-19 | 01 | - | - | (1-5) | |



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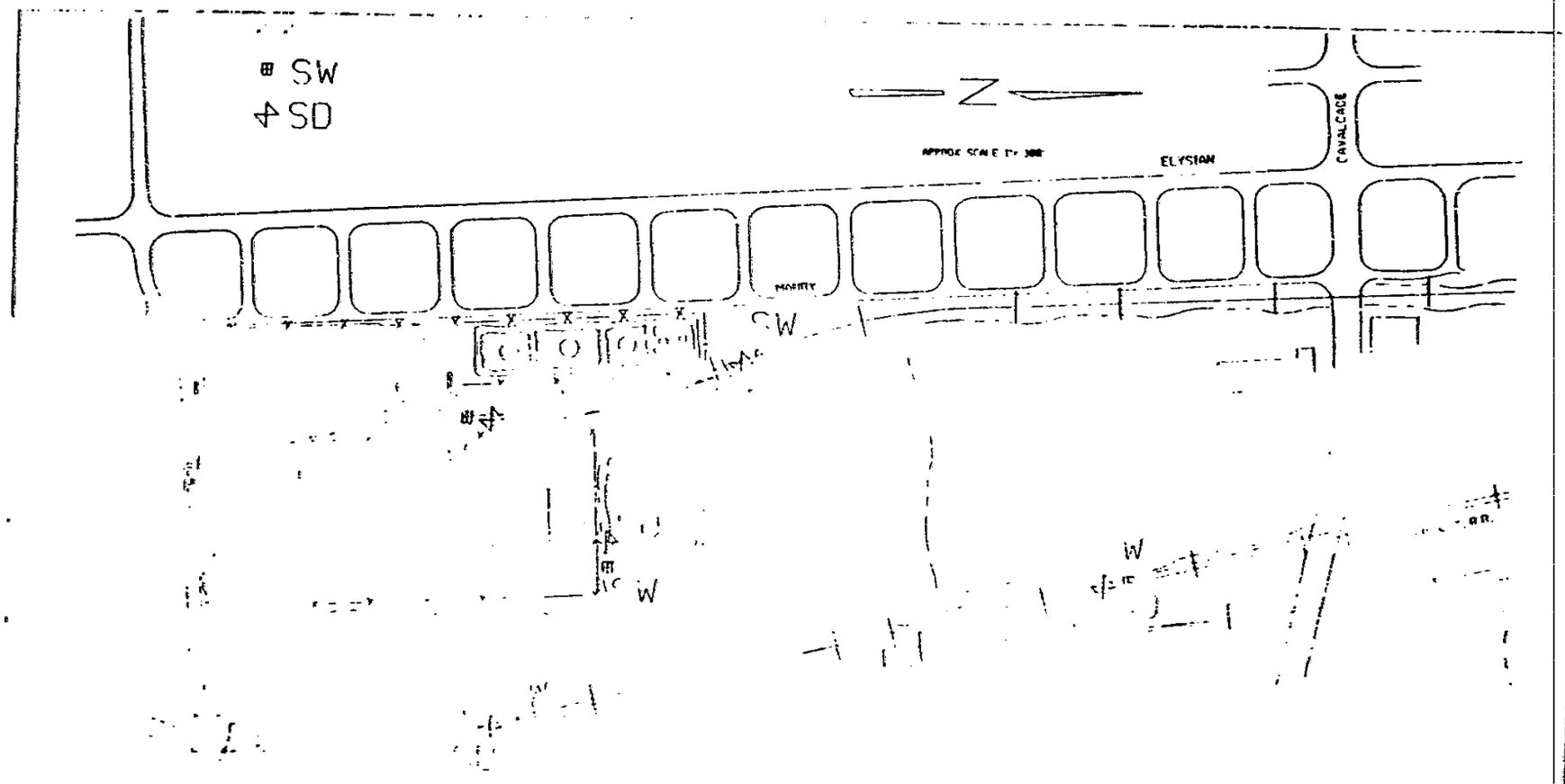


FIGURE 7-6

## 8. SAMPLING CUSTODY

Nancy Johannesmyer

Robert Kier

Standard Operating Procedures (SOPs) clearly define the relevant procedures for sample location identification, sample handling, and sampling containers. They are:

| | |
|---|---|
| Sample Handling and Shipping | 3817001 |
| Sample Identification | 3817003 |
| Sample Container Labeling | 3817004 |
| Chain-of-Custody | 3817005 |
| Sample Bottle Preparation Procedure | 3817007 |

### 8.1 SAMPLE HANDLING AND SHIPPING (3817001)

The protection of personnel involved in the shipment of samples to contract laboratories is important as well as the maintenance of the integrity of the samples themselves. When sent by common carrier, the packaging, labelling and shipping of hazardous wastes and substances is regulated by the U.S. Department of Transportation (DOT) under CFR 49.

Samples obtained at uncontrolled hazardous waste sites are classified as either environmental samples or hazardous samples. Environmental samples are those which contain low levels of contaminants and require implementation of limited precautionary procedures. Hazardous samples are those which could possibly contain dangerous levels of contaminants. Hazardous samples must be packaged and labelled according to procedures specified by the U.S. DOT, or the state DOT, whichever is more stringent.

Environmental samples are collected in an appropriate container allowing approximately 10% air space so that the container is not full at 130°F. If a headspace is not desired for a particular analysis (i.e. volatile organic analyses), the container should be placed inside another container to provide the desired headspace. The sealed and labelled container is then placed inside a ziplock polyethylene bag which is also sealed. The sealed package is then placed inside a shipping container, packed so as to prevent breakage. No precautionary notices are required on the package exterior. Samples not designated as environmental samples or which are known to contain hazardous materials must be considered hazardous. DOT has established a system of priorities for transportation categories which depends on the degree of hazardousness of the material. The relevant portion of this listing is shown in Table 1.

TABLE 1. DOT HAZARDOUS MATERIALS CLASSIFICATION

1. Radioactive Material
2. Poison 'A'
3. Flammable Gas
4. Non-flammable Gas
5. Flammable Liquid
6. Oxidizer
7. Flammable Solid
8. Corrosive Material (liquid)
9. Poison B
10. Corrosive Material (solid)

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All sites are surveyed for levels of radiation during the initial reconnaisance visit. If radiation above 10 millirems/hour is recorded, the advice of a radiation health physicist must be obtained and further work discontinued until it is determined the site is safe.

Poison 'A' is the next category on the DOT list. If the sample is suspected or determined to fall within the Poison 'A' classification, packing procedures specified by DO should be followed.

The next two classification in the DOT series are "flammable" or "non-flammable" gases Few if any gas samples are expected to be collected at uncontrolled hazardous waste sites, therefore, eliminates these from considerations.

The next category to be considered is "flammable liquids". Hazardous samples in liqui form, unless known to fall into a lower category, will be handled, packaged, and shipped at this level of concern.

The following procedure applies to the handling of flammable liquid and solid samples:

### 8.1.1 Packaging

Samples are collected in glass containers with non-metallic, teflon-lined screw caps. Sufficient ullage (10% by volume) is allowed. If an air space in the inner most container cannot be tolerated in order to maintain sample integrity, the sample shall be placed within a second container to provide the required air space.

In collecting a solid material, the container plus contents shall not exceed 1 pound net weight. Large quantities of material, up to one gallon, may be collected if the flash point of the sample can be determined to be 73°F or higher. If this is the case, this information should be marked on the outside container but only a single bottle (1 gallon or less) may be packed in an outside container with 10% air space. The shippir papers are required to state that the "flash point" is 73°F or higher.

Seal the sample container and place each in a separate 2-ml thick (or larger) ziplock polyethylene bag. Each sealed bag shall be placed inside an appropriate sized metal can or other DOT approved container with enough noncombustible, absorbent, cushioning material (e.g. bentonite, vermiculite or diatomaceous earth) to prevent breakage and provide for absorption of liquid; one bag per can. Pressure close the can and use clips, tape or other positive means to hold the lid securely and effectively.

The metal cans or other DOT-approved container shall be placed in a strong outside container and surrounded with noncombustible, absorbing packaging material for stability during transport.

### 8.1.2 Marking and Labeling:

The following information shall be placed on each metal can or other DOT-approved container, or 1-gallon bottle:

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Laboratory Name and Address
"Flammable Liqiud, n.o.s. UN1992" or
Flammable Solid, n.o.s. UN1325"
"n.o.s." (not otherwise specified) is not used
if the flammable liquid or solid is identified

"LABORATORY SUPPLIES" and "THIS SIDE UP" or "THIS END UP" should also be marked on the top and/or frontside of the outside container and upward pointing arrows should be placed on all 4 sides of the exterior container.

8.1.3 Shipping Papers

The bill of lading supplied by the carrier should be completed and the certification statement signed with the following information in the order listed:

"Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325," "Cargo Aircraft Only", "Limited Quantity" or "Ltd. Qty", "Laboratory Samples", "Net Weight ___" or " Net Volume ___" of hazardous contents, by item, if more than one metal can is inside of exterior container.

The net weight or net volume must be placed just before or just after the "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s." description.

A complete chain-of-custody record, enclosed in an envelope is included in the sample container.

8.1.4 Transportation

All samples should be shipped by Federal Express. "Cargo Only" aircraft may be used, but hazardous samples shall not be transported by any carrier which also carries passengers.

Hazardous or environmental samples may be transported personnel in private vehicles.

8.2 SAMPLE IDENTIFICATION (3817003)

A coding system is used to identify each sample taken during the sampling program. This coding system will provide a tracking procedure to allow retrieval of information concerning a particular sample and assure that each sample is uniquely identified.

A listing of the projects and sample identification numbers is to be maintained under the direction of the Sampling and Analytical Coordinator.

Each sample identification number is composed of three components which are described as follows:

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Project information - A three letter designation is used to identify the site where the sample is being collected. The designation will depend on the site name.

Sample Type and Station Location - A two letter designation is used to identify the specific type of sample being taken followed by three digits which indicate the station location. The sample types which will be collected during the remedial site investigations are:

PT - Pump Test
SW - Surface Water
GW - Ground Water
SL - Soil samples
SD - Sediment samples
LG - Lagoon samples
TS - Tank samples
DM - Drum samples
AG - Gaseous air samples
AP - Particulate air samples
AO - Organic air samples
AM - Trace Metal samples
RS - Rock samples

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Sample number - A three number designation is used to number samples according to sample type. The samples are numbered consecutively within the sample type and are not related to the date of collection. The sequence of sample numbers will be obtained from the Sampling and Analytical Coordinator.

As an example, a sample code follows:

SCK-GW-001-005

(South Cavalcade - Groundwater sample collected from Well #1 - 5th groundwater sample collected at the SCK site)

8.3 SAMPLE CONTAINER LABELING (3817004)

All samples must be identified with a self-adhesive Chain-of-Custody label which shall be attached directly to the container. Sample labels must be completed with a waterproof pen. The information recorded on the sample label includes the following:

- Sample Container Prepared by - Initials of lab personnel
- Program Identification Number
- Program - Three letter designation
- Date - Six digit number indicating month, day, year of collection
- Time - Four digit indicating military time

- Station - Sampling station number
- Temperature (°F) - Approximate
- Sample Type - Surfacewater, groundwater, etc.
- Sampled by - Signature of person who collected sample
- Reference - Procedure number of the sampling protocol followed
- Special Instructions/Cautions - Split samples are labelled with identical information and "split" is noted in the special instructions/cautions box. Duplicates are given entirely separate identification numbers and are not identified on the sample label.
- Preservative - If a preservative is added to the sample container it is noted.
- Parameter to be Analyzed - Specific parameters or general groups of parameters.
- Laboratory Number - Sample identification number used by the laboratory analyzing the sample.

As each sample is collected, a record is made in the field notebook and the sample is placed in a numbered container.

## 8.4 CHAIN-OF-CUSTODY (3817005)

These procedures provide documentation of the handling of each sample from the time it is collected until it is destroyed.

To maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory, a "Chain-of-Custody Record" is filled out for each sample type at each sampling location. Each time the samples are transferred to another custodian, signatures of the person relinquishing the sample and receiving the sample, as well as the time and date, should document the transfer.

A sample Chain-of-Custody Record is shown in Figure 8-1. An example of a chain-of-custody sample label is presented on Exhibit 8-1.

FIGURE 8-2. CHAIN-OF-CUSTODY SAMPLE LABEL

Sample Container Prepared By _____

Program Identification No. _____

Program _____ PRESERVATIVE:

Date _____ Time _____ PARAMETERS TO BE ANALYZED:

Station _____ _____ _____

Temp (°F) _____ _____ _____

Sample By _____ _____ _____

Reference _____ _____ _____

SPECIAL INSTRUCTION/CAUTIONS LABORATORY NO.

Actual field forms will include copies so that four forms are filled out simultaneously. The sampling team leader retains the original and any extra copies and one copy remains with the samples until they are received by the laboratory. If samples are split to different labs, a copy will go to each lab. Care must be taken that all four copies are legible. If additional duplicate sheets are required, the person relinquishing the samples is responsible for filling out additional copies, or making reproductions. The original must be returned by the Sampling Team to the Sample Traffic Control Center.

The Chain-of-Custody Record will be placed in a ziplock bag and placed inside of all shipping and transport containers. All samples will be shipped by Federal Express to the laboratory specified by the Sampling and Analytical Coordinator. Samples should be packed so that no breakage will occur. The shipping or external container should be sealed with evidence tape and initialed so that any sign of tampering is easily visible.

### 8.4.1 Field Notebooks

Field notebooks provide means for recording all data collecting activities performed at a site. As such, entries should be as descriptive and detailed as possible, so that a particular situation could be reconstructed without reliance on the collector's memory.

Field notebooks shall be bound, 8-1/2 x 11 inch books with consecutively numbered pages. Notebooks shall be permanently assigned to field personnel, but are to be stored in the Document Control Center (DCC) when not in use. Each notebook is identified by the DCC number which indicates:

## 8. SAMPLING CUSTODY

ZJX - FN - XXXX - XX
(Projected Number - Field Notebook - Owner Identification - Sequence Number)

The cover of each notebook contains the following information:

- o Person or Organization to whom the book is assigned
- o Book Number
- o Project Name
- o Start Date
- o End Date

Entries into the logbook may contain a variety of information. At the beginning of each entry the following information is recorded; the date start time, weather, all field personnel present, level of personal protection being used on-site, and the signature of the person making the entry should be noted.

All measurements made and samples collected are recorded. All entries should be made in pen. No erasures are permitted. If an incorrect entry is made, the data will be crossed out with a single strike mark and initialled. Entries should be organized into easily understandable tables if possible. A sample format is shown in Form 1.

At each station where a sample is collected or a measurement made, a detailed description of the location of the stations which includes compass and rangefinder measurements, are recorded. The film roll number and number of photographs taken at the station are also noted.

All equipment used to make measurements is identified, including the date on which the equipment was calibrated.

Samples are to be collected following the procedures describes in this generic protocol. The equipment used to collect samples should be noted, along with the time of sampling, sample description, depth at which the sample was collected, volume and number of containers. In addition, the identification of the container number into which the sample is placed in the field is recorded. Sample numbers are assigned prior to going on-site. Duplicates, which receive an entirely separate sample number, are noted under sample description. Significant field notebook entries (samples collected, significant observations) must be countersigned by another member of the project team.

FORM 1

TYPICAL FIELD NOTEBOOK ENTRY FORMAT

START TIME: _____ DATE: _____

WEATHER: _____

FIELD PERSONNEL: _____ _____

LEVEL OF PERSONAL PROTECTION: _____

EQUIPMENT (NAME/CONTROL NO.): _____ Calibration Date: _____

Station No./Location Description: _____

Film Roll Number: _____ Photograph Numbers: _____

Station No. _____ (Parameter (Units) _____

Sampling Equipment: _____

| No. | Time | Sample Description | Depth | Number | Volume | Chest No. | Comments |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

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# 9. CALIBRATION PROCEDURES AND FREQUENCY

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## 9.1 GENERAL

### 9.1.1 Equipment

Each piece of equipment used in activities affecting quality is calibrated and maintained periodically to assure accuracy within specified limits.

Specifications for each piece of equipment are available to all personnel and include:

1. equipment identification
2. control number
3. calibration and/or maintenance schedule
4. equipment specification
5. specification verification (where applicable)

All equipment used in analyses or sampling have a documented maintenance and/or calibration procedure. These procedures are available to all personnel and include:

1. equipment identification
2. control number
3. calibration and/or maintenance schedule
4. equipment necessary to accomplish calibration (when applicable)
5. procedure for calibration and/or maintenance

Individual analysts are assigned equipment for which they are responsible. Instrument requiring calibration and/or maintenance have a sticker affixed which contains the following information:

1. Date of calibration and/or maintenance
2. Next due date for calibration and/or maintenance
3. Initials of personnel performing calibration and/or maintenance

An equipment log sheet, as well as calibration worksheets (where applicable) is kept for each piece of equipment whose use affects quality. Equipment log sheets are bound into equipment log books and contain:

1. Date of calibration and/or maintenance
2. All data pertaining to the calibration and/or maintenance procedure (not contained in specific equipment worksheets)
3. Next due date of calibration and/or maintenance
4. Initials of agent performing the calibration and/or maintenance
5. Adjustments made and the accuracy of the equipment prior to and following calibration (where applicable)

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6. Record of equipment failure or inability to meet specifications (where applicable)

If the calibration schedule is not adequately maintained or accuracy as reported in the specifications cannot be attained, that instrument is labeled "HOLD" and is unavailable for use until the specifications are attained.

## 9.2 FIELD INSTRUMENTATION

Calibration procedures and frequency of calibration for field equipment is an integral component of each instrument's Standard Operating Procedure (SOP). For the South Cavalcade Site Sampling and Analytical Plan the relevant SOPs are:

| Instrument | SOP Reference |
|---|---|
| H-Nu Photoanalyzer | 3816008 |
| Portable Organic Vapor Analyzer | --- |

General equipment handling and calibration procedures are detailed in SOP 3817013 contained in the same document.

## 9.3 LABORATORY EQUIPMENT

A general, categorical description of Laboratory calibration procedures and frequency follows.

### 9.3.1 Wet Chemistry

#### 9.3.1.1 Calibration Curves

For most colormetric analyses, a calibration curve consisting of 7 points covering the range of concentrations (including a blank) is established. The calibration curve is verified with each batch of analyses at the 20%, low standard (LS) and the 60%, high standard (HS) of the full scale and a blank. If the verification standards are not within 15% of the LS value and 10% of the high standard value, the analyst may not proceed with the analysis.

#### 9.3.1.2 Static Standards and Blanks

At a minimum, one static blank and one static standard (50% of full scale) are required with each batch of ten or less samples. In sample lots greater than 10, every 10th

sample shall be a static standard or blank. The 50% of full scale standard is used as the method control where appropriate. Results of static standard analyses, percent recovery, date and initials of the analyst are recorded in the Static Standard Log Sheet. At the completion of each 15 static standard analyses, the mean percent recovery and standard deviation of the percent recovery is calculated.

The standard deviation of the percent recovery (Sp) may be calculated using the following formula where Pi = each percent recovery and N = number of observations (15)

$$Sp = \sqrt{\frac{\sum_{i=1}^{N} P_i^2 - \frac{\left(\sum_{i=1}^{N} P_i\right)^2}{N}}{N-1}}$$

Chemical control charts are used to keep a running inventory of the method control relative percent recovery (error) versus the date. It is the responsibility of the analyst to keep the chemical control charts up to date. Control charts are kept, along with other quality control log sheets, in a looseleaf binder, organized by parameter.

An interim 10% control limit will be used until sufficient control data is processed to calculate statistically significant standard deviations to be used as control limits (2 Sp) and action limits (3 Sp).

9.3.1.3 Duplicate Analyses

Every tenth sample processed is run in duplicate. Results of duplicate analyses are reported both in method or personal worksheets, and on the Duplicate Quality Control Log Sheet. For each duplicate set, the date, analysts initials, results of each analysis, mean and range are reported.

9.3.1.4 Spiked Samples

Every twentieth sample run is a spiked sample. Results of the spiked sample analyses percent recovery, date and initials of analyst are recorded in the Spiked Sampled Quality Control Log Sheet. At the completion of every 15 analyses, a mean percent recovery and standard deviation of percent recovery (See Section B.1.2) are calculated.

9.3.1.5 Performance Standards

Blind Performance Standards, supplied by the Environmental Protection Agency, are analyzed (unbeknownst to the analyst) once every fifty analyses, at a minimum of once per year, or as specified in a project scope of work. Standards are submitted by the laboratory supervisor, as specified by the Quality Assurance Coordinator. A record of the accuracy of these analyses is kept by the Quality Assurance Coordinator in the

Performance Standard log book. A report on these results will be submitted annually to the laboratory supervisor and corporate QA manager.

9.4 Gas Chromatography

9.4.1 Standards

Stock Preparation. Some stock standard solutions are commercially prepared.

Otherwise, stock standard solutions are prepared in a methylalcohol. 9.8 ml of methyl alcohol is placed into a 10 ml ground glass stoppered Volumetric Flask. The flask is allowed to stand unstoppered until all alcohol-wetted surfaces have dried and then it is weighted to the nearest 0.1 mg. Using a 25 ul syringe (Hamilton 702 N or equivalent) 2 drops of the assayed reference material are added directly to the alcohol and the flask is immediately reweighed. The solution is mixed by inverting the flask several times. Stock standards are staved at 40°C and are good for a period of one month.

9.4.2 Calibration

Using stock standards, secondary dilution standards are prepared in a suitable solvent. Calibration Standards are then prepared from these secondary dilution standards. Any aqueous calibration standard must be prepared fresh daily.

9.4.3 Quality Control

Before the processing of any samples, an instrument blank is run to check the analytical system for interferences. Calibration standards are then run to verify the performance of the system, and thereafter throughout the period of operation.

A daily record is kept of the recoveries of all standards. Upper and lower concentrations are used to verify that the system is within the stated control limits. The system is in control if the recoveries are within ±20% of the average % recovery stated for individual compounds in each analytical method. The results for duplicate runs are also recorded. This is a further check on the performance of the system and is also a check on the sampling technique when separate sample bottles are used for the duplicate runs.

US EPA Performance Evaluation Standards (WS series) are analyzed twice annually. "WP" series are analyzed once a year.

9.5 Gas Chromatography/Mass Spectrometry

The preparation of standards and routine quality control procedures for Gas Chromatography/Mass spectrometry (gc/ms) are identical to those procedures listed in Section B.3.

## 9.6 Calibration Materials

### 9.6.1 Water

Reagent water, used for all rinsing, sample dilutions and standard preparati
Is obtained from the Nanopure system.

The water produced by this system conforms to ASTM requirements for Type 1 c water. In the Nanopure system, distilled water is passed through two deionization columns, and one organic removal column, followed by filtration through a 0.2 um filter.

The quality of water produced by the Nanopure system is monitored according t the equipment maintenance and calibration procedures and recorded in the Equipment log book.

### 9.6.2 Chemicals

The purity of chemical reagents, solvents, and gases varies with the type o analysis. For most inorganic analyses, analytical reagent grade (AR) is satisfactory. All reagents, solvents, and gases conform to AR specificatio a minimum of purity. All primary and secondary standards materials are eit N.B.S. standards or treatable directly to N.B.S. standards.

a) Primary standards and reagents are used for standarizing all volumetric solutions.

b) Commercially prepared reagents and standards are periodically spot check for accuracy.

Metal analyses require spectroquality reagents and solvents.

a) Analytical-reagent-grade nitric and hydrochloric acid is not suitable for metal analysis. These acids must be purchased with ultra-high purity specifications or the AR acids must be specially prepared by distillatio boreosilicate glass and diluted with deionized distilled water.

b) Fuel and oxidant gases used for atomic absorption or emission spectrosco can be commercial grade. Laboratory air supplies are able to maintain adequate pressure, are oil and water free, and are void of metal contamination from the air lines.

Analytical-reagent-grade Nitrous oxide is used for a number of metal determination.

## 9. CALIBRATION PROCEDURES AND FREQUENCY

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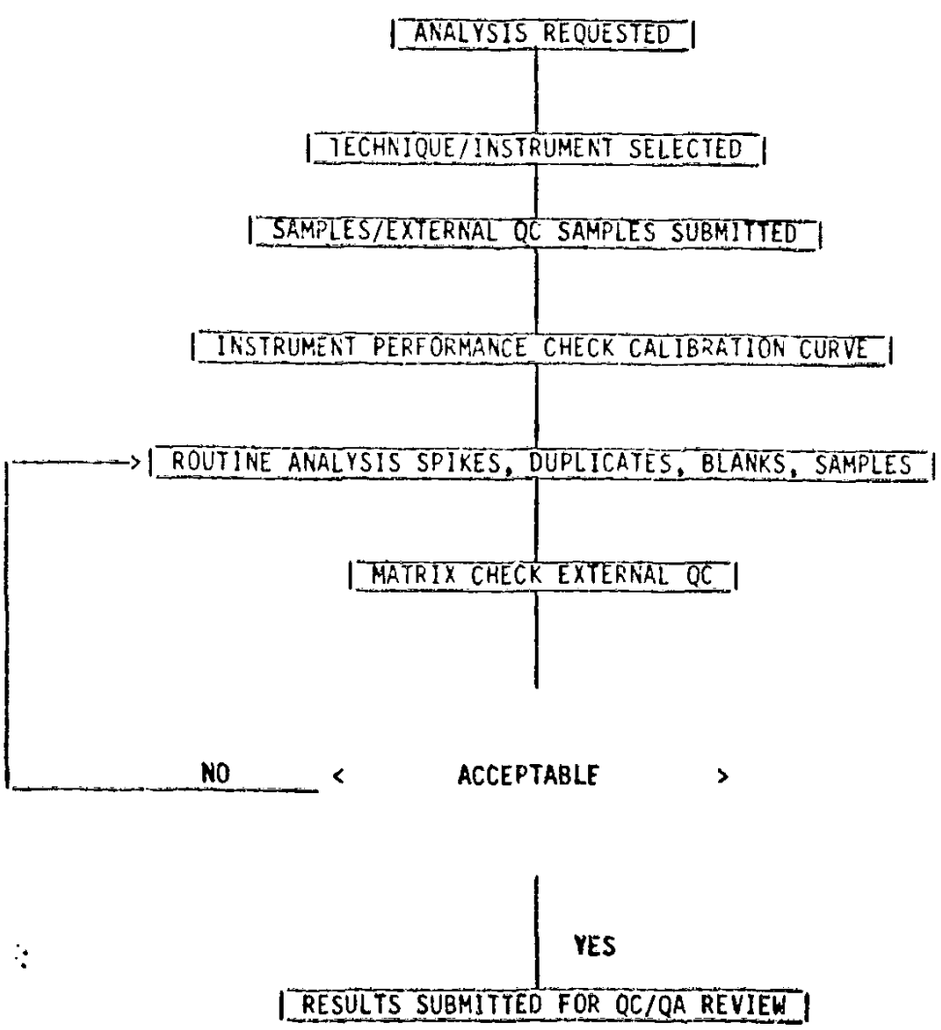
### CALIBRATION PROCEDURES FLOW CHART

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## 9. CALIBRATION PROCEDURES AND FREQUENCY

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### MINIMUM REQUIRED CALIBRATION PROCEDURES AND FREQUENCY

| Analytical Category | Technique | Calibration Check (Type) | Frequency | Quality Control Samples (Type) | Frequency |
|---|---|---|---|---|---|
| Wet Chemistry | Gravimetric | Balances checked with class 'S' weights | Monthly | A1 | With each batch and |
| | | | | A4,5 | As required |
| | | | | C3A | Every 10th sample |
| | | | | E1 | Min. Twice a Year |
| | | | | E2 | As required |
| | Tritrimetric | Standarize titrants/solutions | As necessary | A1 | With each batch a every 10th sample |
| | | | | A4,5 | As required |
| | | | | B2 | With each batch |
| | | | | C1,2,3 | With each titratio |
| | | | | E1 | Min. twice a year |
| | | | | E2 | As required |
| | Potentiometric | Min. 2 point calibration curve | Each batch | A1 | With each batch and every 10th sample |
| | | | | A4,5 | As required |
| | | | | B2 | With each batch |
| | | | | C3A | Every 10th sample |
| | | | | E1 | Min. twice a year |
| | | | | E2 | As required |
| | Colorimetric | 7 point calibration curve | Each time new reagents made | A1,2,3 | With each batch a every 10th sample |
| | | | | A4,5 | As required |
| | | | | B2A | 2 with each batch and every 10th sa |
| | | Curve check | Each batch | B2B | 3 with each curve check |
| | | | | C3A | Every 10th sample |
| | | | | C3B | As required |
| | | | | D1 | Every 20th sample |
| | | | | D2 | As required |
| | | | | E1 | Min. twice a year |
| | | | | E2 | As required |

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MINIMUM REQUIRED CALIBRATION PROCEDURES AND FREQUENCY (Continued)

| Analytical Category | Technique | Calibration Check (Type) | Frequency | Quality Control Samples (Type) | Frequency |
|---|---|---|---|---|---|
| Spectros-copy | Atomic Absorption | 5 point calibra-tion curve | Each Ana-lysis | A1,2,3 | Each batch and every 10th sample |
| | | | | A4,5 | As required |
| | | | | B2A,B | Each analysis |
| | | | | C1,2,-3,A | Every tenth sample |
| | | | | C1,2,-3,B | As required |
| | | | | D1 | As required for standard addition and/or flameless AA |
| | | | | D2 | As required |
| | | | | E1 | Min. twice a year |
| | | | | E2 | As required |
| | Infared | 5 point calibra-tion curve | Each ana-lysis | A3 | Each batch and every 10th sample |
| | | | | B2A,B | Each analysis |
| | | | | C1,2,-3,A | Every 10th sample |
| | | | | C1,2,-3,B | As required |
| | | | | D1,2 | As required |
| | | | | E1,E2 | As required |

## 9. CALIBRATION PROCEDURES AND FREQUENCY

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### LEGEND: QUALITY CONTROL SAMPLE TYPES

**A. BLANKS**

1. Distilled/Dionized Water
2. Reagent - Static
3. Reagent - Dynamic
4. Trip
5. Field

**B. STANDARDS**

1. Internal — SEE D.1
2. External
   - 2A. Static
   - 2B. Dynamic
3. Surrogate

**C. DUPLICATES**

| | A. KNOWN | | B. BLIND |
|---|---|---|---|
| 1A. | Blank | 1B. | Blank |
| 2A. | Standard | 2B. | Standard |
| 3A. | Sample | 3B. | Sample |

**D. SPIKES**

1. Known
2. Blind

**E. EXTERNAL AUDITS**

1. EPA Performance Standards WS/WP Series
2. State Performance Standards
3. SEE C1, 2, 3, B



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## 9. CALIBRATION PROCEDURES AND FREQUENCY

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A much greater purity of reagents and solvents is required for organic analyses. Only pesticide grade solvents and reference-grade standards are used. Assays of the reagents must be obtained whenever available.

a) Gas purity for GC determinations depends upon the type of detector being used. The following type and grades of gases are used: Grade 5 Helium, Grade 5 Nitrogen and Grade 0 Air.

A running inventory of all chemicals stored in the laboratory is maintained on file.

a) All chemicals received are affixed with a label. This label provides the date of receipt, who received it, the date it was opened, and the expiration date (where applicable and/or as specified by the manufacturer).

| | DATE | BY |
|---|---|---|
| RECEIVED | | |
| OPENED | | |
| EXPIRATION | | |

C.8 No chemical is directly taken from its respective container. Reagents are not transferred via spatula or pipet directly from the bottle.

### 9.7 Solutions

All solutions prepared in the laboratory will be affixed with either a Reference Standard Working Solution Label. Each label will be filled out in accordance with the information requested.

| WORKING SOLUTION | |
|---|---|
| Name | |
| Nominal Concentration | |
| Actual Concentration | |
| Exp. Date | By |
| Reference | |

| REFERENCE STANDARD | |
|---|---|
| Name | |
| Code | Conc. |
| Date Prepared | |
| Exp. Date | By |
| Reference | |

## 9. CALIBRATION PROCEDURES AND FREQUENCY

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a) All solutions prepared are recorded in the solution log book. The date the solution was prepared, the weigths and/or volumes used to make-up the solution, the person who did the preparing, the concentration, the reagent assay, and any other applicable notations will be documented in the log. Each solution will be specifically identified and will be labelled with a sequential number. This number will also be on the Reference Standard Label or Working Solution Label and used as a cross-reference to the solution log book.

Solutions prepared must be properly stored and maintained. All solutions and reagents are to be handled, contained, preserved (i.e. refrigerated) and considered useable for the period of time specifically documented under the analytical procedures. The following is a list of consideration which may be noted:

a) Borosilicate glass bottles with ground glass or polyethylene stoppers are used for most standard solutions and reagents.

b) Polyethylene containers are used for alkaline solutions.

c) Plastic containers must not be used for reagents or solvents instead for organic analyses.

d) Reference standards commercially obtained are stored according to manufacturer's direction.

e) Light sensitive reagents and solvents are stored in dark bottles and in cool, dark place.

f) Standards and solutions are not kept longer than recommended by the method or manufacturer due to decomposition on standing.

g) The concentration of standard will change as a result of solvent evaporation and therefore they are kept capped in such a way thay they are air-tight.

h) Solutions and reagents requiring refrigeration are appropriately stored.

i) Certain standard solutions and reagents are susceptible to changes in concentration because of absorption of gases or water vapor and therefore must have known expiration dates.

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# 10. ANALYTICAL PROCEDURES

## 10.1 PHASE I SAMPLING ROUND

Groundwater samples from locations will be taken to determine the areal extent and magnitude of groundwater contamination at South Cavalcade Site, Houston, Texas. Subsurface surficial soil samples will be taken to determine the vertical extent of soil contamination. Surface water and sediment samples will be taken in standing water and drainage pathways to determine surface migration of contaminants. A list of the analytical procedures are listed below with the corresponding laboratory utilization is contained in Tables 7-1, 7-2, 7-3, 7-4, 7-5.

## 10.2 PHASE II SAMPLING ROUND

Wells will be sampled in the second round to monitor groundwater contamination based on results obtained from Phase I. Surface water and sediment will be sampled in the second round based on the results of Phase I. A list of the analytical procedures are listed below with the corresponding laboratory utilization is contained on Table 7-1, 7-2, 7-3, 7-4, 7-5.

## 10.3 METHOD SUMMARY AND MODIFICATIONS

### 10.3.1 Soils, Sediment

All solid matrix analyses will be performed by an analytical laboratory in Houston, TX.

1. Halogenated/Non-Halogenated Volatile Organics

Lab follows EPA methods 8240 without exception.

2. Priority Pollutant Scans

Priority Pollutant Scans consist of Volatile Organics, Acid/Base-Neutral Extractables, PCB, metals, cyanide, and phenol.

Lab follows EPA methods 8240,8250,8270,6010,7061 without exception.

3. Petroleum Hydrocarbons

Lab follows EPA method 418.1 without exception.

TABLE 1. ANALYTICAL PROCEDURES AND LABORATORY UTILIZATION

| Sample Matrix or Type | Analysis Required | Procedure | # of Samples | Labora |
|---|---|---|---|---|
| | | | Refer to Section 7 | To be specii |
| Subsurface Soil, | Volatile Organics | 5030(1)/8240 (2) (1) | | |
| | Petroleum Hydrocarbons | 3540/418.1 | | |
| | Priority Pollutant Scans, consisting of: | | | |
| | - Volatile Organics | 5030/8240 | | |
| | - Acid/Base-Neutral Extractables | 3540/8250/8270 | | |
| | - Priority Pollutant Metals | 3020/3010/6010 | | |
| | - Total Cyanide | 9010 | | |
| Sediment (All Rounds) | Volatile Organics | 5030/8240 | | |
| | Petroleum Hydrocarbons | 3540/418.1 | | |
| | Priority Pollutant Scans | | | |
| | - Volatile Organics | 5030/8240 | | |
| | - Acid/Base-Neutral Extractables | 3540/8250/8270 | | |
| | - Priority Pollutant Metals | 3020/3010/6010 | | |
| | - Total Cyanide | 9010 | | |
| Surface Water | Volatile Organics | 624 | | |
| | Petroleum Hydrocarbons | 418.1 | | |
| | Priority Pollutant Scans: | | | |
| | - Volatile Organics | 624 | | |
| | - Acid/Base-Neutral Extractables | 625 | | |
| | - Priority Pollutant Metals | 200.1/200.2 | | |
| | - Total Cyanide | 335 | | |
| | - Nitrates | 353.3 | | |
| | - Iron | 236 | | |

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TABLE 1. ANALYTICAL PROCEDURES AND LABORATORY UTILIZATION (Cont'd)

| Sample Matrix or Type | Analysis Required | Procedure | # of Samples | Laboratory |
|---|---|---|---|---|
| | | | Refer to Section 7 | To be specified |
| Groundwater Water (1st & 2nd round) | - Volatile Organics | 624 | | |
| | - Acid/Base Neutrals | 625 | | |
| | - Metals | 200.1/200.2 | | |
| | - Total Cyanide | 335 | | |
| | - Petroleum Hydrocarbons | 418.1 | | |
| | - Nitrates | 353.3 | | |
| | - Pesticide and PCB | 608 | | |
| | - Iron | 236 | | |
| | - D.O. | 360.1/360.2 | | |
| | - pH | 150.1 | | |
| | - Temperature | 170.1 | | |
| | - Conductivity | 360.1/360.2 | | |

000811

1. Method for Organic Chemical Analysis of Municipal and Industrial Wastewater, EPA-600/4-82-057, July 1982.

2. Test Methods for Evaluating Solid Wastes, SW-846, July 1982.

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

4. Standard Methods for the Examination of Water and Wastes, 15th edition, APHA-AWWA-WPCF.

Nancy Johannesmeyer

Robert Kier

## 11. DATA REDUCTION, VALIDATION AND REPORTING

### 11.1 DATA LOGGING

Upon receipt of samples for analysis accompanied by a completed request for analysis form and/or chain-of-custody materials detailing requested analysis, the laboratory supervisor or his delegate will:

1) Verify all paperwork, chain-of-custody forms, etc.

2) Log in samples, assign unique log numbers, and attach the numbers to the samp container(s).

3) Open project file and enter data on lab computer.

4) Assign priority and hazard rating criteria.

5) Store samples in refrigerated Sample Bank.

### 11.2 ANALYZING THE SAMPLE AND PROCEDURAL DETAIL

The samples will be analyzed by chemists and/or technicians using approved analytic l procedures (see Section 10).

The chemist/technician will then record the results of analyses and detail all procedural modifications, deviations, or problems associated with analyses in param workbook.

### 11.3 VALIDATION OF DATA

Upon completion of an analytical procedure, data undergoes QA/QC review before final reporting. CDM will be responsible for reviewing analytical results produced by NUS Analytical for completeness, representativeness, accuracy and precision. The QA Officer will review all data for:

1) Completeness of analytical data. This criterion is a measure of the amount valid data obtained from the measurement system compared with the amount th was expected under normal conditions. This criterion is expressed as a percentage.

2) Correctness of analytical data. This criterion is simply a check on all mathematical calculations, data transpositions, units of measure, significant figures etc.

3) Accuracy. This criterion compares reported values to known values, and is usually reported relative to some measurement of dispersion such as standar deviation, or as a percentage.

4) Precision. This criterion measures the reproducibility of a measurement. Precision may also be reported relative to some measurement of dispersion such as standard deviation.

5) Representativeness. In a laboratory setting, this criterion is usually evaluated according to the data's credibility, based on the QA officers past experience with similar samples.

## 11.4 FINAL REPORTING AND REPORT ARCHIVAL

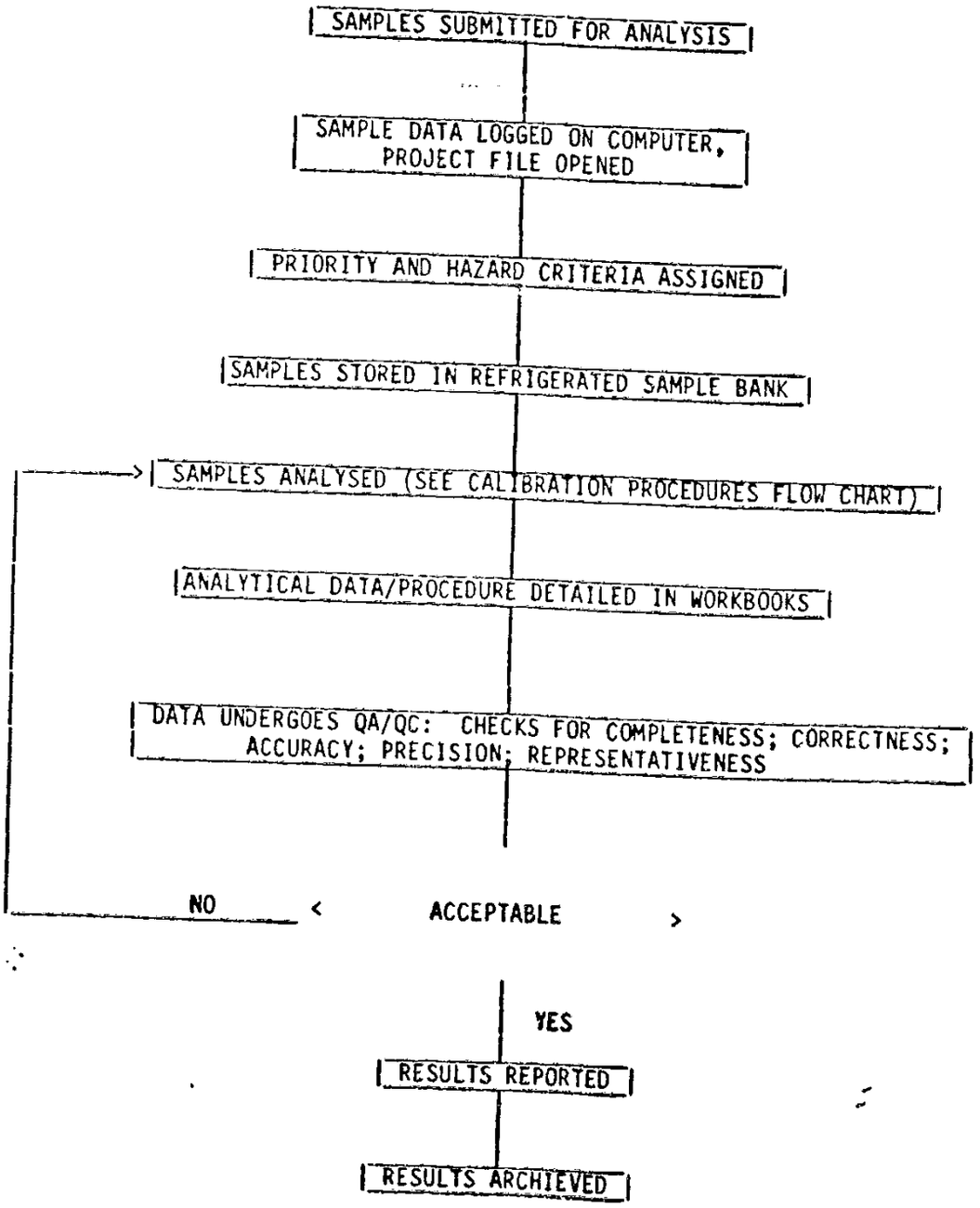
Upon successful completion of the QA/QC process, data is submitted in final report form. This format consists of all pertinent sample and project information as originally provided with sample log in material. It also makes specific reference to analytical notes and references.

Copies of all analytical data and/or final reports are retained in the laboratory files and, at the discretion of the laboratory manager, data will be stored on computer disks for a minimum of one year.

After one year or whenever the data becomes inactive, the files will be transferred to archives in accordance with Standard Laboratory Procedure. Data may be retrived from archives upon request.

## 11. DATA REDUCTION, VALIDATION AND REPORTING

### SAMPLE/DATE REDUCTION, VALIDATION, AND REPORTING FLOW

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Nancy Johannesmeyer

Robert Kier

## 12. INTERNAL QUALITY CONTROL CHECKS AND FREQUENCY

### 12.1 INTERNAL QUALITY ASSURANCE CHECKS

Internal quality assurance procedures are designed to assure the consistency and continuity of data. If required, external quality assurance procedures (interlaboratory checks) are carried out to assess the accuracy of the data generated. Internal qualit assurance procedures:

- o instrument performance checks
- o instrument calibration
- o documentation on the traceability of instrument standards, samples, and data
- o documentation on analytical methodology and QC methodology (QC methodology includes spiked samples, duplicate samples, and split sample use of reference blanks and check standards for method accuracy and precision)
- o documentation on sample preservation and transport

### 12.2 FREQUENCY OF QUALITY CONTROL CHECKS

The frequency of Quality Control Checks is based on the type of analysis. Specific frequency criteria for this program are presented in Section 9.

### 12.3 TYPES OF QC CHECKS

Standard analytical QC include but are not limited to:

1. Duplicate Samples

At selected stations on a random time frame, duplicate samples are collected from two sets of field equipment installed at the site, or duplicate grab samples are collected. This provides a check of sampling equipment and technique for precision.

2. Split Samples

A representative subsample from the collected sample is removed and both are analyzed for the pollutants of interest. The samples may be reanalyzed by IITRI or analyzed by two different laboratories for a check of the analytical procedures.

3. Spiked Samples

Known amounts of a particular constituent are added to an actual sample or to blanks at concentrations at which the accuracy of the test method is satisfactory. The amount added is coordinated with the laboratory. This method provides a proficiency check for the accuracy of the analytical procedures.

## 13. PERFORMANCE AND SYSTEM AUDITS AND FREQUENCY

### 13.1 FIELD AUDITS

For each site where samples are collected, an unannounced audit investigating conformance with QA/QC procedures is performed by the Sampling Quality Assurance Officer (SQA) during the project performance period. A checklist for this audit is shown on the following pages. A written report on the results of this audit, along with (as necessary), a notice of noncomformance is submitted to the:

- o Manager of Quality Assurance
- o Site Project Manager
- o Sampling and Analytical Coordinator
- o Project Director

The Nonconformance Notice (NCN) describes any nonconforming conditions and sets a dat for response and corrective action. This notice is filed in the DCC and SQA files. The response is reviewed by the SQA and if satisfactory, is approved in writing. Approval notice is also filed in the DCC and SQA files. Copies of both the NCN, response and approval is sent to the Manager of Quality Assurance.

At the completion of a particular site response, a final quality assurance audit is performed. A final report is prepared which summarizes any deviations from approved methods and their impacts on results.

### 13.2 QUALITY ASSURANCE REPORTS TO MANAGEMENT

Comprehensive records shall be maintained to provide evidence of the quality assurance activities. Procedures for recording all aspects of the quality assurance program will be written and placed on file. Appropriate personnel will be trained in the use of these procedures.

The proper maintenance of quality assurance records is essential to provide support i evidentiary proceedings and the original quality assurance records will be kept in th Program Quality Assurance Manager's records.

Access to working files will be restricted to only project personnel. Access to all files containing quality assurance reords will be restricted to listed personnel as shown on the attached limited access form. Upon termination of an individual task or work assignment, working files will be processed for storage as quality assurance records.

### 13.3 CORRECTIVE ACTION

When a nonconformance or deficiency is identified during a formal audit or during a routine quality control audit, corrective action will be initiated by the Project Quality Assurance Manager or the appropriate functionary (laboratory quality assuranc manager, etc.). The Auditor will also be responsible for ensuring that the corrective action has indeed been taken, and that it adequately addresses the nonconformance. A nonconformance report form will be field for all non-laboratory related deficiencies.

## 13. PERFORMANCE AND SYSTEM AUDITS AND FREQUENCY

All technical staff shall be responsible for reporting all suspected technical nonconformances by initiating a nonconformance report of any issue deliverable or document. All staff shall be responsible for reporting all suspected quality assurance noncomformances by initiating a nonconformance report. The Project QA Manager will be responsible to ensure that corrective actions for nonconformances are implemented by:

- Evaluating all reported nonconformances;
- controlling additional work on nonconforming items;
- determining disposition or action to be taken;
- maintain a log of nonconformance;
- review nonconformance reports;
- evaluate disposition or action taken; and
- ensure nonconformance

Any staff member who discovers or suspects a nonconformance, which is an identified or suspected deficiency in an approved document, is responsible for initiating a nonconformance report.

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FIELD RELATED QUALITY ASSURANCE
AUDIT CHECKLIST

Project_____ Project Manager_____

Site Location_____ On-Site Coordinator_____

Auditor_____ Date_____

| Audit Question | Yes | No | Comment/Documentation |
|---|---|---|---|
| 1. Was an initial site reconnaissance survey conducted? | | | |
| 2. Was a site specific sampling and analytical plan prepared? | | | |
| 3. Was an on-site coordinator appointed? | | | |
| 4. Was an on-site safety officer appointed? | | | |
| 5. Did site personnel receive a copy of the site specific sampling and analytical plan in a timely manner to allow for sufficient review? | | | |
| 6. Was a briefing held off-site, before any site work was begun to acquaint personnel with sampling equipment and assign field responsibilities? | | | |
| 7. Was a final briefing and safety check conducted? | | | |
| 8. Was a completed "Site Personnel Protection and Safety Evaluation Form" read and signed by all visitors and personnel entering the site? | | | |
| 9. Was a field notebook assigned to field personnel? | | | |
| 10. Were entries made in the field notebook as described in procedure number 3817001? | | | |
| 11. Were sampling stations located as described in procedure number 3817002? | | | |
| 12. Were the number and location of samples collected following procedures as specified in the site specific sampling and analytical plan? | | | |

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FIELD RELATED QUALITY ASSURANCE
AUDIT CHECKLIST

Project _____ Project Manager _____

Site Location _____ On-Site Coordinator _____

Auditor _____ Date _____

| Audit Question | Yes | No | Comments/Documentation |
|---|---|---|---|
| 13. Were samples identified as described in procedure number 3917003? | | | |
| 14. Were samples collected following procedures specified in the site specific sampling and analytical plan? | | | |
| 15. Was a chain of custody form filled out for all samples collected? Were all sample transfers documented? | | | |
| 16. Were samples preserved as specified in the site specific sampling and analytical plan and procedure number 3917007? | | | |
| 17. Were the number, frequency and type of samples (including blanks and duplicates) collected as described in the site specific sampling and analytical plan? | | | |
| 18. Were the number, frequency and type of measurements and observations taken as specified in the site specific sampling and analytical plan? | | | |
| 19. Were blank and duplicate samples properly identified? | | | |
| 20. Is a record maintained of calibration of field equipment? | | | |
| 21. Is field equipment calibrated as required? | | | |
| 22. Are originals of all procedures which form the Generic Site Investigation Protocol retained in the quality assurance file? Is a document log maintained? | | | |
| 23. Have document review forms and responses for all procedures been prepared? | | | |

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FIELD RELATED QUALITY ASSURANCE
AUDIT CHECKLIST

Project_____ Project Manager_____

Site Location_____ On-Site Coordinator_____

Auditor_____ Date_____

| Audit Question | Yes | No | Comments/Documentation |
|---|---|---|---|
| 24. Are completed document review forms for all procedures retained in the quality assurance file? | | | |
| 25. Are revisions to procedures adequately documented? | | | |
| 26. Is a document log for chain of custody records and other sample traffic control forms maintained? | | | |
| 27. Have any accountable documents been lost? | | | |

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# 14. PREVENTIVE MAINTENANCE PROCEDURES AND SCHEDULES

## 14.1 MASTER EQUIPMENT CONTROL RECORD

An inventory control system including all equipment and instrumentation is being used and is maintained by the equipment manager as the basis for maintenance and calibration control. The inventory control documentation includes the following:

(1) Description of item.

(2) Manufacturer, model number, and serial number.

(3) Identification Number.

(4) Name, address, and telephone number of company which services item.

(5) Type of service policy.

(6) Timing and frequency of routine maintenance, servicing, and calibration.

## 14.2 GENERAL EQUIPMENT MAINTENANCE, REPAIR AND CALIBRATION

Standard procedures for equipment maintenance, repair and calibration for all instrumentation and equipment are detailed in SOP 3817013.

## 14.3 CRITICAL SPARE PARTS AND EQUIPMENT IDENTIFIED FOR SOUTH CAVALCADE SITE SAMPLING AND ANALYTICAL PLAN PROJECT

(1) H-Nu Photoanalyzer with 10.2 ionization potential lamp

(2) Organic Vapor Analyzer

(3) Power Auger with 3-foot auger intervals

(4) Cold Packs



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## 14. PREVENTIVE MAINTENANCE PROCEDURES AND SCHEDULES

[PROJECT-SPECIFIC LIST TO BE PROVIDED BY FOP]

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## 15. SPECIFIC ROUTINE PROCEDURES TO BE USED TO ASSESS DATA PRECISION, ACCURACY AND COMPLETENESS OF SPECIFIC MEASUREMENT PARAMETERS INVOLVED

### 15.1 OVERVIEW

The reliability and credibility of analytical laboratory results can be established by the inclusion of a program of randomly-scheduled replicate analyses, analysis of standard or spiked samples, and the cooperative analysis of split samples by several laboratories. These external quality control checks should be an integral part of any sampling and analytical plan.

Regularly scheduled analysis of known duplicates, standards, and spiked samples are a routine aspect of data reduction validation and reporting procedures (see Section 11). The specific procedures used to calculate these values follow.

### 15.2 SCOPE AND APPLICATION

The procedures described herein are designed to procure precise and accurate data for each analytical method and analyst. To insure that reliable data continue to be produced, systematic checks must show that test results remain reproducible and that the methodology is actually measuring the quantity in each sample. Quality Assurance must begin with sample collection and not end until the resulting data have been reported.

### 15.3 STATISTICAL EVALUATION OF QUALITY

Formulae for calculating precision and accuracy.

1. Precision

o Standard deviation(s) from pairs of duplicate measurements:

$$S = \sqrt{d^2/2N}$$

where $d = d_1 - d_2$, the difference in concentrations of the two measurements; and N = the number of duplicate measurements.

o Standard deviation(s) from many measurements on one sample:

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

where $x_1$ = the values of individual measurements; $\bar{x}$ = the mean of all the measurements; and N = the number of measurements.

2. Accuracy

o Accuracy reported as percent spike recovery:

$$\% \text{ Recovery} = \left( \frac{S}{S_1 + S_2} \right) \times 100$$

where S = the concentration of the spiked sample; $S_1$ = the concentration of the unspiked sample; and $S_2$ = the concentration of the spike added to the sample.

3. Limit of Detection (LOD)

The limit of detection is the lowest concentration of an analyte that the analytical process can reliably detect. Method sensitivity is defined as the ratio change in the instrument response to the change in analyte concentration; i.e., the slope of the calibration curve should not be confused with the limit of detection. The LOD in most instrumental methods is based on the relationship between the gross analyte signal $S_t$, the field blank $S_b$, and the variability in the field blank $O_B$. The limit of detection has been variously defined by the extent to which the gross signal exceeds $S_b$.

$$S_t - S_b \geq K_d$$

If field blanks are not available or if a single sample is being analyzed for which there is no field blank data, then the limit of detection is based on the peak to peak noise ($O = O_n$) measured on the base line close to actual or expected analyte peak. Detection should be based on a minimum value for $K_d$ of 3. Thus, the limit of detection is located at 3 above the gross blank signal $S_b$. This is illustrated in Exhibit XIV-1 which depicts the region for detection of analyte in the gross signal as $S_t \geq S_b + 3$ and similarly for the net signal as $S_x \geq S_d$.

4. Limit of Quantitation (LOQ)

The limit of quantitation (LOQ) is located above the measured blank $S_b$ by the following definition:

$$S_t - S_b \geq K_g$$

It is recommended the minimum value be $K_g = 10$. This is illustrated in Exhibit 14-1 where the region for analyte quantitation is expressed in terms of the gross signal as $S_t \geq (S_b + 10)$, and in terms of the analyte signal $S_x \geq 10$. The corresponding expression in terms of concentration would be obtained by using the calibration function. Following the previous example used for the LOD,

$$C_x \text{ (LOQ)} = S_q/a \text{ (for } S_x = a\, C_x)$$

15.4 QUALITY ASSURANCE PROCEDURES

1. Replicate Analyses

A minimum of 10 percent of the parameters of water/wastewater samples submitted to the Laboratory will be analyzed in replicate (duplicate or triplicate). Samples for replicate analyses will be selected at random by the Quality Assurance Officer and so designated at the time they are logged in and the parameters for replicate analyses ar

selected. Samples for replicate analysis may also be designated by field personnel at the time of sample collection.

2. Spiked Samples

A minimum of 10 percent of the samples submitted will be selected for spiking with a known concentration of a given parameter. The spike added to the sample will be of the same order of magnitude as the parameter in question found in the sample. Thus, the percent recovery will accurately reflect the accuracy of the analysis in a given range. Spiking will be done by a Laboratory Supervisor on samples randomly selected by the Data Management Supervisor.

3. Standard Quality Assurance Samples

A selected number of the sample parameters analyzed will require submission of a standard Quality Assurance sample for that parameter. This sample will receive a log number and a bogus identification and be submitted as a bona fide client sample.

4. Round-Robin (Split) Samples

Samples split between several laboratories (such as EPA samples) will be logged in and identified as such. They will be analyzed along with regular samples and whenever possible run in replicate.

5. Standard Curve Validation

All analyses require that standard samples (samples that the analyst has prepared from pure materials and distilled water or from certified materials traceable to the National Bureau of Standards) be analyzed concurrently with the sample. In general, the range covered by the standards should comprise the useful parameter concentration range and sensitivity of the analytical method. A minimum of five points within the useful range are required to establish a valid calibration curve. In most instances, new standard curves must be established with each new group of samples. Where continuing analyses of the same samples are being done, two or more points on the curve may be checked to validate same. (See Section 9 Calibration Procedures and Frequency).

## 15.5 QUALITY CONTROL CHARTS

To portray the variation in the true concentration level of parameters analyzed in an environmental laboratory, the system best suited is a display of the percent recovery calculated as follows:

Standard Samples

$$\text{Percent Recovery (P)} = \frac{\text{Observed}}{\text{Known}} \times 100$$

Spike Samples

$$(P) = \frac{\text{Observed-Background}}{\text{Spike}} \times 100$$

Charts are constructed to evaluate the accuracy of analyses of a given parameter percent recovery against sample numbers of the same type of sample. To establish median, upper control and lower control limits, the average percent recovery must be calculated, then the standard deviation for the percent recovery.

$$\text{The upper control limit} = \bar{P} + 3S_p$$

$\bar{P}$ = average percent recovered

$S_p$ = standard deviation from $\bar{P}$

The completed control charts are shown in Exhibits 15-1, 15-2, 15-3, and 15-4.

Following normal procedures, the control chart must indicate the conditions under wh it was developed; i.e., laboratory name, parameter, method of analysis, date of prepa ration, and any other information unique to the initializing data, such as range of concentration and identification of analyst(s). A control chart is not generally applicable under other conditions.

To verify the control chart, the initializing data should be checked to be sure that none of the values exceeds these new control limits. In addition, if its distributi is proper, about 68 percent of the initializing data should fall within the interval $P \pm S_p$.

In applying the control chart, either of the following two conditions would indicate out-of-control situation:

(1) Any point beyond the control limits.

(2) Seven successive points on the same side of the value P of the central line.

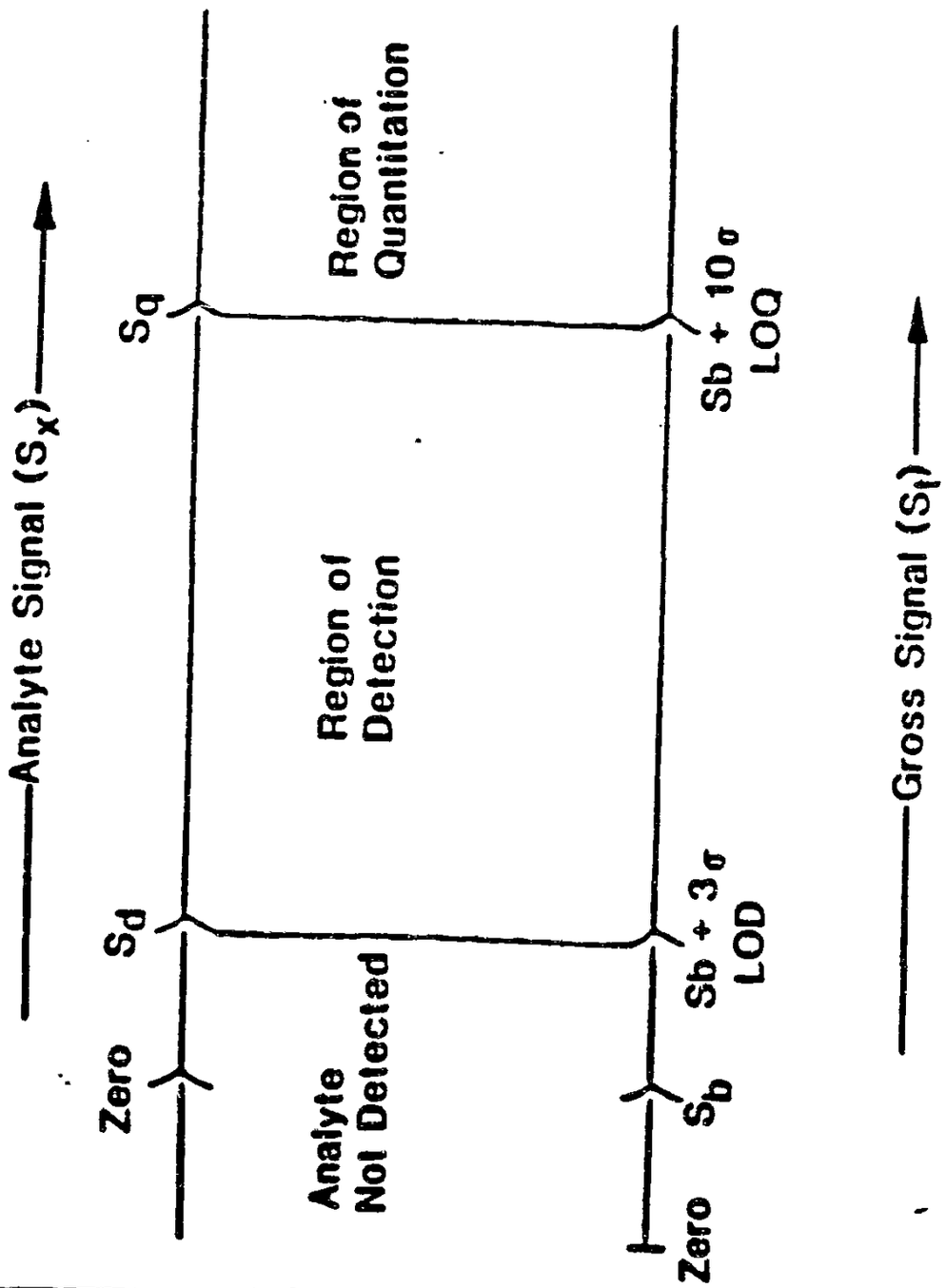
When an out-of-control situation occurs, analyses, must be stopped until the problem has been identified and resolved, after which the frequency should be increased for the next few percent-recovery QC checks. The problem and its solution must be document, and all analyses since the last in-control point must be repeated or discarded.

15.6 ANALYSES AND REPORTING OF RESULTS OF QUALITY ASSURANCE SAMPLES

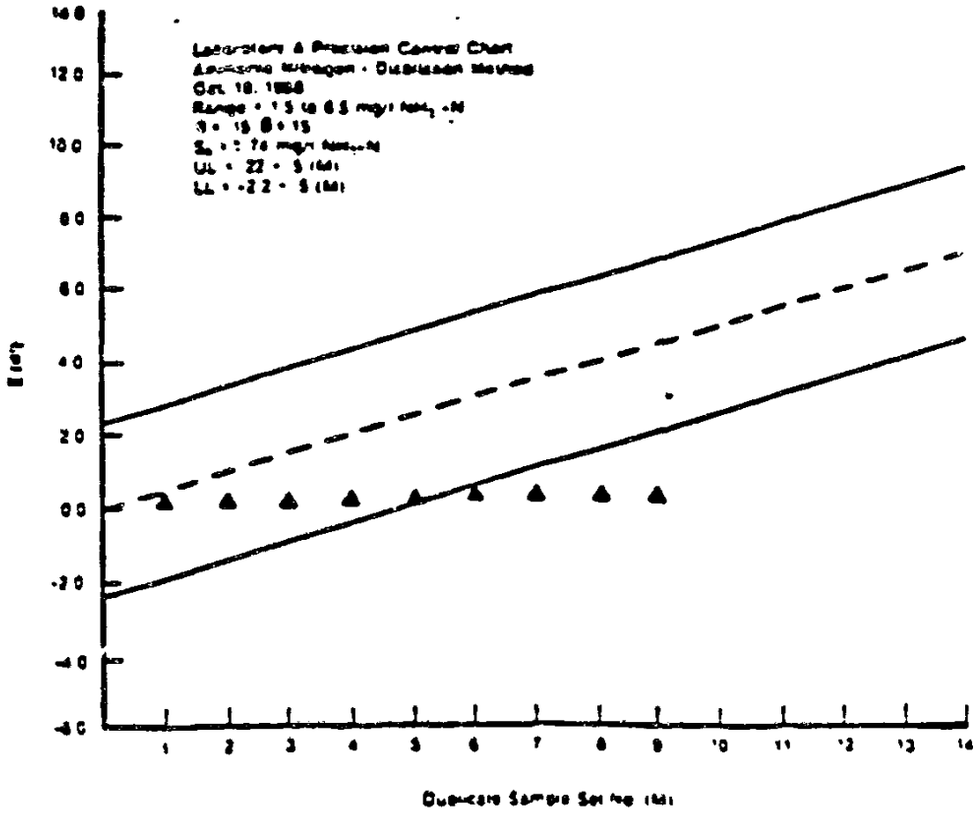
(1) The results of quality assurance sample analyses will be recorded in a permanent bound notebook.

(2) The Quality Assurance Coordinator will analyze the results statistically and di cuss the results with the individual analysts and Laboratory Supervisor. The quality performance of each analyst will become a part of his/her annual revie

| | | | |
|---|---|---|---|
| Document: Project Operations Plan South Cavalcade Site | | No: | Page: |
| | | Date: 2/20/85 | Revision: |
| Subject: FIGURE 15-1 Limit of Detection | | Prepared By: Nancy Johannesmeyer | |
| | | Approved By: Robert Kier | |



| Document: Project Operations Plan South Cavalcade Site | No: | Page: |
|---|---|---|
| | Date: 2/20/85 | Revision: |
| Subject: FIGURE 15-2 Lower Limit Nonconformance | Prepared By: Nancy Johannesmeyer | |
| | Approved By: Robert Kier | |




Corrective Procedures

1. Continue analysis beyond Sample Set 6 through series of samples unless trend changes
2. Assume increased efficiency
3. Construct new chart on recent data
4. Begin plotting Σ(d') at Sample Set 1
5. Observe analyst for false reporting

CONTROL CHART TO ILLUSTRATE "OUT OF CONTROL ON LOWER LIMIT" (CONTINUOUS TREND)

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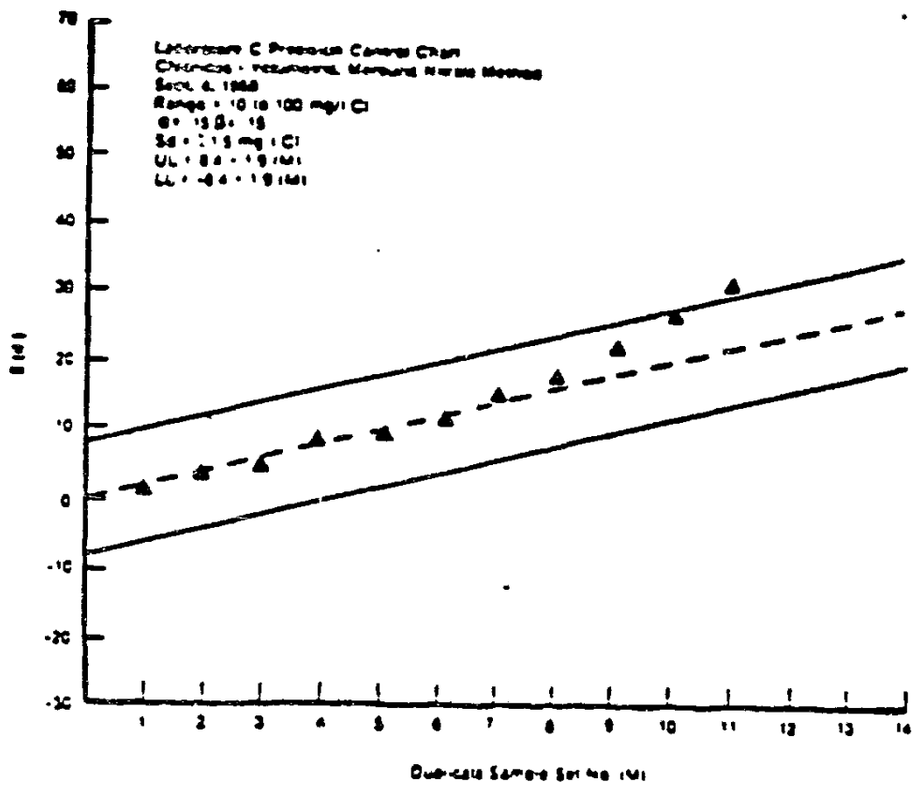
| | | | |
|---|---|---|---|
| **Document:** Project Operations Plan<br>South Cavalcade Site | | **No:** | **Page:** |
| | | **Date:** 2/20/85 | **Revision:** |
| **Subject:** | | **Prepared By:** Nancy Johannesmeyer | |
| FIGURE 15-3<br>Upper Limit Nonconformance | | **Approved By:** Robert Kier | |

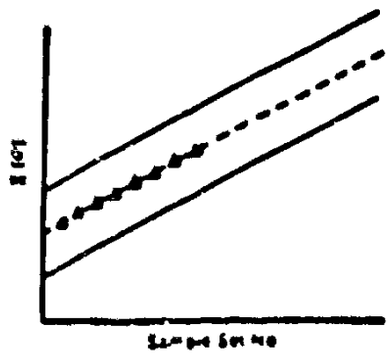



Corrective Procedures:

1. Analysis could have been stopped at Sample Set 9 or 10
2. Analysis definitely stopped at Sample Set 11
3. Locate cause
4. Correct problem
5. If analysis stopped at Sample Set 9 - rerun samples between Sample Sets 8 & 9
6. If analysis stopped at Sample Set 10 - rerun samples between Sample Sets 9 & 10
7. If analysis stopped at Sample Set 11 - rerun samples between Sample Sets 10 & 11
8. In any case begin plotting $\Sigma(d_i)$ at Sample Set 1

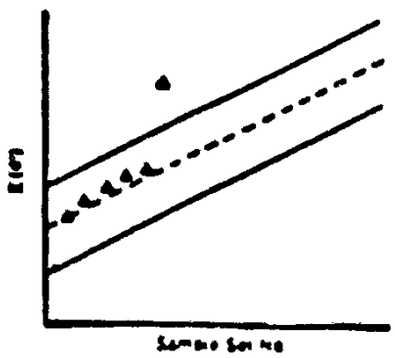
CONTROL CHART TO ILLUSTRATE "OUT OF CONTROL ON UPPER LIMIT"
(CONTINUOUS ERROR TREND)

| Document: Project Operations Plan South Cavalcade Site | No: | Page |
|---|---|---|
| | Date: 2/20/85 | Revision: |
| Subject: FIGURE 15-4 Laboratory Quality Control Chart | Prepared By: Nancy Johannesmeyer | |
| | Approved By: Robert Kier | |



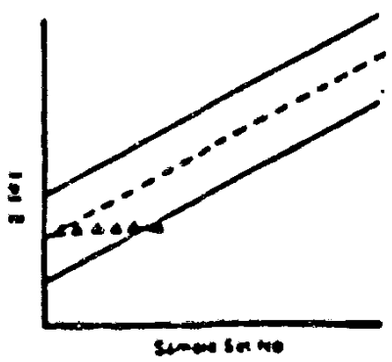

Analysis In Control

No Problems
Continue Analysis



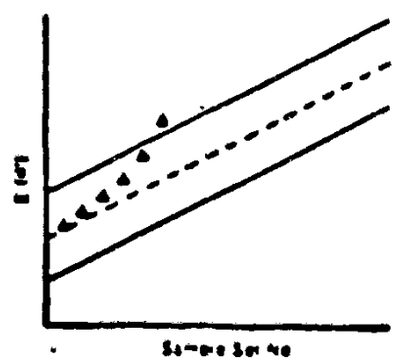

Analysis Out of Control
Upper Limit

Procedures
1. Stop analysis
2. Locate problem
3. Correct problem
4. Rerun Samples
5. Start chart at Sample Set No 1




Analysis Out of Control
Lower Limit

Increased Efficiency or
False Reporting
Procedures
1. Continue Analysis
2. Construct new Chart with recent data
3. Observe Analyst




Analysis Out of Control
Upper Limit

Continuous Error Trend
Procedures
Same as above but stop analysis when trend is detected

LABORATORY QUALITY CONTROL CHARTS

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(3) A monthly Quality Assurance Report will advise the Laboratory Director and the Laboratory Manager of the level of both precision and accuracy of laboratory results.

(4) Reports of quality assurance will be made to individual clients and/or Project managers as the Director of Laboratory Services may direct.

(5) Semi-Annual Reports will be submitted to the QA Board.

15.7 REFERENCES

(1) Handbook for Analytical Quality Control in Water and Wastewater Laboratories, U.S. EPA, Office of Technology Transfer, Cincinnati, OH, March 1979.

(2) QA Program for U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), Department of the Army, Aberdeen Proving Ground, MD, 21010, August 1980.

(3) Analytical Chemistry, Vol. 52, No. 14, December 1980.

(4) Laboratory Quality Assurance Manual, Roy F. Weston, Inc., December 11, 1981, Chapter 7.

(5) Semi-Annual Reports will be submitted to the QA Board.

## 16. OVERVIEW

When a nonconformance or deficiency is identified during a formal audit or during a routine quality control audit, corrective action will be initiated by the Project Quality Assurance Manager or the appropriate functionary (laboratory quality assuranc manager, etc.). The Auditor will also be responsible for ensuring that the corrective action has indeed been taken, and that it adequately addresses the nonconformance. A nonconformance Report Form, Exhibit 16-1, will be filed for all non-laboratory relate deficiencies.

The Auditing Team Leader shall document the completion of the audit by indicating suc on the quality notice form (Exhibit 16-2).

## 16.2 NON-LABORATORY ACTIVITIES

All technical staff shall be responsible for reporting all suspected technical noncon-formances by initiating a nonconformance report of any issued deliverable or document

All staff shall be responsible for reporting all suspected quality assurance noncon-formances by initiating a nonconformance report.

The Project Quality Assurance Manager will be responsible to ensure that corrective actions for nonconformances are implemented by:

- o evaluating all reported nonconformances;
- o controlling additional work on nonconforming items;
- o determining disposition or action to be taken;
- o maintain a log of nonconformances;
- o review nonconformance reports;
- o evaluate disposition or action taken; and
- o ensure nonconformance reports are included in the final site documentation in document control.

Any staff member who discovers or suspects a nonconformance, which is an identified or suspected deficiency in an approved document, is responsible for initiating a noncon-formance report.

The Site Manager shall ensure that no additional work, which is dependent on the nonconforming activity, is performed until the nonconformance report is corrected.

| Document: Project Operations Plan South Cavalcade Site | No: | Page: |
|---|---|---|
| | Date: 2/20/85 | Revision: |
| Subject: Exhibit 16-1 Nonconformance Report Form | Prepared by: Nancy Johannesmeyer | |
| | Approved by: Robert Kier | |

**CDM Team** | NONCONFORMANCE REPORT

| NONCONFORMANCE REPORT NUMBER | INITIATING OFFICE | DATE | ☐ TECHNICAL ☐ QUALITY ASSURANCE |
|---|---|---|---|

NONCONFORMANCE DESCRIPTION (CHECK APPROPRIATE BOXES AS REQUIRED)

| REPORTED BY (NAME) | TITLE | DATE |
|---|---|---|
| COMPLIANCE (QUALITY MANAGER) | | DATE |

RECOMMENDED DISPOSITION (CHECK APPROPRIATE BOXES AS REQUIRED)

☐ REWORK ☐ REJECT
☐ ACCEPTABLE ☐ OTHER (PLEASE EXPLAIN)

| NAME/TITLE | | DATE |
|---|---|---|
| ACTION ASSIGNED TO (NAME) | TITLE | DATE |
| ACTION TAKEN | | |
| EVALUATED ACCEPTED BY SITE MANAGER | DATE | |
| CORRECTIVE ACTION REQUIRED | | |
| CORRECTIVE ACTION DETERMINATION BY (NAME) | TITLE | DATE |
| QUALITY ASSURANCE CLOSEOUT (NAME) | | DATE |

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FORM NO. 1001

| Document: Project Operations Plan South Cavalcade Site | No: | Page: |
|---|---|---|
| | Date: 2/20/85 | Revision: Draft |
| Subject: Exhibit 16-2 Quality Assurance Notice | Prepared by: Nancy Johannesmeyer | |
| | Approved by: Robert Kier | |

**CDM Team** | QUALITY ASSURANCE NOTICE

1 Audit Number _____

2 Date _____

3 Audit Team Leader _____

4 Audit Entity _____

5 Description of Project

6 Findings

7 Nonconformances Observed

8 Corrective Action

☐ Satisfactory

☐ Unsatisfactory

9 Comments

10 Completed _____ Date _____

Auditing Team Leader

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16.2.1 Responsibilities

The Project Manager shall be responsible for carrying out corrective action, as initiated by the Program Quality Assurance Manager. The Project Manager shall evaluate each nonconformance report and shall provide a disposition by checking the appropriate box and describing the action to be taken.

16.3 LABORATORY ACTIVITIES

1. Quality Control Charts

Control charts are used to monitor the day-to-day variations in the precision or accuracy of routine analyses and can detect trends in these variations. Construction of a control chart requires an initial data base to establish the mean and standard deviation of measurements. The data base will consist of measurements obtained from performing the complete analytical method. These control charts fall into two categories: precision control charts, and accuracy control charts. Data falling outside the upper control limit or the lower control limit of either of these charts indicates an "out-of-control" situation. Corrective actions will be taken to ascertain the cause of the out-of-control situation, as follows.

a. Precision

After the day's data have been plotted on the control chart, the data will be pooled with previous data to calculate a new mean and standard deviation for controlling the following day's process. In determining the new mean and standard deviation, the new data should be combined with previous found concentrations and not the mean of the previous found concentrations. Except for the data obtained from standard samples, no data may be discarded unless sufficient reason can be cited to justify the discarding process. That a point is beyond control limits is not sufficient justification to discard the point.

b. Accuracy

Accuracy control charts are constructed by calculating the mean and standard deviation of the slope of the least squares regression line of a plot of found vs. target concentrations. The upper control limit (UCL) and lower control limit (LCL) will be established at three times the standard deviation (3s) above and below the central line, respectively. The slope of a line calculated from the found concentrations of QC spiked natural samples analyzed in a single day will reflect the accuracy for that day. The value of the slope will be plotted on the control chart. If the majority of values fall within the bounds of the UCL and LCL, the process is considered in control. Values consistently falling outside this area indicate an out-of-control situation requiring corrective action. After the slope from the day's data has been determined, this value will be pooled with the slopes obtained from previous days to calculate a new mean and standard deviation to control the following day's process. Except for the data obtained from standard samples, no data may be discarded unless sufficient reason can be cited to justify the discarding process. That a point is beyond control limits

is not sufficient justification to discard the point. An out-of-control situation ma be indicated by:

(1) A value outside the control limits.

(2) A series of seven successive points on the same side of the central line.

An out-of-control analysis, as indicated by QC charts for a given day, will cause the analytical results for that day to be rejected by the Laboratory Data Supervisor, who will notify the Laboratory Quality Control Coordinator (LQCC) and the Laboratory Manager. The LQCC will stop all analyses on the instrument and take the following remedial action:

(1) Check the instrument calibration record and standard samples used for calibration.

(2) Check all calculations for mathematical accuracy.

(3) Have the instrument re-calibrated and re-checked with QC performance standards.

(4) If the instrument is operating satisfactorily, have analyses of samples, duplicates, and spikes repeated.

(5) If the instrument is not operating satisfactorily, label it "out-of-order" and have it repaired by instrument maintenance before re-checking and re-analyzing samples.

(6) No instrument will be returned to operational status until check analyses indicate an "in control" situation.

(7) All results of checks and remedial action will be fully documented.

Nancy Johannesmeyer

Robert Kier

## 17. QUALITY ASSURANCE REPORTS TO MANAGEMENT

### 17.1 OBJECTIVE

This section describes the methods required to store and retrieve quality assurance records.

### 17.2 REQUIREMENTS

Comprehensive records shall be maintained to provide evidence of the quality assurance activities.

### 17.3 IMPLEMENTATION

Procedures for recording all aspects of the quality assurance program will be written and placed on file. Appropriate personnel will be trained in the use of these procedures.

### 17.4 DISCUSSION

The proper maintenance of quality assurance records is essential to provide support in evidentiary proceedings.

The original quality assurance records will be kept in the Program Quality Assurance Manager's records.

A quality assurance records index will be started at the beginning of a project based upon the information presented in the work plan.

All information received from outside sources will be retained by the group using the data.

Access to working files will be restricted to only project personnel.

Access to all files containing quality assurance records will be restricted to listed personnel as shown on the attached limited access form.

Upon termination of an individual task or work assignment, working files will be processed for storage as quality assurance records.

Upon termination of the project all quality assurance records shall be handled as required by USEPA.

### 17.5 RESPONSIBILITIES

The Project Manager shall be responsible for ensuring that quality assurance records are being properly stored and that they can be retrieved.

## 17. QUALITY ASSURANCE REPORTS TO MANAGEMENT

The Program Quality Assurance Manager shall be responsible for maintaining the records which will include quality assurance record files and a quality assurance records index.

The Site Coordinator shall be responsible for identifying the documents to be designated as quality assurance records. These shall be responsible for identifying the documents to be designated as quality assurance records. These shall be delineated in the work plan.

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APPENDIX I

TECHNICAL SPECIFICATIONS FOR
EXPLORATION WELL INSTALLATION

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## DEEP GROUNDWATER OBSERVATION WELLS

The deep well installation program for the South Cavalcade Street Site is to be carried out as follows:

1) Steam clean all downhole equipment and materials to removal all traces of soil, oils, or grease prior to each use at each site.

2) All water used must be from an approved source.

3) The well bore should be advanced initially through the shallow aquifer using mud rotary techniques until "clean" materials are encountered in the underlying formation. The underlying formation may be assumed to be clean if no indications of contamination are detected through visual examination of the soils, with the olfactory senses, or by field instruments and tests for head space analyses, for metals and total petroleum hydrocarbons, described for the subsurface boring program. Samples collected at 5 foot intervals will be examined prior to advancement to the next sample interval. A sample from the terminus of this initial boring will be analyzed in the laboratory to confirm that it was free of contamination. A thick bentonite based mud with no organic polymer additives will be employed. The consistency and weight of this mud must be sufficient to ensure that its density is greater than the density of any known organic contaminants downward. However mud used for this upper shallow aquifer zone will not be recirculated; instead, it will be wasted to a temporary storage tank for ultimate approved disposal.

4) The well bore shall be reamed to a diameter that will accept a 6" or larger diameter in this initial shallow interval.

5) A thick, pure high sodium bentonite based mud with no organic polymer additives shall be employed during reaming of the hole. The well bore will be sealed off with large diameter (6 inches or more) steel casing cemented into place with a non-shrink bentonite - cement grout (ASTM ). Once the grout around the surface casing has cured (24 hours minimum) and the inside surface casing has been thoroughly cleaned, the well bore can be further advanced. All casing installed should be sufficiently plumb and straight for continued drilling below the first horizon.

6) Once installation of the 6-inch casing is complete, a minimum 5 3/4-inch rotary hole shall be advanced to the target detph, again using mud rotary techiques with a new supply of pure, high sodium bentonite mud of specified density. Frequent mud changes is essential throughout the drilling procedure to ensure minimizaton of cross contamination.



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7) Samples will be collected by Shelby tube or split spoon samplers at 5 foot intervals to a depth of 50 feet, 10 foot intervals below 50 feet and at each change in strata. All samples will be logged and visually descrived in the field using the Unified Soil Classification and standard color charts as a basis as well as head space analysis and field tests. All samples shall be handled and stored according to [Specify]. [CFR?]

8) The boring shall be terminated at a depth no greater than 300 feet.

9) The remaining well casing and screen shall have a minimum nominal diameter of 4 inches constructed of Schedule 80 PVC or fiberglass. The use of fiberglass casing must first be approved by the EPA. Ohter casing sizes may be used, however it msut be large enough to permit the passage of a 3 3/5 inch O.D. x 30 inch long submersible pump from the ground surface to the top of the well screen. Larger casing sizes must be evaluated and approved as to their ability to withstand collapse. The screen shall be factory manufactured with an opening of 0.010 inches. All joints must be screw threaded or riveted; no welded joints permitted. The well casing and screen shall be thoroughly steam cleaned prior to installation. A cap or plug shall be placed on the bottom of the well screen.

10) The entire interval of the deeper aquifer shall be screened. The screened interval of the well, to 2 feet above the top of the screen, shall be packed via trenie pipe, pump, or as necessary and approved with clean, suitably graded material to facilitate hydraulic communication between the well and the formation and to prevent clogging of the well screen with fine particles.

11) A 5-foot bentonite seal shall be placed above the screen pack and the remainder of the well bore up to approximately 2 feet below the ground surface, grouted in one continuous operation from the bottom up via trenie pipe, pump or other approved methods with non-shrink bentonite-cement grout (ASTM ). If a cement basket is employed, it shall be completely free of all glues, solvents, or paints.

12) A 6-inch protective steel casing with locking cap will be installed around the PVC casing into the annular space left above the grout, and cemented in place. A 3 foot by 3 foot 6-inch concrete pad around and sloping away from the steel casing will be included. Cement will also be placed between the protective steel casing and the inner casing from the bottom of the annular space to the level of the pad. Three protective steel pipe barriers will be installed around the pad. The barriers will be set at least 2 1/2 feet deep in concrete and filled with concrete to the upper edge. These barriers will also extend 3 feet above the ground surface at a minimum and painted with implement grade yellow paint. The proper identification code for the observation well will be permanently affixed to the protective steel casing.



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13) All drilling mud and residual soil materials from the borehole shall be disposed of at a Class I facility permited by the Texas Department o: Water Resources, unless onsite disposal proves feasible.

14) The wells shall be developed to a condition in which the produced groundwater from the drilling mud and the surrounding formation is free of turbidity and sedimentary particles by pumping, surging or air lifting, as appropriate.

15) Once free of sediment, the well shall be pumped for a minimum of three days or for a period of time equivalent to twice the amount of time required to remove the volume of wtae from the well equal to the estimated volume of water lost during drilling, whichever is longer.

16) All water produced during development of the well and the subsequent pumping period shall be stroed until analysis demonstrates the water to be free of contamination. If the water produced proves to be free of contamination, it may be discharged to waste on the ground surface or disposed of in the sanitary sewer according to conditions imposed by the City of Houston for an industrial waste permit; if discharged onto the ground surface, no runoff from the site shall be permitted. EPA approval is required for discharge.

17) The location of the well shall be surveyed to the nearest 0.01 foot; the ground surface at the well and casing stick-up shall be surveyed to the nearest 0.1 foot and a permanent mark affixed to the casing for subsequent consistent measurement of water levels.

18) The site will be cleared of all residual drilling materials and trash, any disposable materials will be stored for proper disposal. All drilling equipment will be thoroughly cleaned prior to transport to the next drill site.



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## SHALLOW GROUNDWATER OBSERVATION WELLS

The well installation program at the South Cavalcade site is to be carried out as follows:

1. All downhole equipment will be steam-cleaned prior to remove all traces of soils materials, oils, or grease commencing drilling at each hole; all sampling equipment shall be properly cleaned prior to reuse.

2. Drilling will be dry hollow-stem augering to the designated depth.

3. Samples will be collected by split-spoon or Shelby tube samplers continuously down to a depth of two feet below the base of the shallow aquifer.

4. All samples will be logged; visually described using at a minimum of Unified Soil classification system and a standard color chart as a bsis, field tested (including a head space analysis, and labelled and packed according to EPA specified guidelines. All sampling equipment shall be steam-cleaned prior to reuse.

5. At the termination of the boring, the well screen and casing shall be installed through the hollow stem of the auger. The well screen and casing shall meet the following criteria:

   a) 2-inch or 1 1/2-inch, flush-joint, Schedule 40 PVC, with manufactured PVC screens.

   b) All joints screw-threaded or riveted; no solvent welded joints permitted.

   c) Well screens with 0.010 inch openings of sufficient length to screen the entire thickenss of the shallow aquifer and two feet above the indicated water table.

   d) A PVC cap or plug placed at the bottom of the well screen.

6. The entire length of the well screen be two feet above the entire length of the well screen (if possible) shall be packed with an appropriate sized material to facilitate hydraulic communication of the well with the adjacent aquifer and to prevent clogging. Pack material should be installed as the augers are withdrawn from the well bore; use of the 1 1/2-inch PVC rathre than the 2-inch PVC facilitates placement of the pack material, while minimizing clogging or bridging.

7. Approximately two feet of pure, high sodium bentonite will be placed above the pack material and the remainde of the well bore grouted back to approximately 2 feet (as permissible by the total well depth) below the surface with a non-shrink bentonite-cement grout (ASTM ).



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8. A 6-inch protective steel casing with lockable cap will be installed around the PVC casing into the annular space left above the grout, and cemented in place.

   A 3 foot by 3 foot 6-inch concrete pad around and sloping away from the steel casing will be included. Cement will be placed between the protective steel casing and the inner PVC casing from the bottom of the annualr space to the level of the pad. Three protective steel pipe barriers will be installed around the pad.

   The barriers will be set at least 2 1/2 feet deep in concrete and filled with concrete to the upper edge.

   These barriers will extend 3 feet above the ground surface at a minimum and pointed with implement grade yellow paint.

9. The proper identification code of the observation well will be permanently affixed to the protective steel casing.

10. No wells shall be developed to a condition in which the produced groundwater from the drilling mud and the surrounding format. is free of turbidity and sedimentary particles by pumping, surging or air lifting as appropriate. Development shall be for a minimum of four hours. All water produced during development of the wells shall be collected and stored for proper disposal.

11. The location of the wells shall be surveyed to the nearest 0.01 foot; the ground surface at the well and casing stick-up shall be surveyed to the nearest 0.1 foot and a permanent makr affixed to the casing for subsequent consistent measurement of water levels.

12. The site will be cleaned of all residual drilling materials and trash, any disposable materials will be stored for proper disposal. All drilling equipment will be thoroughly cleaned prior to transport to the next drill site.

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APPENDIX II - LABORATORY QA/QC PROCEDURES

STANDARD OPERATING PROCEDURES

(BULKY DOCUMENTS PROVIDED ON REQUEST)

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APPENDIX III - STANDARD OPERATING PROCEDURES FOR REM II WORK

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GLASSWARE PREPARATION AND
EQUIPMENT DECONTAMINATION

Rob Palermo

The following sections are contained in this standard operating guideline

A.1.1 General

A.1.2 Metal Analysis

A.1.3 Extractable Organics

A.1.4 Equipment Decontamination

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G.1.1 Split Spoon

Used to obtain a sample 1.75 to 2.5 inches in diameter up to 2.5 feet in continous length. It is advanced ahead of a boring into undisturbed soils. Samples can be readily inspected and changes in lithology noted.

G.1.2 Shelby Tube

Tubes may be coated with lacquer or zinc chromate which may be transfered to a sample, adversely affection chemical analysis. Samples should be removed from tubes and placed in sample containers as soon as possible. If contamination from the instrument is suspected 1/2 to 1 inch of the outer surface should be scraped off.

G.1.3 Thin Wall Tube

Sampler is pressed or driven into soils without rotation resulting in a nearly undisturbed sample 1.875 to 2 inches in diameter, 2 to 3 feet long. The tube must be allowed to remain in the boring for 10 to 15 minutes to allow build up of skin friction prior to removal. The sampler is then rotated to shear off the soil beneath below and is carefully removed. Disturbed soils from either end of the tube should be removed and the sample logged. Samples obtained for votitile halogenated organic analysis must be promptly removed from sample tubes. Other samples may be sealed with 3 - 1/4 inch successive layer of liquid wax such as Socony vacuum product 2300. Wax is poured into both ends and each successive layer allowed to dry. The remainder of space is filled with Ottawa sand or a similiar product and capped with plastic caps. The tubes must be layered top and bottom noting the depth range and sample location.

GROUNDWATER SAMPLING PROTOCOL

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SURFACE WATER SAMPLING METHODS

John Adams

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E.1 Sample Procurement

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E.1.2 Bailer Decontamination
E.1.3 Bailer String or Line

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## C.1 Sampling Locations

Surface water sampling locations are selected on the basis of their probability for showing contaminants migrating from a site. Prior to sampling the "Initial Site Characterization" must establish site drainage patterns. Topographic maps, river basin studies and air photos may be used to establish and confirm these evaluations.

Sample locations are chosen on the basis of those points most likely to be receiving runoff or leachate from known or suspected areas of contamination. These areas may include rivers, brooks or streams running through or adjacent to a site, including those bodies of water which may receive surface runoff or leachate from a site. In addition, background samples upstream from a site should always be taken in order to establish ambient water quality in an area.

In some instances leachate may "break out" of slopes down gradient from burial sites. In these cases an attempt should be made to obtain a sample of the leachate.

The number of sampling locations is dependent on many site characteristics. The "Initial Site Characterization" may estimate the number of samples locations however the field team must always provide the final determination of exact locations and required samples.

## D.1 Field Measurements and Observations

A number of measurements and observations should be made in the field at the time of sampling. Record this information in the field log book with the appropriate sampling point data to locate them on a site plan and return to the same location for future sampling if required.

The measurements and observations are critical for interpretation of laboratory data. The following list of measurements and observation represent a minimum requirement for surface water samples.

The following sections are contained in this standard operating guideline:

A.1 Objective

B.1 Preliminary Sampling Checks

C.1 Field Measurements

D.1 Purging Methods

F.1 Municipal, Domestic, Barcad, Packers, Multi-level Type Monitoring Systems

G.1 Decontamination of Sampling Equipment

H.1 Equipment List

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A.1 Objective

To establish and define appropriate field methods dealing with the acquisition of groundwater samples at hazardous waste sites.

B.1 Preliminary Sampling Checks

The following field checks should be performed prior to sample procurement:

B.1.1 Casing Integrity - Evaluate the casing integrity. Is the casing bent or damaged? Identify and note the type of casing material used and casing diameter (i.e., PVC, stainless steel, etc.).

B.1.2 Well Security - Is the well properly secured with a security cover and a lock. Are there any distinguishing features on the well (i.e. number, tags, etc.).

B.1.3 Well Information - Obtain whatever information is available regarding well characteristics. Pumping rates, static water level, total depth, casing elevation, screened depth, well logs should all be obtained if and whenever possible.

C.1 Field Measurements

The following field measurement should be undertaken prior to sampling:

C.1.1 Well Parameters - Establish well casing diameter, static water level and depth of the well. Do not use a measuring device which employs large weights. If this becomes necessary resulting from deeper measurements then adjustments will have to be made for displacement of water which would otherwise invalidate the measurement. A minimum of 3 sample volumes must be removed, or the well should be purged dry before a sample is obtained for chemical analyses. In either case the amount of water removed from the well should be recorded. The well should be allowed to completely recover before the sample is taken. Then determine purge volume based on the following formula:

$$V = TR^2(.163)3$$

where:

V = calculated purge in gallons

T = measured water column elevation or linear thickness of water table (feet)

R = inside well casing radius (inches)

.163 = derived constant

3 = total volume multiplier

C.1.2 Purge Methods - Establish method of measuring purged discharge. A flow meter, a graduated measuring device or a manometer to measure fluid pressure can be used to measure the required purge volume. For large discharge volumes a flow meter or manometer would be the preferred method.

C.1.3 pH/conductivity/temperature - this information should be recorded during well evacuation. These measurements are indicators of the degree of groundwater contamination. Measurements should be taken from a container or collection pail collected specifically for that purpose. Measurements described herein should never be taken from sample glassware.

C.1.4 Groundwater characteristics - note the color, turbidity, and odor of the water.

C.1.5 Weather conditions - note ambient air temperature and recent rainfall or drought occurrence(s).

D.1 Purging Methods

Determine the best method of evacuating the well.

D.1.1 Portable motor driven centrifugal pump - recommended for shallow wells (less than 13 feet) where large purge volumes are required.

D.1.2 Peristaltic pump - low discharge rate but is very portable. Recommended for shallow wells only.

D.1.3 Air or Inert Gas Pumps - low discharge rate and not very portable but is recommended for deeper wells.

D.1.4 PVC or stainless steel bailers - recommended for shallow wells with low purge volumes.

D.1.5 Electric submersible pump - recommended for deep wells where large purge volumes are required. Discharge rate and water levels should be closely monitored. If water level drops rapidly or discharge rate significantly decreases purping should be stopped immediately. This may be caused by the intake screen being blocked or poor well yield. Continued operation may cause damage to pump mechanism.

E.1 Sample Procurement - The water level should be recorded previous to sampling for comparison with the static water level previous to purging the well.

E.1.1 Bailer Composition - A stainless steel bailer should be used to obtain the sample. Two bailer volumes should be wasted before sample collection.

E.1.2 Bailer Decontamination - Bailer should be decontaminated or cleaned with a water-miscible organic solvent (i.e. acetone, methanol, hexane) followed by a thorough distilled water wash. The bailer should then be wiped dry with paper towels.

E.1.3 Bailer Line - The line used to lower the bailer down into the well should be wasted after samples have been obtained. The composition of the material should have low water absorbent properties (i.e. nylon monofilament fishing line >60 lb test).

F.1 Municipal, Domestic, Barcad/Multi-Level Type Monitoring Systems

F.1.1 Domestic Well - allow cold water tap to run for three minutes. If possible collect sample before it enters a collection tank or conditioning equipment. If this is not possible make note of what the exact conditions were. Note sample location (i.e., basement, kitchen sink, etc.).

F.1.2 Municipal Well - allow cold water tap to run for three minutes. Collect the sample before it undergoes any treatment or filtration. Make note of the location from where the sample is taken.

F.1.3 Barcad/multi level type monitoring systems - sampling from this type of apparatus requires special equipment and attachments (i.e., gas cylinders, pressure gauges, high density polyethylene tubing, etc.). Contact the appropriate firm or equipment manufacture regarding specific sampling requirements.

G.1 Decontamination of Sampling Equipment

G.1.1 Equipment - Any equipment used in sampling and/or purging a well which is not expendable and is to be reused must be properly decontaminated.

This includes bailers, pumping hose, water level indicators, water level sounding equipment, pH, specific conductance meters, thermometers, etc....

G.1.2 Decontamination Solutions - A reagent grade methanol ($CH_3OH$) or acetone ($CH_3COCH_3$) wash followed by a distilled water rinse will sufficiently clean equipment. If the bailer is grossly contaminated with petroleum products and

oil residues other solvents should be considered (i.e., hexane). Refer to Standard Operating Procedure on Glassware Preparation and Equipment Decontamination.

## H.1 Equipment List

- sample glassware
- sample preservatives
- glassware for field duplicates and field blanks
- monitoring well keys
- pipe wrench
- propane torch
- hammer
- tape measure (steel)
- water level indicator
- pocket calculator
- pump or pumps
- stainless steel, teflon or PVC
- nylon-monofilament line (for bailing)
- decon solution (i.e. methanol and distilled water)
- measuring pail (for purging)
- thermometer
- pH meter
- conductivity meter
- field logbook
- camera, sample tags, chain-of-custody forms, waterproof ink pen

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G.1.1 Split Spoon

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G.1 Borehole Sampling Techniques (Cont'd)

G.1.2 Shelby Tube
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H.1 Equipment

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## A.1 Introduction

Soil samples are obtained to determine the physical and/or chemical property of soil particles and assoicated interestitial materials. Selection of the optimum sampling technique and equipment to be used for obtaining soil samples will depend on the field conditions, amount of sample require and desired depth of sampling. In addition, the sample purpose (i.e. for physcial and/or chemical analysis) must also be considered. Larger sample volumes may be required if both physical and chemical analysis are to be performed or split samples are to be sent to duplicate laboratories.

Chemical analysis of soil samples provides information on the exsistence and extent of contaminant migration. The adsorption and reactivity of contaminants with these materials may also be established. The analysis and physical characterization should assist in evaluating role soil types influence the migration of contaminants.

It is important to determine, prior to sampling, whether the speciments are to be treated as hazardous or environmental samples. This should be established during the preliminary assesment and initial site inspection. If there is any doubt as to the toxicity of the samles they should always be treated as hazardous.

Samplers should never be forced into an abruptly hard material. Do not puncture any containment vessels. This may cause contaminants to leak, explosions and/or unwarrented exposure of the sampling team, the public and the environment to hazardous materials. If such an object is encountered its location should be properly noted in the lob book. Never smell or taste a sample to determine its chemical or physical properties.

## B.1 Sampling Considerations

A. Sample depth
B. Sample quantity
C. Sample analysis

C.1 Sample Containers

The most common sample containers are 8-10 oz. wide mouth jars with tephlon lined screw caps. If hazardous materials are to be sampled the containers should consist of no metal or reactive parts. Containers should be washed with detergent and rinsed with organic free water. If inorganic analysis are to be performed the final rinse should be with distilled or deionized water. If any questions arise concerning the type and size of sample containers to be used, the laboratory performing the analysis should be consulted.

D.1 Soil Sampling Log

A complete log must be maintianed for all samples collected. It should contain a detailed description of soils encountered during the sampling events. In addition, all pertinent weather data should be recorded for each day or if the weather changes during the day. Data to be recorded should include:

A. Horizon
B. Color utilizing Monsell color notation
C. Texture utilizing USDA or unified classification system
D. Density (standard penetration) or consistency
E. Odor
F. Relative moisture content
G. Weather

1. Temperature
2. Wind Speed
3. Precipitation

H. A sketch of sample locations should be made in the log book or included on the site plan.

## E.1 Sample Location

General sampling areas should be identified in the work plan, however the exact sampling locations and horizons should be left to the discretion of field personnel performing the sampling procedures. Areas where evidence of spills and leaks have occurred should be sampled. These sites may be defined by an include:

A. Areas of stained or discolored soils
B. Anomalous areas of vegitation
C. Areas where site records or photographs indicate the possibility or presence of a spill.
D. Areas were overtopping of a dike or dikes is apparent

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The total study area may be divided into a grid system and a number of sample grids can be randomly selected in an effort to characterize a site. In some studies it may be permissible to mix soils from a number of grids creating a composit sample.

In investigations attempting to establish a relationship between soils and a ground water sample the soil sample should be taken as closely as possible to the location where the groundwater sample was obtained. If this is not possible soils should be taken directly up gradient or in drainage channels as close to the water sampling location as possible.

In all investigations, soil samples should be obtained off site and upgradient from areas of contamination in an attempt to establish background information.

## F.1 Surface and Shallow Subsurface Sampling Techniques and Equipment

### F.1.1 Stainless Steel Scoops, Hand Trowels and Shovels

These maybe used to sample from the surface to about six feet in depth. If a composit sample is to be obtained it can be mixed in a shallow high density

polyethylene pan, lined with aluminum foil. Stainless steel seives may be used to remove larger rock fragments.

F.1.2 Slotted Sampling Trier

Sample depth capability - 2.5 to 3 feet depending upon soil conditions. Samplers range in diameter from 1 to 2 inches. They allow for visual inspection of the specimen before it is placed into a sample container.

F.1.3 Hand Auger

Sample depth capability - 4 to 5 feet generally 1 to 1/2 inches in diameter. Soil sample mixes during the procedure destroying soil cohesion, structure and stratigraphy.

F.1.4 Hollow Stem Hand Auger

Sample depth capability - 3 to 4 feet may be used to obtain a small sample for soil logging or chemical analysis. Liner tubes may be constructed of brass, plastic or inert materials in which samples may be stored for transport or transfered to an appropriate sample container.

F.1.5 Hand Driver Split Spoon

Sample depth capability - 5 plus feet allows for collection and visual inspection of an undisturbed soil sample. Use is very dependent on soil types.

F.1.6 Hand Driven Hollow Stem Sampler

Sample depth capability - to 16 feet allows for visual inspection of an undisturbed soil sample. Samplers range from 1/2 to 3 inches in diameter. The larger the diameter the more depth limited the device is by soil type.

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F.1.7 Bucket Auger

Sample depth capability - 4 feet the samplers range from 3 to 4 inches in diameter and collects a disturbed sample from soils containing fine gravel and smaller fractions. It may be used to obtain samples in saturated soils.

F.1.8 Test Pits

Sample depth capability - 5 to 10 feet pits are generally dug with back hoes equipped with front end loaders. Samples are collected with a stainless steel trowel or shovel. Pits deeper than 5 feet should not be entered unless property brased. Pits displaying slumps or cracks in head walls should not be entered. Fences should be erected around the perimeter for accident prevention. Pits should be filled in as soon as possible.

The advantages of these techniques are their low equipment and the rapid aquisition of samples. The disadvantags are that small sample volumes are generally collected, which are typically disturbed and may not be suitable for laboratory analysis. In addition, these techniques are restricted to shallow depth and are very dependent on the rock content in soils.

G.1 Borehole Sampling Techniques

The advantages of borehole sampling include the increased depth capability and the aquisition of a soil sample from a known depth. The information derrived from these processes may be used to evaluate the site characteristics, detect the presence of any containants and evaluate the potential for polution migration. Techniques used to advance the boring include wash boring, auger boring and rotary drilling. Samples can be obtained at predetermined depths or intervals, at every change in lithology or continously.

G.1.1 Split Spoon

Used to obtain a sample 1.75 to 2.5 inches in diameter up to 2.5 feet in continous length. It is advanced ahead of a boring into undisturbed soils. Samples can be readily inspected and changes in lithology noted.

G.1.2 Shelby Tube

Tubes may be coated with lacquer or zinc chromate which may be transfered to a sample, adversely affection chemical analysis. Samples should be removed from tubes and placed in sample containers as soon as possible. If contamination from the instrument is suspected 1/2 to 1 inch of the outer surface should be scraped off.

G.1.3 Thin Wall Tube

Sampler is pressed or driven into soils without rotation resulting in a nearly undisturbed sample 1.875 to 2 inches in diameter, 2 to 3 feet long. The tube must be allowed to remain in the boring for 10 to 15 minutes to allow build up of skin friction prior to removal. The sampler is then rotated to shear off the soil beneath below and is carefully removed. Disturbed soils from either end of the tube should be removed and the sample logged. Samples obtained for votitile halogenated organic analysis must be promptly removed from sample tubes. Other samples may be sealed with 3 - 1/4 inch successive layer of liquid wax such as Socony vacuum product 2300. Wax is poured into both ends and each successive layer allowed to dry. The remainder of space is filled with Ottawa sand or a similiar product and capped with plastic caps. The tubes must be layered top and bottom noting the depth range and sample location.

## C.1 Sampling Locations

Surface water sampling locations are selected on the basis of their probability for showing contaminants migrating from a site. Prior to sampling the "Initial Site Characterization" must establish site drainage patterns. Topographic maps, river basin studies and air photos may be used to establish and confirm these evaluations.

Sample locations are chosen on the basis of those points most likely to be receiving runoff or leachate from known or suspected areas of contamination. These areas may include rivers, brooks or streams running through or adjacent to a site, including those bodies of water which may receive surface runoff or leachate from a site. In addition, background samples upstream from a site should always be taken in order to establish ambient water quality in an area.

In some instances leachate may "break out" of slopes down gradient from burial sites. In these cases an attempt should be made to obtain a sample of the leachate.

The number of sampling locations is dependent on many site characteristics. The "Initial Site Characterization" may estimate the number of samples locations however the field team must always provide the final determination of exact locations and required samples.

## D.1 Field Measurements and Observations

A number of measurements and observations should be made in the field at the time of sampling. Record this information in the field log book with the appropriate sampling point data to locate them on a site plan and return to the same location for future sampling if required.

The measurements and observations are critical for interpretation of laboratory data. The following list of measurements and observation represent a minimum requirement for surface water samples.

## A.1 Introduction

Surface water samples are obtained to determine the quality of surface water entering, leaving or affected by a site. These surface water bodies may include streams, rivers, lakes, ponds or impoundments either located on site or in close proximately to a site. Although surface water samples are generally diluted they may contain sufficient quantities of contaminants to be considered hazardous samples.

The "Initial Site Characterization" should determine the contaminants expected to be present. This is necessary so that proper sampling techniques, containers and preservation is employed during the sampling process. In addition, specific safety precautions may be required for various contaminants.

Either grab or composite samples may be collected. Grab samples are collected at one particular point and time. Flow- or time-weighted composite samples are composed of more than one aliquot collected at various sampling sites and/or at different points in time. Because of the unknown safety risks, as well as the changes in chemical nature of the sample that may occur through compositing, samples containing hazardous materials at significant concentrations shall not be composited. Environmental samples containing low levels of toxics may be composited however, as described in the site specific sampling and analytical plan.

Visual indicators of high concentration include coloration, turbidity, odor, multiphasic layering and spontaneous formation of precipitates.

## B.1 Containers

The chemical constituents for which the samples will be analyzed dictates the type of container, cleaning and preservation method used. This can be determined from previous sample results or a review of site handling, storage and/or disposal records. The enclosed table provides information concerning container type, duplicates, volume, cleaning, preservation and maximum holding times for selected types of analysis.

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3. Turbidity.
4. Multiphasic layering.
5. Spontaneous formation of precipitates.

J. Stream Characteristics - fast running and mixing with leachate or slow moving to stagnant.

K. Evidence of Dead Vegetation of Animals

E.1 Sampling Techniques

Most samples are considered grab samples, however some variations may be made to obtain a vertical or horizontal composite sample. The container is immersed in the stream or lake upside down. By tipping the container, water is allowed to displace the air. If the container is raise and lowered, or moved to one side or to the other as it is being righted, a composite of that section will be taken. In addition, care should be taken not to collect any surface scum as the container is lowered into the water. Following are some tips which may result in more representative samples being obtained.

A. The most representative sample from a well mixed stream is obtained from mid-channel at 0.6 total depth.

B. Zones of varying degrees of contamination may exist in areas of stagnation. The concentrations may be dependent on the physical/chemical properties of the contaminant.

C. Sample containers should be rinsed with water from the area to be sampled even though they have been cleaned in the laboratory.

D. When sampling fast running streams it is suggested to start at the farthest point downstream and work upstream. This will result in collecting increasing levels of contaminants and less sediment in samples from stream bed agitation.

SURFACE WATER SAMPLING METHODS

John Adams

A. Sample location, identification number, date and time

B. Water temperature at the point and time of sampling

C. pH of water sampled - do not immerse indicator paper of electrodes in samples to be sent to the laboratory. Either duplicate samples may be obtained for field measurements or in-situ measurements may be taken if the appropriate equipment or sampling condition is present.

D. Dissolved oxygen content of water sample

E. Depth of stream or pond-average and at sample point

F. Velocity of stream estimated from a floating object

G. Flow rate of stream. The cross sectional area (A) may be estimated as a triangle with its width (w) and depth at its deepest point (d).

$$A = 1/2\ wd$$

The cross sectional area may then be mulitplied by the velocity to derive a rough flow rate.

H. Weather Conditions

1. Air temperature.
2. Sky condition.
3. Recent precipitation or drought.

I. Observable Physical Characteristics

1. Odor.
2. Color.

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SURFACE WATER SAMPLING METHODS

John Adams

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E. Samples should not be agitated, especially if volatile analysis are to be performed.

G. When obtaining 40 ml samples for volatiles take care to exclude air bubbles from the sample.

F.1 Sample Equipment

The sample container will generally serve as the sampling device, however, in some instances special sampling equipment is required. When a sampling device is used it should be cleaned utilizing the same methods as are employed when cleaning sample containers. The following list contains suggestd equipment to be available to the field team for use during surface water sampling.

A. Appropriate sample containers.
B. Sample preservative.
C. Cooler with ice.
D. Field blanks.
E. Telescoping aluminum pole with clamp and teflon beaker
F. Thermometer
H. Field log book
I. Camera and film
J. Sample tags, chain of custody forms, receipt for sample forms and waterproof pen.

Proper preparation, sampling and preservation techniques must be followed to attain maximum efficiency in sampling operations. Potential sample locations should be predetermined in an effort to minimize lost time by the field team. Finally, the health and safety plan must be complied with to minimize the risk to the field team.

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SEDIMENT SAMPLING

John Adams

## A.1 Objective

Sediment samples are obtained to determine the chemical and/or physical nature of sediments and associated interstitial materials. Interpretation of the resulting data may establish the relationship between the sediments, surface water and groundwater. The type of sampling device, preservation technique and transport container to be used is dependent on the analyses to be performed on the sample.

## B.1 Introduction

Sediment sampling is a valuable tool for locating the presence of low water solubility and/or high sediment binding affinity contaminants. Pollutants with high binding affinities may be transported on suspended sediment particles and deposited some distance from its source. Contaminants with low water solubility are more likely to be deposited closer to a source. Heavy metals and high molecular weight halogenated organics are examples of compounds which may be present in very different concentrations in sediments than in the water column.

Geohydrologic consideration should be given to the relationship between the contaminant source and presence in the sediments. Factor including the influent or effluent nature of a stream and whether the surface water or groundwater is the source of contamination must be examined.

Several samples must be obtained from areas of expected contamination. Areas to be sampled may be separated into grids and samples obtained from each grid or randomly selected to characterize the sediments.

In addition, upstream samples should be obtained to determine the ambient water and sediment quality. All efforts must be taken to minimize the effects of dilution and loss of materials as the sample is moved through the water column.

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When sediment sampling is done from a boat or other floatation device particular precautions must be taken to insure the safety of those involved. A minimum of two individuals should undertake the sampling and a third party sgould remain on shore in visual contact with the operation. The individuals doing the sampling must wear life preservers in addition to any other level of protection prescribed by the health and safety coordinator.

C.1 Sample Containers

The most common sample containers are 8-10 oz. wide mouth jars with teflon lined screw caps. If hazardous materials are to be sampled the countainers should consist of no metal or reactive parts. Containers should be washed with detergent and rinsed with organic free water. If inorganic analysis are to be performed the final rinse should be with distilled or deionized water. If any questions arise concerning the type and size of sample containers to be used, the laboratory performing the analysis should be consulted.

D.1 Sampling Equipment and Techniques

A number of field measurements and analyses must be conducted and their results recorded in the field log book. This information must include the sample identification number, location (with tie lines if possible), depth, horizon, temperature and pH at the sediment-water interface, sample setting (fast running or stagnant water) and sample description. The site Plan of Operations may call for additional measurements to supplement this information.

In the following sections, sediment samplers and their uses are described.

D.1.1 Sample Container

In the simplest situations the sample container may be used to scoop or scrape a sediment sample from small streams or near shore. Care should be taken to provide a clean surface for the cap to contact the jar.

D.1.2 Dip Sampler

A dip sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

The dip sampler is operated by submerging the jar or scoop and pulling it through the sediments to be sampled. The samples retrieved are then transferred into the appropriate sample cntainer by decanting liquid phase and retaining the sediments.

D.1.3 Hand Operated Core Samplers

Hand operated sediment core samplers are used to obtain sediment samples in shallow water (<3 ft). These samplers operate in a manner similar to that described for soil core samplers. However because of the saturated conditions of sediments, provisions must be provided so that the sample is retained within the core. Core samplers are generally constructed of an outer rigid metal tube into which a 2 inch ID plastic core sleeve fits with minimal clearance. The cutting edge of the core sampler has a recessed lip on which the plastic sleeve rests and which accomodates a plastic nest. This nest is oriented such that when the sampler is pressed into the sediment, the core is free to move past the nest. Due to construction of the nest, the core will not fall through the nest upon removal of the sampler from the sediment.

When the sampler is removed from the sediment, the plastic sleeve is removed sealed and labeled. Core sleeves should be sealed by packing ends with clean sand and placing plastic caps secured with friction tape over ends. Care should be taken in handling samples and the orientation of the sample core shall be indicated on the sleeve.

Because core sleeves and nests are generally made of plastic, special provisions should be made if samples are to be tested for chlorinated organics.

The land operated core sampler will not be useful for obtaining samples of gravelly, stoney or consolidated sediments.

D.1.4 Gravity Core Samplers

Gravity core samplers are used to obtain sediment samples in water bodies or lagoons with depths of greater than 3 to 5 feet. These types of samplers can be used for collecting 1 to 2 foot cores with a 2 inch ID, of surface sediments at depths of up to 100 feet beneath the water surface.

As with all core type samplers, they are not suitable for obtaining samples of coarse - gravelly, stoney, or consolidated deposits. They are, however, useful for fine grained inorganic and organic sediment sampling.

The gravity core sampler operates in a manner similar to the hand operated core in that a plastic sleeve of 2 inch ID fits within a metal core housing fitted with a cutting edge. Plastic nests are used tor etain the core within the plastic sleeve. An opening exists above the core sleeve to allow free flow of water into and through the core as it moves vertically downward to the sediment. The sampler has a messenger-activated valve assembly which seals the opening above the plastic sleeve followign sediment penetration. This valve is activated by the messenger creating a partial vacuum to assist in sample retention during retrieval.

Samples are obtained by allowing the sampler which is attached to approximately 100 feet of aircraft cable to drop to the benthic deposits. The weight of the sampler drives to core into the sediment to vary depths depending on the characteristics of the sediments. The messenger is then dropped on tha taut aircraft cable to seal the opening above the plastic sleeve. The sampler is then carefully retrieved.

Upon retrieval of the sampler, the plastic core sleeve is removed and void spaces at either end packed with clear sand. The sample is then sealed with plastic caps attached using friction tape. Care should be exercized in labeling in order to properly identify sample orientation.

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D.1.5 Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices or when large quantities of materials are required. Various dredge designs are available for sampling in deep or turbulent waters and for obtaining samples from gravelly, stoney or dense deposits.

Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a messenger.

Dredges are commonly quite heavy and therefore require use of a winch and crane assembly for sample retrieval.

Upon retrieval of the dredge, the sample can either be sieved or transfered directly to a sample container for labeling and storage.

Dredge types which could be used for sampling include Ponar, Petersen and Ekman dredges.

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MONITORING WELL INSTALLATION

Rob Palermo

The following sections are contained in this standard operating guideline:

A.1 General

B.1 Locating the Well

C.1 Materials Used in Well Construction

D.1 Design of the Well

E.1 Well Types

F.1 Drilling Techniques

G.1 Well Installation

H.1 Developing the Well

I.1 Other Considerations

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## A.1 General

Groundwater monitoring systems should be selected based upon specific study objectives. The type, arrangement, and configuration of the monitoring well-network should address the specific requirement of the project. Vertical and horizontal extent of contamination, aquifer characteristics, rate, magnitude, and direction of contaminated flow, movement of various pollutants within the aquifer or aquifers, are some of the usual hydrogeological factors taken into consideration when planning a water quality monitoring program.

It is essential that the monitoring program be well thought out and planned by a competent hydrogeologist so that the desired results are obtained. There are several factors which must be taken in mind, such as, siting of the wells, materials used, well design, well development, various drilling techniques, etc. Some of these factors will be determined by and dependent upon the information which you are attempting to secure. For example, it may be determined that a 6" well would be more appropriate than a 4" well because it would better define the boundary conditions of a high yield aquifer, yet, most disposal sites are underlain by low yield aquifers. Also, a 6" well might serve a dual purpose for both monitoring and contaminant removal acting also as a barrier well at some later point in time if properly located.

The objective of this guideline is to define a general technical approach in the selection and design of a groundwater monitoring system and to spell out what constitutes a well planned monitoring program. The emphasis of this documentation concerns itself with the monitoring of hazardous wastes on or at potential hazardous waste sites.

### A.1.1 Legal and Regulatory Considerations

The selected groundwater monitoring program should be in agreement with existing state and federal requirements. Well specifications and construction procedures should comply with all existing regulatory requirements.

Also, the municipality's Department of Public Works and all appropriate utility companies should be consulted in an attempt to locate buried pipe lines, sewers, and power cables etc., located in the vicinity of the drilling.

Permission should be obtained, preferably in writting from all property owners before any wells are located on or around the periphery of the site.

## B.1 Locating the Well

Before any wells can be sited a preliminary hydrogeologic review should be conducted. Existing data regarding the geology of the site, topography and other surficial features should be investigated. An exhaustive background information search should be undertaken in an attempt to secure all site specific information. Sampling data, geological reports, engineering reports, geophysical studies should all be obtained and reviewed prior to well siting since this information will assist in positioning the wells. The hydraulic gradient, saturated thickness, depth to bedrock, confining soil layers are some of the parameters which will determine well location and depth. If groundwater gradient data is not already available for the area in question, it may prove necessary to install piezometers to monitor flow direction.

The screened depth of the well provides information not only on the vertical distribution of heads but also information relative to the vertical distribution of contaminants in the well. In general wells drilled and isolated in bedrock should be set at least 20 feet into bedrock. Should deeper weather bedrock zones be identified by geophysical investigations then the well should advance to deeper levels. In the overburden materials the screened depth of the well will be determined by evaluating the specific levels in the saturated zone for which that contaminant would be found. For example, compounds lighter than water (such as hydrocarbons) will be found at the top of the saturated zone while compounds with specific gravities heavier than water migrate vertically through the saturated zone.

The vertical positioning of the well screen is critical if the groundwater quality is to be accurately quantified. Groundwater quality within the saturated zone will vary due to the stratification of the contaminant water, variations in permeability, and confining clay or silt deposits acting to redirect or divert flow. If the vertical distribution of hydraulic heads and the concentrations of constituents present are desired, a multi level monitoring system is recommended.

The geographic locations of the wells are determined by study objectives. For example, the study area might encompass a large watershed boundary or on the other hand, may be more localized and confined to a specific landfill site.

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C.1 Materials Used in Well Construction

Well casings are specified by diameter, type of casing, and nominal thickness of the pipe. The thickness of the pipe is determined by the appropriate schedule, for most groundwater monitoring system PVC, schedule 40 or 80 is used.

Stainless or galvanized steel casing wall thickness is specified by pipe wall gauge thickness. Usually standard strength is adequate for most groundwater monitoring. Pipe distributors generally carry only one wall thickness. As a general rule, the wider the casing diameter the thicker the casing needs to be to prevent deformation of the pipe.

The type of construction material used depends upon the selected drilling method, contamination present, and water quality and depth. Well materials can contribute to as much as 32% of the drilling program costs if stainless steel is used and approximately 12% if PVC is used. Commonly used materials are PVC, galvanized steel, stainless steel and teflon, of these the two most widely used are PVC and steel. Teflon is the more preferred casing material but it is very expensive and cost approximately 3 times that of stainless steel. Thus the choice of the well material does have a significant cost impact.

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Cost alone should not preclude the use of a certain material. The final ruling should be determined by the conditions governing selection of the pipe. For example, metal pipes will corrode and release metal ions or chemically react with the organic contaminants. Inorganic analysis of this well water might reveal elevated levels of cadmium and zinc and inversely organic analysis revealing lower than actual levels. PVC is believed to react with ketones, aromatics, and alkyl sulfides yet has many advantages since it is readily available in all sizes, is light weight, low cost, easily handled, and when schedule 80 is used has a good crushing strength. It is recommended that whenever PVC is used the pipe joints should be threaded, no glue or adhesives should ever be used to join the pipe sections.

## D.1 Design of the Well

### D.1.1 Casing and Borehole Diameter

For groundwater monitoring usually 2" or 4" diameter wells are installed. An important consideration in selecting the right well diameter is the size of the equipment the well will have to accommodate. When the depth to water exceeds 25 feet the use of a electric submersible pump to purge the well would probably be used. The smallest commercial pump of this kind on the market requires at least a 2" inside well diameter to accommodate the lowering of the submersible, yet, if the casing is too large, purge volumes will be overly excessive.

Two or four inch diameter wells reduce the volume of stagnent water in the water column which reduce costs and the water table stabilizes more readily, while providing good representatives samples from the aquifer.

A bench mark should be established and the elevation of each well casing surveyed to an accuracy of 0.01 of a foot.

### D.1.2 Casing, Screen Dimensions and Materials

The purpose of the well screen is to allow water to enter the well without permiting

the intrusion of large amounts of sediments. The selected slot size of the screen is determined by evaluating the grain size of the formation and filter packing material. For most applications a 0.010 inch slot size with a gravel pack for a fine grained unconsolidated formation is recommended. The screen should not pass more than 5-10 percent of the surrounding pack or in-situ materials. The filter pack will minimize the entry of the finer grained soils into the well and subsequently allow the use of larger screen slot sizes thereby increasing the water collection ability through the screen. The filter packing media should be composed of an inert material (i.e., 60/40 Ottawa sand) and should extend above the screen elevation at a distance of at least 10 percent of the screen length. This will help prevent the settling of overyling annular fill material into the filter packing. Packing emplacement is a delicate procedure and consideration should be given to prevent bridging of the material in the annulus. When possible the filter packing material should be deposited by the use of a tremie pipe with water to help drive the material through the pipe outlet.

### D.1.3 Drilling Muds

Bentonite or other clay drilling muds should not be used when constructing a well for which metal analysis will be performed on because clays have the capacity to adsorb heavy metal ions. Also, organic polymer drilling muds should not be used for installing wells from which samples will be collected for organic analyses or for the identification of micro-organisms since they add significant amounts of organic materials to the aquifer. Drilling techniques which do not utilize drilling muds (i.e., hollow stem augering or air rotary) should be used whenever possible.

### D.1.4 Annular Backfilling

The annular space above the filter pack and seal is usually grouted with a bentonite, bentonite/cement or cement grout with a shrinkage reducer. The purpose of the grouting is to prevent vertical movement of water into the groundwater intake zone and to help stabilize the well casing. The diameter of the hole into which the casing is placed must be at least large enough to accommodate the casing plus the placement of a grout seal around the outside. Backfill should be placed in the annulus so that a minimum of

1-2" of material exist between the casing and the natural formation material. For overburden wells the annular cavity between the casing and borehole should be backfilled with a 60/40 Ottowa Sand or equal and to an elevation of approximately 1 foot above the top of the screen followed by a 2 foot Bentonite pellet seal. For wells drilled into rock a ten foot injected Bentonite slurry seal (3:1 Bentonite to cement) should be used to seal the well.

D.1.5 Grouting Techniques

Several chemical reactions can occur between the grout and the groundwater. Cement based grouts typically leach calcium, hydroxides, carbonates and bicarbonates. These reactions can include leaching of the grout and a resulting alteration of the groundwater and/or reaction with the groundwater and the grout that can result in an alteration of the physical properties of the grout.

Bentonite pellets formed into balls can be droped into the annular cavity. These pellets are easy to use and require no mixing or tremieing into position. The material is inserted into the well dry and swells to approximately 12 times its original size but this method is only userful when the well depth is shallow with a wide annulus.

Bentonite slurry is another method where powdered bentonite is mixed with water and pumped into the annulus in the form of a slurry. The slurry is emplaced by using a tremie pipe which is lowered to the desired elevation. No swelling occurs since conditioning takes place at the ground surface. A problem exists with the slurry in that the seal which is provided by the slurry has little appreciable strength.

Cement grout can also be mixed at the surface and placed into the borehole by the use of a tremie pipe. Seals comprised of cements are typically strong and exhibit moderate permeability. Bonding between the cement and the borehole is excellent. The preferred mixing ratio is about 5 - 6 gallons of water to a 94 pound pack of cement. Several types of cements should be considered based upon the groundwater characteristic and the expected results. Cements types range from standard to special sulfate resistant, rapid hardening and crack resistant.

A Cement/Bentonite slurry mix requires approximately 6 percent sodium bentonite by weight hydrated at the surface for about one hour. It is then mixed with about 20 percent cement by weight and can then be pumped by a tremie pipe into the borehole. This technique provides excellent formation bonding, developes a strong compressive strength, reduces the likelihood of cracking and is moderately permeable. The inherent disadvantage is of course the leaching of the cement in the slurry but it is considerably less than with pure cement grout.

E.1 Well Types

E.1.1 Single Interval - wells are screened at a specific vertical interval. They are relatively simple to install and inexpensive but will only provide water quality data on the zone or level in the aquifer that it is placed.

E.1.2 Telescoping Wells - are used to penetrate deeper water bearing zones which require that the overlying zone be sealed off in order to prevent cross-contamination from the upper zone into the lower zone. This requires that a large borehole be drilled to accommodate lowering of the casings. The procedure is as follows: a large diameter hole is bored, a casing with an outside diameter of 2 to 4 inches less than the diameter of the hole is centered and set into the grout to provide an effective bottom seal. A bentonite or cement or bentonite/cement grout is then placed in the annulus space to the ground surface. Once the grout has set, the borehole is advanced to the desired depth by drilling or coring inside the installed casing with a bit smaller in diameter than the casing.

E.1.3 Cluster Wells - are a combination of single interval or telescoping wells which are installed in close proximity to one another but screened at various depths. This allows sampling and monitoring of the aquifer(s) at various levels within the same aquifer or from an underlying aquifer separated by a confining layer.

E.1.4 Nested Wells - consist of several well casings installed within a single borehole. The problem with nesting wells is that the likelihood of cross-contamination is high even though attempts are made to seal the well above and below the screen.

Drilling Techniques

F.1.1 Wash Boring - involves advancing the steel casing by driving and washing out the formation material. The casing is hammered into the ground (usually by a drive weight) and the soils are washed out of the casing by water which is pumped into the well. Chopping bits are utilized to loosen the soils prior to washing. This method does not require the use of drilling muds and is recommended when loosely packed glacial deposits (i.e., sand, silts, clays) are encountered. Since the water return is being carried to the surface the potential for volatilization of the organic constituents in the groundwater and cuttings at the breathing zone may constitute an inhalation hazard. Also, it may prove necessary to employ splash protection clothing depending upon the extent and degree of contamination.

F.1.2 Augering

Hollow stem or solid flight helical augers are advanced hydraulically through the unconsolidated deposits. This method is fast, does not use drilling fluids and can be used in saturated or unsaturated soils. Usually the auger sections are about 5 feet long and are joined together by a key and bolt. A removable plug attached to an equal length of rod goes down with the auger to prevent soil from moving into the auger casing. When the augers reach a saturated thickness in sands, water is then poured into the auger casing before the plug is removed to prevent the formation material from being washed into the casing.

F.1.3 Hydraulic Rotary Drilling

The borehole is excavated by the rotation of a drag or roller bit and by circulation of a drilling fluid to the bottom of the borehole to retrieve drilled cuttings. The drill bit is attached to a drill stem and rotated at the ground surface as a drilling mud is circulated down the drill stem and out the bit then up the annular cavity between the borehole and the drill stem. Usually, a mud pit or tank are used to collect the settled cuttings. It may prove necessary to use casing to keep the borehole from collapsing in loose formation materials but in most cases a well casing is not employed

during drilling. The drilling fluid used can be clear water, a water bentonite mixture or a water mixed with a biodegradable organic "mud".

This method allows drilling into all formations at any depth without a casing being required and is relatively inexpensive. Some inherent drawbacks include problems associated with the removal of the drilling muds from the borehole and with their ability to adsorb metals and to interfere with the analyses of other sampling parameters (i.e., bacterial analyses and organic analyses). This method also tends to circulate contaminants. The same health and safety considerations as discussed in section F.1.1 for Wash Borings should also be applied here for this method (i.e., air quality monitoring, splash protection, etc.).

F.1.4 Air Rotary

This method is very similar in operation to the hydraulic method except that air is directed down the drill pipe and returns the cuttings up the annular cavity. The major advantage of air rotary drilling is that a drilling mud need not be used; therefore, contamination, dilution or adsorbtion of the formation water is not a concern. Air rotary rigs are readily available at most locations and operate best in hard rock formations. Casing is required to maintain the borehole in soft collapsing formations below the water table.

F.1.5 Jetting

Jetting consists of pumping water or a drilling mud down through a samll diameter pipe. The pipe is usuually fitted with a chisel bit or jetting screen. The formation material is removed by both the bit and jetting action of the water under pressure. Cuttings are removed from the horehole by return flow of the drilling fluid. The disadvantages of this method are that large quantities of water are often used . Also, jetting is only possible in very soft formations. Also, a considerable amount of jetted water is introduced into the formation to be sampled.

## G.1 Well Installation

### G.1.1 Subsurface Soil Sampling

As the drilling proceeds and casing is advanced into the borehole, subsequently, the surrounding soils become disturbed. In order to obtain accurate representation of the soil materials at a specific depth an in-situ soil fraction should be obtained.

### G.1.2 Split Spoon Samples

Split spoon samples are taken at predetermined depths or at every change in strata. Samplers come in various lengths and barrel diameters. The relationship between the hammer driving weight, drop length and blow counts required to advance the split spoon 6 inches (in 6-inch increments) is a function of the density or consistency of the soils. For most applications a 24 inch long, 2 inch outside barrel diameter sampler with a 140 pound drive weight falling 30 inches until either 18 inches have been penetrated or 100 blows have been applied will be used. The sampler should be fitted with a retaining device to prevent loss of saturated non-cohesive samples obtained within the saturated zone.

The sampler must be checked and cleaned before each sample is secured. The cleaning process consist of rinsing the entire sampler with drinking quality water then with methanol, and a final rinse again with water.

Specimens obtained should be preserved in a wide mouth, 8-10 ounce, air tight, glass jar. The jars should be tightly capped (and wrapped in aluminum foil if clays or silts) to preserve the original moisture content. The jars should then be boxed, marked, and identified with legible labels as directed by the CDM field supervisor. Labeling should include the sampling date, well location number, sample number, depth at which the sample was taken, nature of material, blow counts and other comments.

Upon opening the split spoon the soil sample should be immediately screened using a Century Organic Vapor Analyzer (OVA-Model 128). The instrument in the survey mode measures total organic vapors. One 44 ml septum sealed vial will be partially filled with soil for OVA headspace analysis. Injection of headsapce vapors (gas chromatography) will be made with a gas tight syringe onto OVA G-24 column. If the initial survey reading indicates an elevated reading, a chromatrogram will be obtained and recorded on a strip chart recorder. Headspace analysis will be performed on split spooned samples and drilling wash water during the entire length of the drilling program.

Specific procedures are outlined as follows:

(1) Before the first blow is applied check to see if the sampler is below the depth of the casing.

(2) With the sampler positioned at the bottom of the hole, drive the sampler with a 140-lb hammer falling 30 inches until either 18 inches have been penetrated or 100 blows have been delivered.

(3) Blows per 6 inch of penetration will be recorded and are defined as follows:

1st 6" is defined as the seating drive
2nd + 3rd 6" defined as the peneration resistance = N

If the sampler is driven less than 18 inches then N is determined by using the 1st foot of penetration. If less than 1 foot is penetrated, the logs shall note the number of blows and the fraction of 1 foot penetrated.

(4) Open the sampler and perform initial OVA screening as described previously in section G.1.2. Describe the soil according to the Burminster Soil Classification Method section G.1.3, a copy of which is attached and follows this page. The soil composition, structure, consistency, color, and condition should all be recorded. For wells which are suspected to be contaminated

protective clothing, gloves, footware and appropriate respirators should be worn. Refer specifically to the Health and Safety plan which has been developed for that project.

Collect the sample using either a stainless steel scoop or trowel in a 8-10 ounce, air tight, glass jar. If a headspace sample is determined necessary a 44 ml vial should alo be collected at this time.

G.1.3 Soil Classification System

Soil sampling identification will be done using the Burmister Soil Classification System. Classifying soils uniformly and consistency is essential to the analysis of all engineering problems dealing with earth materials. Valuable hydrologic information can be derived from this classification, such as, soil porosity, permeability, transmissivity, vertical extent of deposits, etc. This information can be instrumental in evaluating the movement of contaminants through the saturated and unsaturated zones.

Soils will be described in the field based on visual inspection and by performing some simple tests. Soil classifying systems can be overly detailed and cumbersome and in some cases due to their complexity can produce non-uniform and inconsistent results.

I. Interpretation and Description

1. Soil types - gravel, sand, silt and clay. Most soils contain a mixture of the above with partly decomposed organic material.

2. Soil texture - coarse and fine grained soils can be identified by eye while the finer grained particles require simple testing.

3. Soil properties - coarse grained soils are mineral fragments that may be identified primarily on the basis of particle size, sand and gravel. Finer grained soils are clays and silts. Silts being the coarses portion of

microscropic soils, and possesses little or no plasticity or cohesion. Clays are aggregates of microscopic and submicroscopic flake-shaped crystalline materials. They are plastic, cohesive, and readily adsorbent.

II. Burmister Method

A. Sand and Gravels (estimates by eye)

1. Major Constituent and Minor Percent

| | | |
|---|---|---|
| and | (a.) | 35-50% |
| some | (s.) | 20-35% |
| little | (l.) | 10-20% |
| trace | (t.) | 1-10% |

2. Key word is ESTIMATE

B. Silts and Clays (estimate using tests)

1. DRY STRENGTH (dried on hood on in the sun)
2. DILATANCY or SHAKE TEST (looks at the permeability of fines)
3. TOUGHNESS (plasticity at low water content)
4. USE ALL OF THESE TESTS TO ESTIMATE THE SILT/CLAY FRACTIONS

C. Description

1. Color, grain size range, consistency as adjectives preceeding the major and minor components.

2. Plasticity, minerology, structure follow the main description.

3. Geologic origin/history: fill, till, outwash, peat, etc. are placed after and separated from the main description.

4. Highly heterogeneous soils (varved clay) require special attention.

5. Closer designations can be done using PLUS/MINUS

| Typical Name | Dry Strength | Dilatancy Reaction | Toughness of Plastic Thread |
|---|---|---|---|
| Sandy silt | None to very low | Rapid | Weak to friable |
| Silt | Very low to low | Rapid | Weak to friable |
| Clayey silt | Low to medium | Rapid to slow | Medium |
| Sandy clay | Low to high | Slow to none | Medium |
| Silty clay | Medium to high | Slow to none | Medium |
| Clay | High to very high | None | Tough |
| Organic silt | Low to medium | Slow | Weak to friable |
| Organic clay | Medium to very high | None | Tough |

GENERAL NOTES

Silts, dry sand and gravel mixtures tend to remain on your hand similar to a powder.

The general cohesive/plastic nature of the sample while your removing it from the split-spoon sample.

The consistency of the soil sample is determined from the blow counts as in the table below:

| BLOW COUNT | CONSISTENCY |
|---|---|
| 0-4 | very loose |
| 4-10 | loose |
| 10-30 | medium |
| 30-50 | dense |
| >50 | very dense |

Clay/silt ranges will normally be between CLAY & SILT to Clayey SILT (paper clip to pencil diam. threads).

Silt that feel "gritty" during Dilatancy Tests probably contain fine sands.

## BURMISTER SOIL CLASSIFICATION SYSTEM

### Basic System

The Burmister Classification System is intended only to describe the gradation characteristics and plasticity of the soil.

The first step is to estimate the major constituent of the material and the relative percentages of the lesser soil fractions as broken down in Table I. Note that, in the description, the major constituent (or constituents when using "and") is written entirely in capitals, while with the minor fractions, only the first letter is capitalized. The relative percentages of the lesser sizes are described by "and," "some," "little," and "trace," as described on Table I.

In this system, it is recognized that it is impossible to determine the gradation of the fines passing the No. 200 sieve. Thus, no attempt is made to express the relative percentages of clay and silt sizes in the fines. Rather, the philosophy is merely to estimate the plasticity of the fines and express this in the descriptions shown on Table II. Thus, the description "silty clay" does not mean 70% clay sizes and 30% silt sizes, but means that the fines have a plasticity index of between 20 and 40.

Of greater importance than the plasticity of the fines is the overall plasticity of the soil. This should be mentioned, when necessary, at the end of the gradation description, using the adjectives to define the "Degree of Overall Plasticity" listed on Table II. Note that a soil described as "sand and silt" cannot have any overall plasticity since silt alone is nonplastic. Thus, if the overall soil has some plasticity, the soil description must contain the word "clay" (or clayey").

Refinements in the Basic System

(1) In addition to the gradation and plasticity characteristics, the description should include pertinent adjectives to further define the material. In general, adjectives describing consistency, color, and grain size range should precede the soil component name, while further details, such as plasticity, minerology, structure, etc., should follow the main body of the identification.

Example:

Medium-dense, red-brown, fine to coarse SAND, little fine Gravel, little Clayey Silt. Slight overall plasticity, gravel waterworn, sand subangular.

(2) The Burminster Identification System is only a means to describe the soil -- that is, its characteristics -- such as consistency, color, size, plasticity, structure, etc. Often, it is important to classify the soil in terms of geologic origin and history, such as Fill, Glacial Till, Peat, Outwash, etc. When needed, these terms should be placed after and separate from the main body of the description.

Example:

Gray, coarse to fine SAND, some fine Gravel, little Silty Clay. Slight overall plasticity. TILL.

(3) The Burmister System is intended only to describe uniform soils. When describing a heterogeneous material, such as varved clay, the different layers should be identified and described separately, with reference made to the relative percentages of each constituent.

Example:

Soft, brown CLAY and SILT, alternately layered, medium to high overall plasticity.

Layers: CLAY layers, 3/8" to 5/8" thick, comprise 60%± of sample. SILT layers, 1/8" to 3/8" thick, comprise 40%± of sample. VARVED CLAY and SILT.

## BURMISTER'S SYSTEM OF SOIL IDENTIFICATION

TABLE I -- DEFINITIONS OF TERMS FOR THE IDENTIFICATION OF GRANULAR SOILS
SOILS AFTER BURMISTER, 1950

| (a) DEFINITION OF TERMS IDENTIFYING GRADATION THE COMPOSITION OF GRANULAR SOILS | | | | | | (b) DEFINITION OF TERMS IDENTIFYING OF GRANULAR COMPONENT | | |
|---|---|---|---|---|---|---|---|---|
| Component | Identification | | Proportion Terms[a] | | Defining Ranges of Percentages by Weight | Gradation Designations for Identification | | Defining Proportions |
| | Written | Symbol | Written | Symbol | | As Written | Symbol | |
| Principal Component | GRAVEL | G | | | | coarse to fine or | cf | All fractions greater than 10% of the component, but the medium fraction predominates[b] |
| | SAND | S | | | 50 or more | coarse to medium to fine | cmf | |
| | SILT | S | | | | coarse to medium | cm | Less than 10% fine |

TABLE I -- (Continued)

| (a) DEFINITION OF TERMS IDENTIFYING GRADATION THE COMPOSITION OF GRANULAR SOILS | | | | | | (b) DEFINITION OF TERMS IDENTIFYING OF GRANULAR COMPONENT | | |
|---|---|---|---|---|---|---|---|---|
| Component | Identification | | Proportion Terms[a] | | Defining Ranges of Percentages by Weight | Gradation Designations for Identification | | Defining Proportions |
| | Written | Symbol | Written | Symbol | | As Written | Symbol | |
| Minor Component | GRAVEL | G | and | a. | 35 to 50 | medium to fine | mf | Less than 10% coarse |
| | SAND | S | some | s. | 20 to 35 | medium | m | Less than 10% coarse to fine |
| | SILT | S | little | l. | 10 to 20 | fine | f | Less than 10% coarse to medium |
| | | | trace | t. | 1 to 10 | | | |

(c) Definitions of Identifying Soil Characteristics

General color of the whole soil, preferably moist -- gray (g), brown (b), yellow-brown (yb), red-brown (rb), light gray (lg), medium gray (mg), dark gray (dg),etc.
Maximum particle size of gravel.
Predominating grain shape -- water-worn, subangular, angular, scale-like, etc.
Kind of rock or mineral -- granite, limestone, shale (fragments), and quartz, feldspar, etc.
Hardness, soundness, or friable condition.
Constituents -- mica, shells, roots and humus, organic matter, foreign matter (brick, glass, concrete, etc.), etc.

FOOTNOTES TO TABLE I:

[1]Proportions refer to percentages of the whole soil finer than and coarser than the principal component. Closer designations of proportions may be used, if considered significant, particularly for the gravel component, as follows:

| | | |
|---|---|---|
| Plus | (+) | Nearer the upper limit of a proportion. |
| Minus | (-) | Nearer the lower limit of a proportion. |
| No Sign | | Middle range of a proportion. |

For example: "some-" = nearer 20 percent
"little+" = nearer 20 percent

[2]The predominating fraction, especially for the gravel component, may be designated by adding a plus (+) sign immediately following the fraction term, if considered significant.

For example: "coarse+ to fine Gravel"
"medium to fine+ Sand"

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## BURMISTER'S SYSTEM OF SOIL IDENTIFICATION

TABLE II -- DEFINITIONS OF TERMS FOR THE IDENTIFICATION OF COMPOSITE CLAY-SOILS ON AN OVERALL PLASTICITY BASIS

| DEGREE OF OVERALL PLASTICITY,[a] PI' | OVERALL PLASTICITY INDEX, PI' SAND-SILT-CLAY COMPONENTS | IDENTIFICATION PRINCIPAL COMPONENT WRITTEN SYMBOL | IDENTIFICATION MINOR COMPONENT WRITTEN SYMBOL | SMALLEST DIAMETER OF THREADS, IN. |
|---|---|---|---|---|
| Nonplastic..... | 0 | SILT S | Silt S | None |
| Slight S..... | 1 to 5 | CLAYEY SILT CYS | Clayey Silt CY'S' | 1/4 - Pencil |
| Low L..... | 5 to 10 | SILT & CLAY S-C | Silt & Clay S-C | 1/8 |
| Medium M..... | 10 to 20 | CLAY & SILT C-S | | 1/16 - Paper Clip |
| High H..... | 20 to 40 | SILTY CLAY SYC | | 1/32 |
| Very High VH.... | 40 and greater | CLAY C | | 1/64 - Hair |

[a]Closer designations may be made, if considered significant, of plasticity by the use of the plus (+) and minus (-) signs immediately following the plasticity term.

Symbol designations of plasticity, where used, should be written as follows, for example:

Slight- Plasticity, S-PI'
Low Plasticity, LPI'
High+ Plasticity, H+PI'

G.1.4 Rock Coring

Coring techniques are used when formation materials are too hard to be penetrated or sampled by conventional soil techniques. Before coring begins, casing is set into bedrock to prevent cross contamiantion and to contain the drilling fluid and cuttings from the overlying formation. Coring provides a solid cylindrical fraction of rock which is removed or cut from the formation by the use of a core barrel tube and drilling bit. Coring is expensive, yields better quality data than air rotary drilling and can drill through rock for thousands of feet depending on the size of the drill rig. The first few feet of bedrock coring will advance by using a diamond tipped core bit. The rate of rock drilling is proportional to rock drillability, and is partially a function of rock drilling strength and chagnes due to alternating lithologies.

The U.S. Bureau of Mines has conducted studies in bedrock coring. Studies were performed using a commerically avaialble diamond drill, mounted on a two wheel trailer. This research yielded a theoretical equation for predicting core-drilling rates, by simplifying the general equation, the folloing resutls are obtained:

$$D = \frac{T}{5\ CA}$$

Where:

d = penetration per revolation (in./rev.)
T = Ftr
Ft = tangential force at bit face (lb.)
r = bit radius (in.)
C = compressive strength or rock (psi)
(i.e., Hematite = 88,1000 psi))
A = $(\pi/4)\ (Do^2 - Di^2)$
Do = outside diameter of diamond core bit (in.)
Di = inside diameter of diamond core bit (in.)

## 1.0 EQUIPMENT

2.1 Drill rig, with crew and coring equipment
2.2 Barrel, core, and bit
2.3 Rods, drill
2.4 Water supply
2.5 Time piece
2.6 Boxes, core (standard size)
2.7 Pen, indelible
2.8 Labels
2.9 Camera (optional))
2.10 Hammer, Schmidt (optional)
2.11 Knife, pocket
2.12 Lens, hand, magnifying
2.13 Callapsible folding ruler, 6-ft. length
2.14 Tape, cloth 100-ft. length
2.15 Device, sounding
2.16 Reference materials and forms
2.17 Notebook, field, bound

## 2.0 DECONTAMINATION OF EQUIPMENT

To reduce the risk of transfer of contaminants onto and off of the site, decontamination of all equipment by steam-cleaning procedures is required prior to entering or leaving the site.

To reduce the risk of transfer of contaminants within the site, decontamination of all equipment and containers by washing equipment is required between sampling locations.

The following general washing procedure is recommended:

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- o Brush loose soil particles off of equipment.
- o Wash equipment with laboratory grade detergent.
- o Rinse equipment with tap water (minimum of three rinses).
- o Rinse equipment with distilled water.
- o Rinse equipment with reagent grade methanol.
- o Allow methanol to evaporate before reusing the equipment.

All wash and rinse water should be collected and disposed of in a manner established by the On-Site Coordinator.

Specific procedures should be established for each site based on the degree of hazard associated with the material and the amount of contact with hazardous material from the work.

Equipment which cannot be contaminated by such procedures, such as field notebooks, forms, and photopgrahic equipment should be handled in a manner which will minimize direct contact with core samples of drilling fluids.

3.0 PROCEDURE

3.1 Prior to commencing the field explorations, the Project Geologist should specific the following items:

- o Locations of rock-coring explorations.
- o Depth of rock-core penetration.
- o Length of core-run (usually 5 ft.)
- o Specific rock-coring procedures.

3.2 The Field Geologist should identify the locations of rock-core explorations with survey stakes and flagging. Locations of explorations should be approximately determined by the Field Geologist using pocket-transit and pace method and should be plotted on the site base map.

3.3 The Project Geologist should indicate the information to be recorded by the Field Geologist during the rock-coring operation. The recorded information should inclue but not necessarily be limity to the following:

- o Drill rate (minutes per foot)
- o Type and size of bit
- o Core number
- o Depth range
- o Core recovery (inches)
- o Rock Quality Designation (RQD in percent; for NX-size core only).

3.4 The rock core should be classified by the Field Geologiest using a rock classification system established by the Project Geologist, who manages the exploration program.

3.5 There is no universal core barrel or drilling equipment for rock coring. The geologic and topographic conditions as well as the requirements of the project will dictate the type of equipment to be employed.

The following factors can result in good core production and should be observed during rock coring.

3.5.1 Prepare a level and stable drilling platform before commencing the boring.

3.5.2 Keep the drill stem as nearly vertical as possible. On deep core holes, true alignment of the casing is critical. The driller may elect to use a heavy drilling mud instead of casing to support the bore hole walls; this procedure is not as desirable under some conditions, but acceptable if satisfactory information is obtained.

3.5.3 Wash the casing out thoroughly before inserting the core barrel.

3.5.4 Inspect the selected core barrel and bit for wear, general cleanliness, and free movement of all parts. Reject any barrel or bit that appears unsatisfactory.

3.5.5 Pump recirculated drill fluid down the drill rods and observe a return flow before commencing drilling operations.

3.5.6 Carefully measure all lengths of rod, core barrel, and stick-up through all phases of drilling for accurate depth determination.

3.5.7 Drill with minimal vertical pressure and rotation. Most rigs are equipped with a selection of gear ratios and a variable hydraulically-controlled feed mechanisms. Driller expertise in selecting the correct combination of speed and feed rate is invaluable.

3.5.8 Water return should be no more than just sufficient to bring the bore hole cuttings to the surface.

3.5.9 Place the core carefully in the core box from left to right, top of bottom.

3.5.10 If 100 percent recovery was not obtained, the bore hole should be sounded to determine if the missing core still remains in the bottom of the borehole.

4.0 REFERENCES

Acker III, W.L. 1974. Basic Procedures for Soil Sampling and Core Drilling. Acker Drill Co., Inc., Scranton, PA. 246 p.

G.1.5 Supervision

The engineer, project manager or geologist supervising the drilling is responsible for making all decisions relative to overseeing the drilling operation. It is this

individual responsibility to ensure that all appropriate proceudres are followed including health and safety considerations by the drilling party.

The daily field logbook, soil and rock samle labeling and classification must all be performed and kept up to date by the project field geologist.

## H.1 Developing the Well

The purpose of developing the well is to move the formation fines (clays, silts, drilling fluids, etc.) into the well so that they can be removed by a bailer. If this was not done the finer grained materials could cause clogging thus restricting the movement of water throughout the packing and well screen.

### H.1.1 Surge Block

A surge block is a round (rubber type) plunger with pliable edges which is designed not to jam in the well screen. The surge block is forced up and down inside the well screen. The motion of the water causes the fine-grained materials to accumulate in the bottom of the well.

### H.1.2 Overpumping and Backwashing

This involves washing or overpumping the well at rates higher than would be normally used. Some of the drawbacks with pumping may result from contaminants being drawn into the well from other zones due to a large cone of depression which may be induced by overpumping.

An alternate pumping method of starting and stopping the pump so that the water is pulled into the well then backflushed through the screen is often used.

H.1.3 Air Lift

Compressed air is forced into the casing at a depth above the well screen through a pipe. Air is injected into the well only for short durations. This causes the water level to rise in the well. The air supply is then cut off allowing the raised waste column to subside. This procedure causes a backflushing effect in the well. The fines are then blown out of the well.

H.1.4 Bailing

A bailer of sufficient weight which should sink rapidly through the cased water column can be raised and lowered through the well screen. The water column is disturbed by the action of the bailer similar to the agitation caused by a surge plunger/block. The bailer, however, has an added advantage of removing the fines each time it is brought to the surface and emptied.

H.1.5 Surge Plunger

Surging can also be accomplished with a plunger which approximates the diameter of the well. There are two basic types, solid and valve surge plungers. For those formations with relatively high water yields a solid plunger is more effective and produces a stronger surging motion. Valved plungers are designed to produce a greater intake of water than the backflush water moving oppositely through the well screen.

H.1.6 Jetting

One of the more effective ways of developing a well is by high velocity jetting. In this method water is forced at high velocities through openings in a plunger type device. The jetting device is rotated and raised and lowered the length of the well screen to develop the entire screened area. The sediments which are washed into the casing settle at the bottom of the well and can be removed either by bailing or pumping.

VOLATILE ORGANICS BY PURGE AND TRAP
MASS SPECTROMETER - GAS CHROMATOGRAPH

## 1.0 Introduction

This method is designated to determine those "unambiguous priority pollutants", associated with the Consent Decree, that are amenable to the purge and trap method. Analyses of EPA specified priority pollutant volatile organic compounds are performed according to the EPA Chromatographic/Mass Spectrometric (GC/MS) procedures specified in the US EPA Analytical Method 624 Purgables (44 CFR 69532, Monday, 3 December 1979). Quality Assurance procedures are consistent with Appendix 3 (44 CFR 69532, Monday, 3 December 1979).

## 2.0 Scope and Application

Certain compounds, acrolein and acrylonitrile, are only detected at high concentrations due to inefficient recovery by this method, and are determined by direct aqueous injection GC/MS. Direct aqueous injection GC/MS is recommended for all compounds whose concentration exceeds 1000 µg/l.

The purge and trap and the liquid/liquid extraction methods are complimentary to one another. There is an area of overlap between the two and some compounds may be recovered by either methods. However, the efficiency of recovery depends on the vapor pressure and water solubility of the compounds involved. Generally, the area of overlap may be identified by compounds boiling between 130°C and 150°C with a water solubility of approximately two percent. Some compounds are efficiently recovered by both methods. The GC/MS conditions selected for the purge and trap method are generally not suitable for the determination of compounds eluting later than ethylbenzene.

Written By: JFO Approved By: DJY
Date: 6/25/82 Date: 6/25/82
Corporate QA Approval: DJY Date: 6/25/82

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3.0 Sample handling and preservation

Samples are collected in screw-cap septa bottles that have been appropriately washed and rinsed according to the procedure described in bottle cleaning for extractable organics heated at 170°C for a minimum of one hour to drive off any volatile organics present). Air bubbles should not be present in bottles after collection and teflon side of septa should be facing sample. Samples are refrigerated upside down until approximately one hour prior to analysis.

4.0 Equipment

4.1.1 5993A GC/MS Hewlett-Packard

1.2 7906 Disc Drive

1.3 21MX E-Series Computer

1.4 2648A Graphics Terminal

1.5 Tektronix 4632 Video Hard Copy Unit

4.2 18961A Purge and Trap Sampler - Hewlett-Packard

4.3 9825 Corning Culture Tube with Screw Cap (25x200 mm)

4.4 Hamilton Syringes - 800 Series and 7000 Series for liquids

5.0 Purge Parameters for VOA Analysis

5.1 Purge gas - Helium, high purity grade
Purge time - 15 minutes
Purge flow 30 ml/min
Trap dimensions - 1/8 in. O.D. (0.09 to 0.105 in. I.D.) x 6 in. long
Trap sorbent - Tenax-GC, 60/80 mesh 4 in. plus Type 15 silica gel, 35/60 mesh (2 in.
Desorption flow - 30 ml/min

Written By: JFO. Approved By: DZY
Date: 6/25/82 Date: 6/29/82
Corporate QA Approval: DZY Date: 6/29/82

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Desorption time - five (5) minutes
Desorption temperature - 180°C
Vent time - fifteen (15) minutes

5.2 Gas Chromatographic - Mass Spectrometer Paramaters

Column - Stainless steel, 8 ft. long x 1/8 in. O.D.
(0.09 to 0.105 in. I.D.) packed with 1% SP 1000 (80/100 mesh)
Carrier gas - Helium at 30, ml/min.

5.3 Program Parameters

Run Time - 28 minutes
Start/Stop Masses - 33, 200
A/D Measurements per Datum Point - 3.0
Threshold - 75
Scan Start Delay - 3
GC Temperature 1 - C 50°C
Time at Temperature 1 - four (4) minutes
Rate - 8/minute
GC Temperature 2 - 220
Time at Temperature 2 - sixty (60) minutes
Injection Port Temperature - C 230 - C
Electron Multiplier Voltage - 1600
Sample Name - Sample description, concentration of internal standards present, electron multiplier voltage used.
Miscellaneous Data - Date of run

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Written By: [illegible] Approved By: [illegible]
Date: 6/25/82 Date: 6/29/82
Corporate QA Approval: [illegible] Date: [illegible]

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## 6.0 Procedure for VOA Analysis

### 6.1 Standard Preparation

6.1.1 Commercial Stock Standards (0.2 µg/l) are available from Supelco and obtained from the CDM/EED Standard Library. They are divided into the following groups:

Purgable A - Methylene chloride
1,1-Dichloroethylene
1,1-Dichloroethane
Chloroform
Carbon tetrachloride
1,2-Dichloropropane
Trichloroethylene
1,1,2-Trichloroethane
Dibromochloromethane
Tetrachloroethylene
Chlorobenzene

Purgable B - Trichlorofluoromethane
trans-1,2-Dichloroethylene
1,2-Dichloroethane
1,1,1-Trichloroethane
Bromodichloromethane
trans-1,3-Dichloropropane
cis-1,3-Dichloropropene
Benzene
Bromoform
1,1,2,2-Tetrachloroethane
Toluene
Ethylbenzene

Purgable C - Chloromethane
Dichlorodifluoromethane
Bromomethane
Vinyl chloride
Chloroethane

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6.1.2 Preparation of Standards from pure reference standards

Prepare standard stock solutions (approximately 2 µg/ul) by adding, from a 100 ul syringe, one (1) to two (2) drops of the 99+% pure reference standard to methanol (9.8 ml) contained in a tared 10 ml volumetric flask (weighed to nearest 0.1 mg). Add the compound so that the two (2) drops fall into the alcohol and do not contact the neck of the flask. Use the weight gain to calculate the concentration of the standard. Prepare gaseous standards, i.e., vinyl chloride, in a similar manner using a 5 ml valved gas-tight syringe with a 2 in. needle. Fill the syringe (5.0 ml) with the gaseous compound. Weigh the 10 ml volumetric flask containing 9.8 ml of methyl alcohol to 0.1 mg. Lower the syringe needle to about 5 mm above the methyl alcohol meniscus. Slowly inject the standard into the flask. The gas rapidly dissolves in the methyl alcohol. Reweigh the flask, dilute to volume, mix, tightly stopper, and store in a freezer. (It is advisable at this time to prepare a stock standard containing all compounds to be determined.) Such standards are generally stable for at least one (1) week when maintained at less than 0°C. Stock standards of compounds which boil above room temperature are generally stable for at least four (4) weeks when stored at 4°C.

SAFETY CAUTION: Because of the toxicity of most organohalides, primary dilutions are prepared in a hood. Further, it is advisable to use an approved respirator when handling high concentration of such materials.

From the primary dilution secondary dilution mixtures in methyl alcohol are prepared so that the unknowns produce responses close to those of the standards selected (which should include concentrations of 10. PPB, 100. PPB and 1000. PPB).

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000911

6.1.3 Low Level VOA Analysis

For the analysis of samples for low level volatile organics, quantification is based on a single low level standard of approximately 25. PPB. This standard is prepared by dilution of stock standard solutions obtained from Supelco.

6.1.4 Addition of Internal Standards

From stock standard solutions, a solution that contains 1 µg/ml each of bromocloromethane, 2-bromo-1-chloropropane and 1,4-dichlorobutane is prepared. A fresh internal standard mixture is dosed into every sample and the standard analyzed is referenced.

000912

6.2 Preliminaries for Analysis

6.2.1 Preliminary Treatment of Sample

Samples are removed from cold storage approximately one (1) hour prior to analysis and brought to room temperature by placing in a warm water bath at 20-25°C.

6.2.2 Purging and Trapping Procedure

The helium purge gas flow is adjusted to approximately 30. ml/min. The sample is placed in the Purge and Trap sample vessel and 2000. ng. of internal standard is added. The sample vessel is attached to the instrument and the purge cycle is started.

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### 6.2.3 GC/MS Determination

The GC/MS is programmed in the Aquire Mode with parameters listed in Section 5.2. At the termination of the Purge Cycle the GC/MS run is initiated by pressing the "return" key and opening the MS valve. The GC/MS will end the run automatically and will allow the option of saving or erasing the designated run. If the user decides to save the spectra the run information (i.e. sample no., date, electron multiplier voltage) is recorded in the designated book.

## 6.3 Qualitative and Quantitative Determination

The characteristic masses or mass ranges listed in Table 1 are used for qualitative and quantitative determination of volatile organics. They are used to obtain an extracted ion current profile (EICP)[1] for each compound. For very low concentrations, the same masses may be used for selected ion monitoring (SIM)[2].

000913

Samples are quantified by comparing the area of a single mass (see Table 1) of the unknown in a sample to that of a standard. When positive responses are observed, a reference standard is analyzed so that the standard response closely approximates the sample response. The concentration in the sample is calculated as follows:

$$\frac{\text{(Area for unknown)}}{\text{(Area for standard)}}$$

Concentration of standard (µg/l) = µg/l of unknown

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1 EICP is the reduction of mass spectrometric data acquired by continuous, repetitive measurement of spectra by plotting the change in relative abundance of one (1) or several ions as a function of time.

2 SIM is the use of a mass spectrometer as a substance selective detector by measuring the mass spectrometric response at one (1) or several characteristic masses in real time.

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Date: 6/25/82 Date: 6/29/82

Corporate QA Approval: [signature] Date: 6/25/82

## 7.0 Reporting of Data

All results are reported to two (2) significant figures or to the nearest 10 ug/l. Internal standard data is reported to two (2) significant figures.

As the analyses are completed, GC/MS data is saved on magnetic tape. All quality control (QC) data is reported along with the analytical results for the samples.

### 7.1 Data Validation Criteria

The area of the quantifying ion for individual internal standard(s) is calculated for each analysis. To be considered valid the recovery of the internal standard from individual samples must be 100 ± 25% of the internal standard of the corresponding dynamic standard.

In addition to the aforementioned performance criteria the following analytical criteria must also be met in order to quantify specific compounds listed in Table 1.

First, the characteristic ions for the compound must be found to maximize in the same spectrum. Second, the time at which the peak occurs must be within a window of ± 1 minute for the retention time of this compound. Finally, the ratios of the three peak heights must agree with the relative intensities given in Table 1.

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Table I

Characteristic Ions of Volatile Organics

| Compound | EI Ions (Relative intensity) | Ion used to quantify |
|---|---|---|
| chloromethane | 50(100); 52(33) | 50 |
| dichlorodifluoromethane | 85(100); 87(33); 101(13); 103(9) | 101 |
| bromomethane | 94(100); 96(94) | 94 |
| vinyl chloride | 62(100); 64(33) | 62 |
| chloroethane | 64(100); 66(33) | 64 |
| methylene chloride | 49(100);51(33); 84(86); 86(55) | 84 |
| trichlorofluoromethane | 101(100); 103(66) | 101 |
| 1,1-dichloroethylene | 61(100); 96(80); 98(53) | 96 |
| bromochloromethane(IS) | 49(100); 130(88); 128(70); 51(33) | 128 |
| 1,1-dichloroethane | 63(100); 65(33); 83(13); 85(8); 98(7); 100(4) | 63 |
| trans-1,2-dichloroethylene | 61(100); 96(90); 98(57) | 96 |
| chloroform | 83(100); 85(66) | 83 |
| 1,2-dichloroethane | 62(100); 64(33); 98(23); 100(15) | 98 |
| 1,1,1-trichloroethane | 97(100); 99(66); 117(17); 119(16) | 97 |
| carbon tetrachloride | 117(100); 119(96); 121(30) | 117 |
| bromodichloromethane | 83(100); 85(66); 127(13); 129(17) | 127 |
| bis-chloromethyl ether | 79(100); 81(33) | 79 |
| 1,2-dichloropropane | 63(100); 65(33); 112(4); 114(3) | 112 |
| trans-1,3-dichloropropene | 75(100): 77(33) | 75 |
| trichloroethylene | 95(100); 97(66); 130(90); 132(85) | 130 |
| dibromochloromethane | 129(100); 127(78); 208(13); 206(10) | 127 |
| cis-1,3-dichloropropene | 75(100); 77(33) | 75 |

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Table I (cont'd)

| Compound | EI Ions (Relative intensity) | Ion used to quantify |
|---|---|---|
| 1,1,2-trichloroethane | 83(95); 85(60); 97(100); 99(63); 132(9); 134(8) | 97 |
| benzene | 78(100) | 78 |
| 2-chloroethylvinyl ether | 63(95); 65(32); 106(18) | 106 |
| 2-bromo-1-chloropropane(IS) | 77(100); 79(33); 156(5) | 77 |
| bromoform | 171(50); 173(100); 175(50); 250(4); 252(11); 254(11); 256(4) | 173 |
| 1,1,2,2-tetrachloroethylene | 129(64); 131(62); 164(78); 166(100) | 164 |
| 1,1,2,2-tetrachloroethane | 83(100); 85(66); 131(7); 133(7); 166(5); 168(6) | 168 |
| 1,4-dichlorobutane(IS) | 55(100); 90(30); 92(10) | 55 |
| toluene | 91(100); 92(78) | 92 |
| chlorobenzene | 112(100); 114(33) | 112 |
| ethylbenzene | 91(100); 106(33) | 106 |
| acrolein | 26(49); 27(100); 55(64); 56(83) | 56 |
| acrylonitrile | 26(100); 51(32); 52(75); 53(99) | 53 |

000916

## 8.0 Quality Assurance

### 8.1 Blanks

The analysis of blanks is most important in the purge and trap technique since the purging device and the trap can be contaminated by residues from very concentrated samples or by vapors in the laboratory. Prepare blanks by filling a sample bottle with Nanopure water (blank water) that has been prepared by passing distilled water through a pretested activated carbon column. Blanks should be sealed, stored at 4°C, and analyzed with each group of samples.

After each sample analysis, thoroughly flush the purging device with blank water and bake out the system. Subsequently, analyze a sample blank (one that has been transported to and from the sampling site). If positive interferences are noted, analyze a fresh laboratory sample of blank water. If positive interference still ocurrs, repeat the laboratory blank analysis. If interference persists, dismantle the system, thoroughly clean all parts that the sample, pruge gas and carrier gas come into contact with and replace or repack the sorbent trap and change purge and carrier gas.

D00917

### 8.2 Precision

~~To determine the precision of the method, a precision criterion~~ is developed from 15 sets of replicate results accumulated over a period of time during the routine analysis program. At least two (2) replicate aliquots of a well-mixed sample are analyzed with each set of 20 samples analyzed at a given time.

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Initially, samples selected for replicate analyses are those that are most representative of the interference potential of the sample type. As the program progresses, samples representing the entire range of concentrations and interference potential are

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and periodically (after 25 to 30 additional pairs of replicate results are obtained) the table of critical range values is revised, updated, and improved.

8.3 Accuracy

In addition to the initial determination of the precision of the method, a program is maintained to verify that the laboratory accuracy continues under control. This program is concurrent to the spiked sample analysis program outlined below and is carried out by preparing check standards and analyzing them according to the method. The check standards are approximately equal to the concentration found in routine samples. The standard is analyzed and $O_i$ (the observed value) is calculated. The percent recovery ($P_i$) is then calculated as follows:

$$P_i = \frac{100\ (O_i)}{T_i}$$

where $T_i$ = the true value.

After determining the $P_i$ for approximately 15 check standards, the mean ($\bar{P}$) and standard deviation ($S_p$) of the percentages as follows:

$$\bar{P} = \frac{\sum_{i=1}^{n} P_i}{n}$$

and:

$$S_p = \sqrt{\frac{1}{n-1}\left[\sum_{i=1}^{n} P_i^{\,2} - \left(\sum_{i=1}^{n} P_i\right)^2/n\right]}$$

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designed into the replicate analyses program.

After 15 replicate results have been obtained, the range ($R_i$) of these results is calculated as follows:

$$R_i = \left| X_{i1} - X_{i2} \right|$$

where $R_i$ is the difference between the results of the pair ($X_{i1} - X_{i2}$) from sample i=1 through n. The concentration of each sample is represented by the mean:

$$\bar{X}_i = \frac{(X_{i1} + X_{i2})}{2}$$

where $\bar{X}_i$ is the average of the results of the replicate pair. A preliminary estimate of the critical difference ($R_c$) between replicate analyses for any specific concentration level (C) is calculated as:

$$R_c = 3.27 \left( C \sum_{i=1}^{n} R_i \right) \Big/ \left( \sum_{i=1}^{n} \bar{X}_i \right)$$

From these data a table of such $R_c$ values for various C values that span the concentration range of interest is developed.

These preliminary critical difference values are used to judge the acceptability of the succeeding replicate results. To do this, the mean ($\bar{X}$) and difference (R) between the replicate results are calculated. Referring to the table of critical range values developed above, the C nearest to $\bar{X}$ is found and its $R_c$ is used to evaluate the acceptability of R. If the R is greater than $R_c$, the system precision is out of control and the source of this unusual variability is identified and resolved with routine analyses. The results of all replicate analyses are recorded

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where n = the number of results available.

If the percent recovery for succeeding check standards is not within the interval of $\bar{P} \pm 2\ S_p$, the system is checked for problems. If problems exist, they are resolved before continuing with routine analysis.

At least one check standard is analyzed along with each set of twenty (20) samples that is analyzed at a given time.

The recovery of all check standards is recorded and periodically the accuracy criteria is revised, updated, and improved.

8.4 Recovery

The recovery of the method for the analysis of environmental samples by adding a spike ($T_i$, true value) suffcient to approximately double the background concentration level ($\bar{X}_i$) of the sample selected earlier for replicate analysis is determined as part of the overall Quality Assurance Program. If the original concentration is higher than the midpoint of the standard curve (range of the method), then the concentration of the spike is approximately one-half the original concentration. If the concentration of the original sample was not detectable, the concentration of the spike is five (5) to fifteen (15) times the lower limit of detection. The volume of standard added in aqueous solution does not dilute the sample by more than ten (10) percent. The volume of standard added in an organic solvent solution is kept small (100. µl/l or less), so that the solubility of the standard in the water will not be affected.

The sample is analyzed and the observed value ($O_i$) is calculated. Then the recovery for the spike is obtained as follows:

$$P_i = 100(O_i - \bar{X}_i)/T_i$$

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where $P_i$ is the percent recovery. If the sample was diluted due to the addition of the spike, $\bar{X}_i$ is adjusted accordingly.

After determining $P_i$ for fifteen (15) spike results, the mean percent recovery ($\bar{P}$) and standard deviation ($S_p$) of the recovery are calculated as follows:

$$\bar{P} = \left(\sum_{i=1}^{n} P_i\right) \Big/ n$$

$$S_p = \sqrt{\frac{1}{n-1}\left[\sum_{i=1}^{n} P_i^{\,2} - \left(\sum_{i=2}^{n} P_i\right)^2 / n\right]}$$

where n = number of percent recovery values available.

If the percent recovery of the spike is not within the interval of $\bar{P} \pm 3\ S_p$, the system accuracy is out of control and the source of this systematic error is identified and resolved before continuing with routine analysis.

At least one spiked sample is analyzed along with each set of twenty (20) samples that is analyzed at a given time. This spiked data is obtained for each parameter of interest. The recovery data of all spiked analyses is recorded and periodically (every twenty-five to thirty data points) the accuracy criteria is revised, updated and improved.

8.5 Additional Routine Quality Control Practices

In addition to the foregoing formal control program, certain other practices are included during the routine analyses to eliminate determinate errors and to insure the quality of the data. These practices include: instrument calibration and performance checks, preparation and daily check of calibration curves, method blank analyses, and field blank analyses.

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8.5.1 Calibration Check for the GC/MS System

At the beginning of each day's operation, the calibration, resolution, and sensitity of the system is adjusted by running the program "Autotune". The system can be checked further by following the procedures listed below:

When analyzing the purgeable organics or semi-volatile acids, the system is checked by directly injecting and analyzing 100 nanograms of Bromofluorobenzene (BFB). System performance is determined using the ion abundance criteria for this compound listed in Table 2. If this test shows that the system is not properly calibrated the program "Autotune" is run.

8.5.2 Internal Standards

Internal standards are used to check the total analytical procedure. The internal standards are selected based upon prior knowledge of the sample source and type. They are similar to the compounds being determined, but do not co-elute with them. At least two (2) internal standards are selected for each class of compounds of interest.

000922

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Available from Aldrich.
Available from PCR, Inc.

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# IRON
## Method 236.1 (Atomic Absorption, direct aspiration)

**STORET NO. Total 01045**
**Dissolved 01046**
**Suspended 01044**

**Optimum Concentration Range:** 0.3–5 mg/l using a wavelength of 248.3 nm
**Sensitivity:** 0.12 mg/l
**Detection Limit:** 0.03 mg/l

**Preparation of Standard Solution**

1. Stock Solution: Carefully weigh 1.000 g of pure iron wire (analytical reagent grade) and dissolve in 5 ml redistilled $HNO_3$, warming if necessary. When solution is complete make up to 1 liter with deionized distilled water. 1 ml = 1 mg Fe (1000 mg/l).
2. Prepare dilutions of the stock solution to be used as calibration standards at the time of analysis. The calibration standards should be prepared using the same type of acid and at the same concentration as will result in the sample to be analyzed either directly or after processing.

**Sample Preservation**

1. For sample handling and preservation, see part 4.1 of the Atomic Absorption Methods section of this manual.

**Sample Preparation**

1. The procedures for preparation of the sample as given in parts 4.1.1 thru 4.1.4 of the Atomic Absorption Methods section of this manual have been found to be satisfactory.

**Instrumental Parameters (General)**

1. Iron hollow cathode lamp
2. Wavelength: 248.3 nm
3. Fuel: Acetylene
4. Oxidant: Air
5. Type of flame: Oxidizing

**Analysis Procedure**

1. For analysis procedure and calculation, see "Direct Aspiration", part 9.1 of the Atomic Absorption Methods section of this manual.

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**Notes**

1. The following lines may also be used:
   248.8 nm Relative Sensitivity 2
   271.9 nm Relative Sensitivity 4
   302.1 nm Relative Sensitivity 5
   252.7 nm Relative Sensitivity 6
   372.0 nm Relative Sensitivity 10
2. Data to be reported into STORET must be reported as ug/l.
3. The 1,10-phenanthroline colorimetric method may also be used (Standard Methods, 14th Edition, p. 208).
4. For concentrations of iron below 0.05 mg/l, either the Special Extraction Procedure given in part 9.2 of the Atomic Absorption Methods section or the furnace procedure, Method 236.2, is recommended.

**Precision and Accuracy**

1. An interlaboratory study on trace metal analyses by atomic absorption was conducted by the Quality Assurance and Laboratory Evaluation Branch of EMSL. Six synthetic concentrates containing varying levels of aluminum, cadmium, chromium, copper, iron, manganese, lead and zinc were added to natural water samples. The statistical results for iron were as follows:

| Number Of Labs | True Values ug/liter | Mean Value ug/liter | Standard Deviation ug/liter | Accuracy as % Bias |
|---|---|---|---|---|
| 82 | 840 | 855 | 173 | 1.8 |
| 85 | 700 | 680 | 178 | -2.8 |
| 78 | 350 | 348 | 131 | -0.5 |
| 79 | 438 | 435 | 183 | -0.7 |
| 57 | 24 | 58 | 69 | 141 |
| 54 | 10 | 48 | 69 | 382 |

000924

# MANGANESE
## Method 243.2 (Atomic Absorption, furnace technique)

**STORET NO. Total 01055**
**Dissolved 01056**
**Suspended 01054**

**Optimum Concentration Range:** 1–30 ug/l
**Detection Limit:** 0.2 ug/l

**Preparation of Standard Solution**

1. Stock solution: Prepare as described under "direct aspiration method".
2. Prepare dilutions of the stock solution to be used as calibration standards at the time of analysis. These solutions are also to be used for "standard additions".
3. The calibration standard should be diluted to contain 0.5% (v/v) $HNO_3$.

**Sample Preservation**

1. For sample handling and preservation, see part 4.1 of the Atomic Absorption Methods section of this manual.

**Sample Preparation**

1. Prepare as described under "direct aspiration method". Sample solutions for analysis should contain 0.5% (v/v) $HNO_3$.

**Instrument Parameters (General)**

1. Drying Time and Temp: 30 sec–125°C.
2. Ashing Time and Temp: 30 sec–1000°C.
3. Atomizing Time and Temp: 10 sec–2700°C.
4. Purge Gas Atmosphere: Argon
5. Wavelength: 279.5 nm
6. Other operating parameters should be set as specified by the particular instrument manufacturer.

**Analysis Procedure**

1. For the analysis procedure and the calculation, see "Furnace Procedure" part 9.3 of the Atomic Absorption Methods section of this manual.

**Notes**

1. The above concentration values and instrument conditions are for a Perkin-Elmer HGA-2100, based on the use of a 20 ul injection, continuous flow purge gas and non-pyrolytic

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graphite. Smaller size furnace devices or those employing faster rates of atomization can be operated using lower atomization temperatures for shorter time periods than the above recommended settings.

2. The use of background correction is recommended.
3. Nitrogen may also be used as the purge gas.
4. For every sample matrix analyzed, verification is necessary to determine that method of standard addition is not required (see part 5.2.1 of the Atomic Absorption Methods section of this manual).
5. If method of standard addition is required, follow the procedure given earlier in part 8.5 of the Atomic Absorption Methods section of this manual.
6. Data to be entered into STORET must be reported as ug/1.

**Precision and Accuracy**

1. Precision and accuracy data are not available at this time.

000926

# MANGANESE
## Method 243.1 (Atomic Absorption, direct aspiration)

**STORET NO. Total 01055**
**Dissolved 01056**
**Suspended 01054**

**Optimum Concentration Range:** 0.1–3 mg/l using a wavelength of 279.5 nm
**Sensitivity:** 0.05 mg/l
**Detection Limit:** 0.01 mg/l

**Preparation of Standard Solution**

1. Stock Solution: Carefully weigh 1.000 g of manganese metal (analytical reagent grade) and dissolve in 10 ml of redistilled $HNO_3$. When solution is complete, dilute to 1 liter with 1% (V/V) HCl. 1 ml = 1 mg Mn (1000 mg/l).
2. Prepare dilutions of the stock solution to be used as calibration standards at the time of analysis. The calibration standards should be prepared using the same type of acid and at the same concentration as will result in the sample to be analyzed either directly or after processing.

**Sample Preservation**

1. For sample handling and preservation, see part 4.1 of the Atomic Absorption Methods section of this manual.

**Sample Preparation**

1. The procedures for preparation of the sample as given in parts 4.1.1 thru 4.1.4 of the Atomic Absorption Methods section of this manual have been found to be satisfactory.

**Instrumental Parameters (General)**

1. Manganese hollow cathode lamp
2. Wavelength: 279.5 nm
3. Fuel: Acetylene
4. Oxidant: Air
5. Type of flame: Oxidizing

**Analysis Procedure**

1. For analysis procedure and calculation, see "Direct Aspiration", part 9.1 of the Atomic Absorption Methods section of this manual.

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**Notes**

1. For levels of manganese below 25 ug/l, either the furnace procedure, Method 243.2, or the Special Extraction Procedure given in part 9.2 of the Atomic Absorption Methods section is recommended. The extraction is carried out at a pH of 4.5 to 5. The manganese chelate is very unstable and the analysis must be made without delay to prevent its resolution in the aqueous phase.
2. The following line may also be used:
   403.1 nm Relative Sensitivity 10.
3. Data to be entered into **STORET** must be reported as ug/l.
4. The persulfate colorimetric method may also be used (Standard Methods, 14th Edition, p 225).

**Precision and Accuracy**

1. An interlaboratory study on trace metal analyses by atomic absorption was conducted by the Quality Assurance and Laboratory Evaluation Branch of EMSL. Six synthetic concentrates containing varying levels of aluminum, cadmium, chromium, copper, iron, manganese, lead and zinc were added to natural water samples. The statistical results for manganese were as follows:

| Number of Labs | True Values ug/liter | Mean Value ug/liter | Standard Deviation ug/liter | Accuracy as % Bias |
|---|---|---|---|---|
| 77 | 426 | 432 | 70 | 1.5 |
| 78 | 469 | 474 | 97 | 1.2 |
| 71 | 84 | 86 | 26 | 2.1 |
| 70 | 106 | 104 | 31 | -2.1 |
| 55 | 11 | 21 | 27 | 93 |
| 55 | 17 | 21 | 20 | 22 |



000928

# SODIUM

## Method 273.1 (Atomic Absorption, direct aspiration)

**STORET NO.** Total 00929
Dissolved 00930
Suspended 00928

**Optimum Concentration Range:** 0.03–1 mg/l using a wavelength of 589.6 nm
**Sensitivity:** 0.015 mg/l
**Detection Limit:** 0.002 mg/l

**Preparation of Standard Solutions**

1. Stock Solution: Dissolve 2.542 g of NaCl (analytical reagent grade), dried at 140°C, in deionized distilled water and make up to 1 liter. 1 ml = 1 mg Na (1000 mg/l).
2. Prepare dilutions of the stock solution to be used as calibration standards at the time of analysis. The calibration standards should be prepared using the same type of acid and at the same concentration as will result in the sample to be analyzed either directly or after processing.

**Sample Preservation**

1. For sample handling and preservation, see part 4.1 of the Atomic Absorption Methods section of this manual.

**Sample Preparation**

1. For the analysis of total sodium in domestic and industrial effluents, the procedures for the determination of total metals as given in parts 4.1.3 and 4.1.4 of the Atomic Absorption Methods section of this manual have been found to be satisfactory.
2. For ambient waters, a representative aliquot of a well-mixed sample may be used directly for analysis. If suspended solids are present in sufficient amounts to clog the nebulizer, the sample may be allowed to settle and the supernatant liquid analyzed directly.

**Instrumental Parameters (General)**

1. Sodium hollow cathode lamp
2. Wavelength: 589.6 nm
3. Fuel: Acetylene
4. Oxidant: Air
5. Type of flame: Oxidizing

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000929

**Analysis Procedure**

1. For the analysis procedure and the calculation, see "Direct Aspiration", part 9.1 of the Atomic Absorption Methods section of this manual.

**Notes**

1. The 330.2 nm resonance line of sodium, which has a relative sensitivity of 185, provides a convenient way to avoid the need to dilute more concentrated solutions of sodium.
2. Low-temperature flames increase sensitivity by reducing the extent of ionization of this easily ionized metal. Ionization may also be controlled by adding potassium (1000 mg/l) to both standards and samples.
3. Data to be entered into STORET must be reported as mg/l.
4. The flame photometric method may also be used (Standard Methods, 14th Edition, p. 250).

**Precision and Accuracy**

1. In a single laboratory (EMSL), using distilled water samples spiked at levels of 8.2 and 52 mgNa/l, the standard deviations were ±0.1 and ±0.8, respectively. Recoveries at these levels were 102% and 100%.

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# Total Dissolved Solids

## 1.0 Introduction

1.1 This method also goes by the name of Total Filterable Solids.

1.2 A well-mixed sample is filtered through a standard glass fiber filer. The filtrate is evaporated and dried to constant weight at 103°C.

1.3 If residue, non-filterable is being determined, the filtrate from that method may be used for residue, filterable.

1.4 Filterable residue is defined as those solids capable of passing through a glass fiber filter and dried to constant weight.

## 2.0 Scope and Application

2.1 This method is applicable to drinking, surface, and saline waters, domestic and industrial waste.

2.2 The practical range of the determination is 10 mg/l to 20,000 mg/l.

## 3.0 Sample Handling and Preservation

3.1 Preservation of the sample is not practical; analysis should begin as soon as possible.

3.2 Refrigeration or icing to 4°C, to minimize microbiological decomposition of solids, is recommended.

## 4.0 Interferences

4.1 Highly mineralized waters containing significant concentrations of calcium, magnesium, chloride and/or sulfate may be hygroscopic and will require prolonged drying, desiccation and rapid weighing.

4.2 Samples containing high concentrations of bicarbonate will require careful and possibly prolonged drying at 103°C to insure that all the bicarbonate is converted to carbonate.

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Written By:_____ Approved By:_____
Date:_____ Date:_____

Corporate QA Approval:_____ Date:_____

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4.3 Too much residue in the evaporating dish will crust over and entrap water that will not be driven off during drying. Total residue should be limited to about 200 mg.

5.0 Apparatus

5.1 Glass fiber filter discs, 4.7 cm or 2.1 cm, without organic binder, Reeve Angel type 934-AH, Gelman type A/E, or equivalent.

5.2 Filter holder, membrance filter funnel or Gooch crucible adapter.

5.3 Suction flask, 500 ml.

5.4 Evaporating dishes, porcelain, 100 ml volume. (Vycor or platinum dishes may be substituted).

5.5 Steam bath.

5.6 Drying oven, 180°C ±2°C.

5.7 Desiccator

5.8 Analytical balance, capable of weighing to 0.1 mg.

6.0 Procedure

6.1 Preparation of glass fiber filter disc: Place the disc on the membrance filter apparatus or insert into bottom of a suitable Gooch crucible. While vacuum is applied, wash the disc with three successive 20 ml volumes of distilled water. Remove all traces of water by continuing to apply vacuum after water has passed through. Discard washings.

6.2 Preparation of evaporating dishes: If Volatile Residue is also to be measured heat the clean dish to 550 ±50°C for one hour in a muffle furnace. If only Filtarable Residue is to be measured heat the clean dish to ±2°C for one hour. Cool in desiccator and store until needed. Weigh immediately before use.

6.3 Assemble the filtering apparatus and begin suction. Shake the sample vigorously and rapidly transfer 100 ml to the funnel by means



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sample thorugh the glass fiber filter, rinse with three
of distilled water and continue to apply vacuum for about
r filtration is complete to remove as much water as

100 ml (or a larger volume) of the filtrate to a weighed
and evaporate to dryness on a steam bath.

vaporated sample for at least one hour at ±2°C. Cool in a
weigh. Repeat the drying cycle until a constant weight is
til weight loss is less than 0.5 mg.

ilterable residue as follows:

$$\text{Filterable residue, mg/l} = \frac{(A-B) \times 1{,}000}{C}$$

= weight of dried residue + dish in mg
B = weight of dish in mg
= volume of sample used in ml

, Standard Methods for the Examination of Water and
h. ed., 1975

By:_____ Approved By:_____
:_____ Date:_____
te QA Approval:_____ Date:_____

# APPENDIX IV - BIBLIOGRAPHY

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## BIBLIOGRAPHY

(1) Remedial Investigation/Feasibility Study for Western Sand and Gravel, Arthur D. Little, Inc., May 22, 1984 (Sections 3.1 through 4.5.3.).

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# APPENDIX V - SITE INVESTIGATIONS PROCEDURES

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# SUBSURFACE SOIL SAMPLING

## 1.0 GENERAL

The objective of subsurface sampling is to obtain soil from known depths in order to evaluate site characteristics, detect the presence of any contaminants and to evalutate the potential for pollutant migration. In the following sections, the equipment and techniques used to collect subsurface soil samples are described. General procedures which shall be followed during soil sample collection, including the cleaning of sampling equipment, are presented in method number 3816009.

## 2.0 BOREHOLE DRILLING

Subsurface soil samples from boreholes can be obtained at specified depths or continuously. Several techniques can be utilized for advancing borings including jetting, wash boring, auger boring, or rotary drilling. These techniques are briefly described in procedure number 3816013. Jetting, is not appropriate where soil samples are of concern.

In some instances borehole advancement, in connection with soil sampling, is accomplished by continuous sampling.

## 3.0 SOIL SAMPLING

The boring techniques utilized to excavate a borehole result in considerable disturbance of soil and do not allow for accurate determination of the depth from which soil materials have been excavated. Therefore split spoon, thin wall tubes or other sampling techniques must be used in conjunction with boring operations to obtain soil samples.

Subsurface samples may be obtained at predetermined depths, at every change in lithology or continuously. Continuous sampling provides the most accurate record of subsurface conditions for interpretive purposes.



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## 3.1 Split Spoons

Split spoons are devices used to obtain subsurface samples of up to 2.5 feet in length within hollow stem auger flights, cased borings, and mudded holes. The 1.75 to 2.5 in ID split spoon samplers are advanced into the undisturbed material beneath the bottom of the casing or borehole by use of weighted hammer and drill rod. The relationship between hammer weight, drop and blows required to advance the split spoon in 6-inch increments is an indicatoin of density or consistency of subsurface soils. After the split spoon has been driven the prescribed depth, it is removed carefully to avoid loss of soil materials. In non-cohesive or saturated soils a nest shall be used to help retain the sample.

Following removal of the split spoon from the casing, it shall be detached from the drill rod and opened to allow for visual classification of the sample. When less than a 10-inch sample has been obtained, a second cleaned sampler shall be lowered into the hole and a second sample shall be obtained. The first sample collected, if any, shall be retained unless greater sample recovery is obtained during the subsequent sampling attempts. The entire sample (except the top several inches of possibly "disturbed" material) shall be retained.

Samples of cohesive clays or silts shall be wrapped in aluminum foil prior to storage in jars, to preserve as undisturbed a sample as possible.

Once an adequate sample is collected, the sample shall be inspected, described, planed in wide mouth jars, labeled, and stored for transportation to the laboratory.

If volatile organic analyses are to be performed, VOA vials shall be filled immediately from the split spoon before jarring. Subsamples for other specific chemical analyses shall be taken as soon as possible as required.



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## 3.2 Thin Wall Tubes

Thin wall tubes are hollow pipes which are pressed or driven into the soil without rotation to obtain core samples of relatively undisturbed soils.

Thin wall tube samplers are generally 1.875 in ID, 2 in OD and 2 to 3 feet long, but may be of any size convenient for sampling. The thin wall tube has a sharp cutting edge and a positive inside clearance.

Thin wall tube samplers may be pushed or driven into soils inside hollow stem auger flights, wash bore casings or uncased boreholes. The tubes are pushed into the soil without rotation until the desired depth is attained or to refusal. If the sample tubes can not be advanced by pushing, it may be necessary to drive the tube into the soil, without rotation, using hammers and drill rods. The tubes are generally allowed to remain in the boring for 10 to 15 minutes to allow buildup of skin friction prior to removal. The sampler is then rotated to shear the sample from the soil below and carefully removed from the borehole.

Following removal of the tube sampler from the drilling equipment, the sampler is inspected to ensure that an adequate length of sample as been obtained. This sampling procedure shall be repeated until an adequate soil core is obtained provided that the material being sampled is of a nature which would permit retention in the sampler.

Upon successful retrieval of a soil core it shall be described and recorded in the log book and any disturbed soil shall be removed from each end of the tube. Samples for volatile organic analysis must be extracted from the soilds sample as soon after the sampler is withdrawn as possible. During transport to the sampling station, the tube should be capped with a non-reactive material. For other parameter, the shelby tube shall be sealed by pouring three 1/4 inch layers of liquid wax such as Socony Vacuum Product 2300 in each end allowing the wax to solidify between each layer. The remaining space



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shall be filled to the end of the cylinder with Ottawa sand or other similar sand and allowed to settle and compact. Plastic caps shall be taped over the ends of the cylinder and then sealed by successively dipping the ends into liquid wax. The tube shall then be labeled. Care should be taken in handling to label the top and bottom of the tube.

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# SEDIMENT SAMPLING

## 1.0 GENERAL

Sediment samples are obtained at uncontrolled hazardous waste sites and controlled substances work areas in order to provide information on transport of contaminants. Sediments consist of soil materials which have been transported to ponds or streams due to surface soil erosion or those materials that occur naturally under submerged conditions. Sediments are generally saturated and may be composed of mineral or organic materials or a combination of these.

## 2.0 SAMPLING EQUIPMENT AND TECHNIQUE

Sediment samples may be obtained using on-shore or off shore-techniques. Sediment sampling equipment and techniques must be designed to minimize the risk of dilution or loss of material as the sample is moved through the water column. For these situations where floatation devices or boats are required for sampling, extra precautionary measures must be employed. At a minimum, life preservers must be provided and two individuals shall undertake the sampling and an additional person shall remain in visual contact on-shore to observe the operations.

In the following sections, sediment samplers and their use are described.

### 2.1 Dip Sampler

A dip sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

The dip sampler is operated by submerging the jar or scoop and pulling it through the sediments to be sampled. The samples retrieved are then transferred into the appropriate sample container by decanting liquid phase and retaining the sediments.



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## 2.2 Hand Operated Core Samplers

Hand operated sediment core samplers are used to obtain sediment samples in shallow water (<3 ft). These samplers operate in a manner similar to that described for soil core samplers. However because of the saturated conditions of sediments, provisions must be provided so that the sample is retained within the core. Core samplers are generally constructed of an outer rigid metal tube into which a 2 inch ID plastic core sleeve fits with minimal clearance. The cutting edge of the core sampler has a recessed lip on which the plastic sleeve rests and which accomodates a plastic nest. This nest is oriented such that when the sampler is pressed into the sediment, the core is free to move past the nest. Due to construction of the nest, the core will not fall through the nest upon removal of the sampler from the sediment.

When the sampler is removed from the sediment, the plastic sleeve is removed sealed and labeled. Core sleeves should be sealed by packing ends with clean sand and placing plastic caps secured with friction tape over ends. Care should be taken in handling samples and the orientation of the sample core shall be indicated on the sleeve.

Because core sleeves and nests are generally made of plastic, special provisions should be made if samples are to be tested for chlorinated organics.

The land operated core sampler will not be useful for obtaining samples of gravelly, stoney or consolidated sediments.

## 2.3 Gravity Core Samplers

Gravity core samplers are used to obtain sediment samples in water bodies or lagoons with depths of greater than 3 to 5 feet. These types of samplers can be used for collecting 1 to 2 foot cores with a 2 inch ID, of surface sediments at depths of up to 100 feet beneath the water surface.



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As with all core type samplers, they are not suitable for obtaining samples of coarse - gravelly, stoney, or consolidated desposits. They are however, useful for fine grained inorganic and organic sediment sampling.

The gravity core sampler operates in a manner similar to the hand operated core in that a plastic sleeve of 2 inch ID fits within a metal core housing fitted with a cutting edge. Plastic nests are used to retain the core within the plastic sleeve. An opening exists above the core sleeve to allow free flow of water into and through the core as it moves vertically downward to the sediment. The sampler has a messenger-activated valve assembly which seals the opening above the plastic sleeve following sediment penetration. This valve is activated by the messenger creating a partial vacuum to assist in sample retention during retrieval.

Samples are obtained by allowing the sampler which is attached to approximately 100 feet of aircraft cable to drop to the benthic deposits. The weight of the sampler drives to core into the sediment to vary depths depending on the characteristics of the sediments. The messenger is then dropped on the taut aircraft cable to seal the opening above the plastic sleeve. The sampler is then carefully retrieved.

Upon retrieval of the sampler, the plastic core sleeve is removed and void spaces at either end packed with clear sand. The sample is then sealed with plastic caps attached using friction tape. Care should be excerised in labeling in order to properly identify sample orientation.

## 2.4 Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices or when large quantities of materials are required. Various dredge designs are available for sampling in deep or turbulent waters and for obtaining samples from gravelly, stoney or dense deposits.

Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a messenger.



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Dredges are commonly quite heavy and therefore require use of a winch and crane assembly for sample retrieval.

Upon retrieval of the dredge, the sample can either be sieved or transfered directly to a sample container for labeling and storage.

Dredge types which could be used for sampling include Ponar, Petersen and Ekman dredges.

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# SURFACE WATER SAMPLING

## 1.0 OBJECTIVE

The objective of obtaining surface water samples is to determine the surface water quality entering, leaving or affected by the site. Surface water samples are considered environmental samples (containing low concentrations of contaminants) but accurately quantifying the contaminants present is of utmost importance. In order to obtain a representative sample, the hydraulics of the water course must be determined before sampling, so that the most representative sample can be obtained.

Either grab or composite samples may be collected. Grab samples are collected at one particular point and time. Flow- or time-weighted composite samples are composed of more than one aliquot collected at various sampling sites and/or at different points in time. Because of the unknown safety risks, as well as the changes in chemical nature of the sample that may occur through compositing, samples containing hazardous materials at significant concentrations shall not be composited. Environmental samples containing low levels of toxics may be composited however, as described in the site specific sampling and analytical plan.

If it is necessary to wade into the water course to obtain a sample, the team member shall be careful not to disturb bottom sediments and shall enter the water course downstream of the sampling location. While in reality, it is difficult to prevent disturbance of the sediments, it is the responsibility of the team member to minimize the introduction of sediments into the sample. If necessary, the sampling technician shall wait for the sediments to settle before taking the sample.

If the water course is moving, a depth integrated grab sample shall be obtained. A depth integrated sample is collected by lowering an open container (shown in Figure 1) against the flow, to a depth just above bottom. The container is then turned into the flow and raised at a rate that allows it to just fill when it reaches the surface. The sample shall be collected in the middle of the stream.



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## 2.0 EQUIPMENT

The best choice of sampling equipment depends on the particular conditions at the site and the water body being sampled. The tyes of samplers available are:

- o Open tube
- o Pond Sampler
- o Manual Hand Pump
- o Weighted Bottle Sampler
- o Kemmerer Sampler
- o Extended Bottle Sampler.

Of these, the pond sampler and the weighted bottle sampler will be used most often. The criteria for selecting a sample collector are:

- o Disposable and/or easily decontaminated - A collection device may not be used again without sufficient cleaning.

- o Inexpensive - This is a necessity if the item is to be disposed of.

- o Each of operation - Cumbersome safety clothing and the use of protective respiratory equipment dictate the use of simple tools.

- o Nonreactive - The device must not react with the sample in such a manner as to contaminate it.

- o Safe - The unit must not present a safety threat to the user.

## 3.0 SAMPLING METHODS

### 3.1 Pond Sampler

The pond or dip sampler (Figure 1) consists of a container attached to the end of a long pole by an adjustable clamp. The pole can be of any



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non-reactive material such as wood, plastic or metal, as it will not be in contact with the sample itself. The sample shall be collected in a jar or beaker made of stainless steel, glass or non-reactive plastic. Preferably, a disposable beaker which can be replaced, shall be used at each station. Liquid wastes from water courses, ponds, pits, lagoons or open vessels are "ladeled" into a sample container.

### 3.2 Manual Hand Pumps

Manual pumps are available in various sizes and configurations. Manual hand pumps are commonly operated by peristaltic, bellows or diaphragm, and siphon action. Manual hand pumps which operate by a bellow or diaphragm, and siphon action should not be used to collect samples which will be analyzed fo volatile organics.

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The pump is operated according to manufacturer's instructions. The sample inlet hose is inserted into the liquid to be sampled, and a crank or bellows is activated.

To avoid contamination of the pump, a liquid trap consisting of a vacuum flask is inserted at the sample inlet hose to collect the sample (Figure 2). Teflon tubing shall be used for the inlet hose which the liquid sample in order to avoid sample contamination. The hose and trap must be flushed between stations with a minimum of three volumes of liquid, and cleaned or replaced at the end of each day.

### 3.3 Weighted Bottle Sampler

The sampler (Figure 3) consists of a glass bottle, a weight sinker, a bottle stopper, and a line that is used to open the bottle and to lower and raise the sampler during sampling. There are variations of this sampler, as illustrated in the ASTM methods D 270 and E 300. This sampler can be either fabricated or purchased. Procedure for use:

1. Assemble the weighted bottle sampler as shown in Figure 3.
2. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely.



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3. Pull out the stopper with a sharp jerk of the sampler line.
4. Allow the bottle to fill completely, as evidenced by the cessation of air bubbles.
5. Raise the sampler and cap the bottle.
6. Wipe the bottle clean. The bottle can be used as the sample container.

Alternatives to the weighted bottle sampler are the Kemmerer sampler and the extended bottle sampler.

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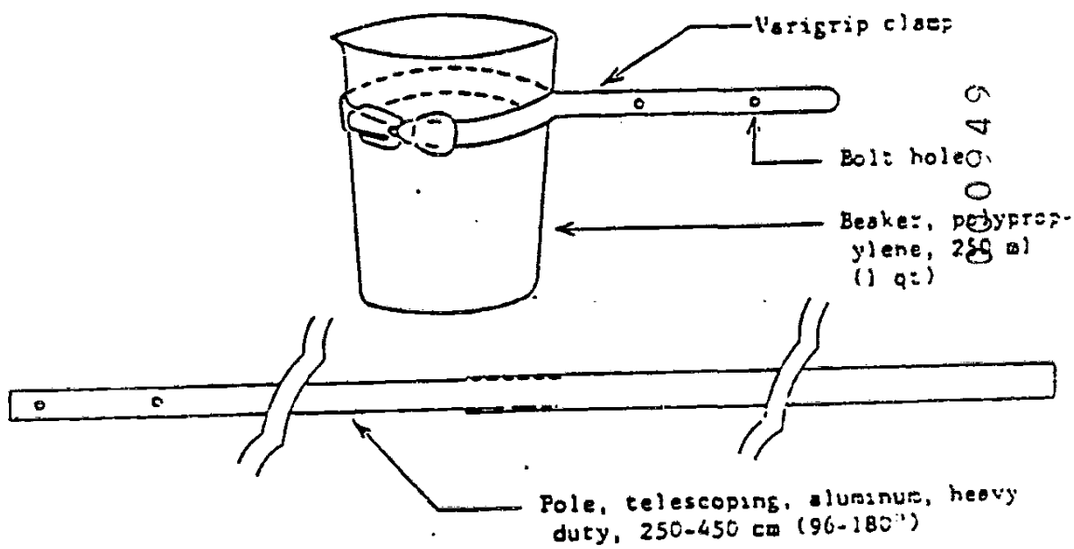



Figure 5.4.1 Pond sampler.

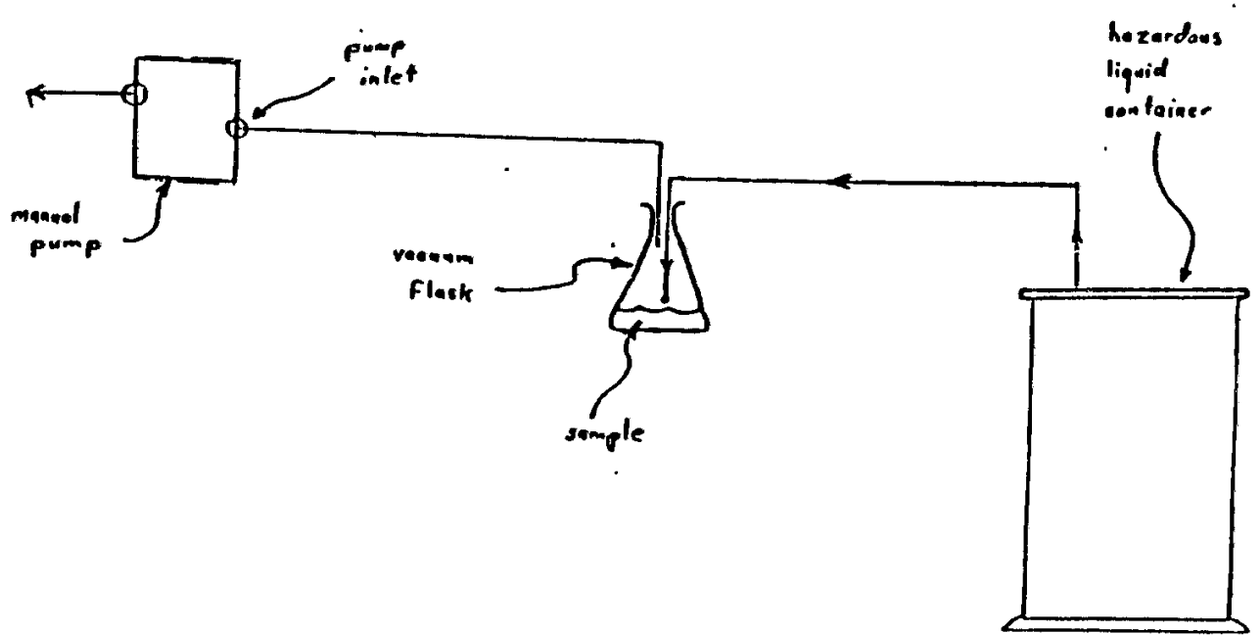
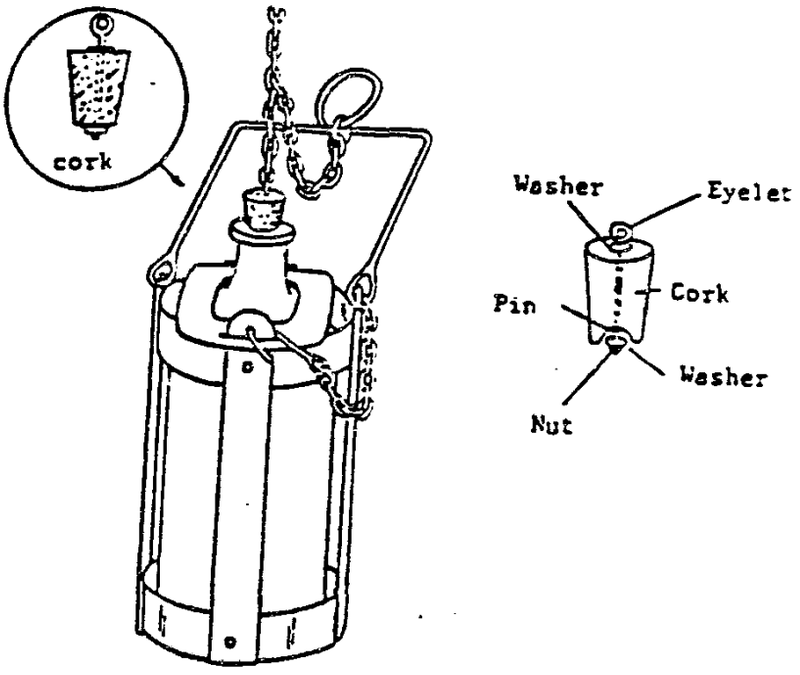

pump inlet
manual pump
vacuum Flask
sample
hazardous liquid container

FIGURE 5.4.2




1000 ml (1-quart) weighted bottle catcher

Figure 5.4.3 Weighted bottle sampler.

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# MONITORING WELL INSTALLATION and GROUNDWATER SAMPLING

## 1.0 GENERAL

Monitoring wells are installed at or adjacent to hazardous waste sites in order to provide an understanding of the overall groundwater regime, to evaluate flow patterns and hydraulic head fluctuations of the groundwater immediately surrounding the site and for the collection of groundwater samples to determine the extent of contamination in instances where the site in question has affected quality of the groundwater. It is essential that samples be collected from sources in a manner that will accurately assess the concentrations of constituents present. This may include the collection of groundwater samples from existing monitoring wells and large diameter production wells and possibly other sources (under certain circumstances, i.e. springs, etc.), in addition to samples collected from monitoring wells installed for this purpose. Generally, the installation of monitoring wells includes soil sampling--the collection of which is described in procedure number 3816017. In the following sections, techniques are generally described for the installation and sampling of monitoring wells.

In instances where new monitoring wells are necessary, a review of all prior data pertaining to the groundwater regime and the quality of the groundwater in the area is a necessary part of the decision-making progress involved with siting the new wells. Well installations may be accomplished through a contract based on a rigid set of specifications and unit price payments or by a time of materials contract. While the former is normally considered preferrable, the number of unknowns (both in location and subsurface conditions) may dictate that the latter course be followed.



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## 2.0 MONITORING WELL INSTALLATION

### 2.1 Installation - General

Monitoring wells or permanent sampling devices completed in unconsolidated materials above bedrock are generally installed in boreholes constructed using wash boring or augering techniques. In some instances, it may be appropriate to use jetting, rotary drilling or other boring techniques where local practice or subsurface conditions dictate such a consideration.

The general description for monitoring well and permanent sampling device installation which follows is provided as an overview. Specific materials to be used and methods for the construction of monitoring wells shall be developed based on the particular needs at each site and described in the site specific sampling and analytical plans and/or the specifications developed for the boring contractor.

Where well drilling techniques, or where the purpose of the well, requires that the well be developed and/or purged of induced waters, a period of ten days shall be provided after development for stabilization prior to sampling. The requirement for developing or purging of wells shall be specified in the site specific plan.

Addtional information on monitoring well installation may be found in the Manual for Groundwater Sampling procedure[1].

### 2.2 Monitor Well Drilling Techniques

Several techniques can be utilized for drilling in connection with the installation of monitoring wells. These techniques include wash

[1]Scalf, M.R., J.F. McNabb, W.J. Dunlap, R.L. Cosby and J. Fryberger, 1981. Manual for Ground Water Sampling Procedures. NWWA.



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borings, auger borings, rotary drilings, or jetting as briefly described below.

2.2.1 Wash Boring

This method involves advancing steel casing by driving and washing out the material to the bottom of the casing with chopping bits. The excavated materials are removed from the borehole by the return flow of water. This drilling technique employs a casing to stabilize the borehole walls. Telescoping of the casing is desirable in some instances to prevent cross contamination between specified layers. Samplers, such as the split spoon or solid tube type, can be driven or pushed into the undisturbed material at the bottom of the borehole to extract subsurface soil samples. The wash boring method is commonly used in soils which do not contain large cobbles and boulders or cemented horizons.

2.2.2 Auger Borings

This method involves advancing helical augers, either solid flight or hollow stem to the required sampling depth. This is a fast method for advancing the borehole, without the use of fluids, in partially saturated or unsaturated materials above the groundwater table. Conventional soil sampling procedures are employed.

Hollow stem augers are advanced hydraulically into the overburden to the top depth of the sample required, the auger acting as a casing. A removable center plug allows passage of the sampling equipment to the required depth. Augers are usually in five-foot sections. Some disturbance of the sampling zone may be created during the augering. Auger borings are not desirable where cross contamination can occur unless a large diameter hollow stem is used, into which a casing can then be telescoped.

2.2.3 Hydraulic Rotary Drilling

This method of drilling boreholes consists of the rotation of a drill bit to excavate the borehole and the continuous circulation of a drill fluid to the bottom of the borehole to retrieve drill cuttings



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and maintain the borehole. The drill bit is attached to the drill pipe (called the drill stem) and rotated from the ground surface by the drill rig. Water and drilling fluid (usually mud) are circulated down the drill stem, out the bit and up the anular space between the borehole and drill stem. Generally, a mud pit or tank at ground surface receives the driling fluid and allows the subsurface drill cutting to settle out.

Well casing is generally not employed during drilling except to maintain an open borehole above the water table or where especially loose formation materials are encountered. Below the water table, in most normal circumstances, the thick drilling muds "pack" open the borehole, permitting placement of well screens and casing after the drill bit and stem are removed from the borehole.

Two common variations of hydraulic rotary drilling are air rotary and reverse circulation rotary. Air rotary is commonly employed in consolidated rock drilling where compressed air of high volume and pressure removes drill cuttings and the borehole remains open due to its consolidated nature. Reverse circulation rotary is a method which uses water along as the drilling fluid with the water flow up the drill stem and down the anular space between the borehole and drill stem (in the opposite direction from hydraulic or straight rotary drilling). In reverse circulation drilling, the hydrostatic pressure of continuous water circulation maintains the borehole prior to screen and casing placement.

Rotary drilling is most similar to another drilling method known as jet drilling or jetting.

### 2.2.4 Jetting

Jetting involves the use of water or drilling muds under pressure to advance the casing. Cuttings are removed in advance of the borehole by the return flow of the drilling fluid. The borehole may be stabilized by the drilling fluid on casing.



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Accurate and precise groundwater quality monitoring requires sophisticated well installations. Several basic design criteria must be followed to insure quality installations in the highly variable geologic conditions encountered.

Well driling methods and equipment are highly specialized, and therefore, well driling crew qualifications, equipment and experience are important to the successful completion of the work. However, well drillers typically only provide operational capabilities; they require the guidance and assistance of the certified geologist or engineer to interpret the application of of the basic criteria to the changing geologic at a given site. In addition, onsite observation of the well driller's operations by an independent party provides a check of specific product details, which are most important to the interpretation of the water quality results obtained. The certified geologist or engineer would provide services including, but not limited to the following:

- All matters pertianing to pay estimates, contractor claims, progress of work, deficiencies.

- Reviewing the contractor's proposed plans, schedule, program, and other data to be submitted in compliance with requirements of a purchase order or specifications, such as any plans for special testing work, soils sampling, developing, grouting, and locking cap devices.

- Reviewing and approving all equipment and methods the contractor proposes to use.

- Records of operation, such as: procurement, storage and installation of all materials and equipment; all well logs, special testing reports, progress reports, equipment reports, safety reports.



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- Observing, measuring, and recording all operational tests such as soil or core sampling, special testing, logging and water sampling.

- Satisfying that information on screen settings and other decisions dependent upon field conditions encountered during the progress of the work are handled expeditiously and promptly and properly transmitted to the Contractor.

## 3.0 PERMANENT SAMPLING DEVICES

In addition to monitoring wells, permanent sampling devices such as "Barcads" or suction lysimeters may be installed in order to obtain groundwater samples. Installation techniques for these devices will be developed recognizing the special requirements of these devices. In general, however, permanent sampling devices will be installed in boreholes excavated using wash bore or augering techniques as discussed previously. Such devices may also be installed in boreholes that have been drilled with other equipment and in boreholes drilled in bedrock where conditions require.

The sampler shall be positioned in the borehole at the desired depth for sampling and packed with clean mono-mineralic filter sand. The method by which sand is added to the borehole and tamped shall be such as not to damage the sampling device.

Normally such devices are utilized where multiple levels groundwater levels are to be monitored and bentonite pellets shall be used to isolate samplers and prevent cross contamination of aquifers. The interval to be sealed will be determined by subsurface strata encountered during the boring and the thickness of the seal and method by which it is installed will be determined based upon the type of boring equipment utilized and the geologic dormation into which it is placed. Groundwater samples should be



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obtained in accordance with procedures outlined by the manufacturer.

Following the placement of a sampling device and bentonite seal, the borehole shall be backfilled with cement grout or material of sufficiently low permeability and of such quality that the potential for contamination from overlying zones is minimized. Similar material shall be placed in the intervals between devices where multiple zones are to be monitored.

## 4.0 SAMPLING FROM A MONITORING WELL

When sampling a monitoring well, the following procedure should be followed:

- Check the well for above ground damage.
- Remove the well cap (a wrench may be needed).
- Measure and record the depth to water and the time of measurement.
- Measure the total depth of the well.
- Remeasure and record the depth of water after a lapse of 4 to 8 minutes following initial measurement and record the depth to water and time of measurement.
- If successive measurements show essentially no difference, continue the sampling procedure. Where the level change is greater than 1/100th ft, delay the remaining procedures until the change observed and recorded is less than that figure.
- Determine the amount of water in the well (depth of water x cross sectional area).
- Purge the well by either removing all the water from the well and allowing it to recover three to ten times, or by removing the equivalent of three to ten well volumes of water. The procedure to be used will be determined by the on-site coordinator on the basis of geologic and/or hydrogeologic conditions and on well construction details. Well purging can be accomplished with centrifugal pumps, peristaltic pumps or



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bailers. The well purging equipment shall be cleaned as described for samplers in Section 4.1 following.

- Clean the sampler as described in the following Section (4.1) immediately prior to inserting it into a well.
- Collect samples using a bailer, pump, or positive pressure sampler dependent upon the general nature of the contaminants of concern. Sampler materials of construction shall be specifically selected for each contaminant.

## 4.1 Sampler Cleaning

Sampler cleaning is to be performed immediately prior to sampling from any well. Any portion of the sampling device which contacts contaminated water shall be cleaned or disposed of between wells. For example, the cable used for bailing shall be subjected to the same cleaning requirement for a length at least equal to twice the depth to the water surface. Where pumps are used, short sections of sample tubing may be disposed of rather than cleaning. The following procedure is followed for cleaning samplers and equipment:

- Rinse with clean tap water.
- Rinse with reagent grade methanol and allow to air dry.
- Rinse at east once with clean tap water.

If appropriate the above procedure can be preceded with a wash with soap (Alconox or Liqinox). Line and cables used to lower samplers into monitoring wells will be disposed of in an appropriate manner dictated by the On-site Coordinator or cleaned and rinsed using the procedures outlined above for cleaning sampling devices. Persons obtaining groundwater samples will wear chemically inert protective gloves to prevent skin contact with sampling devices, lines and cables and potentially contaminated groundwater.

## 4.2 Bailing

A bailer made of PVC, Teflon, or stainless steel can be used to remove the stagnant water in monitoring wells and obtain samples. The problems with this method are: a) cross-contamination between wells can occur; b) the method is time-consuming; and c) contaminants can easily enter the water with many trips up and down the well. Properly used, a bottom filling bailer should not significantly alter the water quality. It is a cost-effective method if the wells are shallow have adequate size for the sampler and only need to be sampled infrequently.

### 4.3.1 Equipment

Bottom Filling Bailer - Stainless steel bailers with inert fittings (such as teflon) shall be used to collect samples. Water enters the bailer through a hole drilled through the bottom end plug and is prevented from draining out by an inert ball check valve. The plug fits tightly inside the bailer and requires no adhesives, which might contaminate the water. A cable made of nickel (or some other noninterfering material) wire is used to raise and lower the bailer.

### 4.3.2 Sampling Procedure

The cable supporting the sampler should be prevented from coming in contact with the water in the well. The bailer should not come in contact with any materials outside of the well casing. When emptying the bailer, a new pair of disposable gloves are to be worn for each individual well sampling.

Samples are carefully poured from the bailer into clean serum bottles or screw-cap vials of appropriate size (usually 40-125 ml), avoiding turbulence, which might result in loss of volatile organics and/or excessive oxygenation of the samples. Care shall also be exercised to eliminate the entry of or contact with any substance and the interior surface of the vials or caps other than the water sample being collected. The containers are topped-off to avoid gas space and tightly closed with teflon-lined septums held in place by



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open-top screw caps. The sample bottles should be prepared with appropriate preservatives prior to sampling. The bailer must be cleaned as described in the previous section before reuse.

4.4 Pumping (for suction lifts up to 25 feet)

The peristaltic pump is the preferred type of pump for sampling groundwater (except when samples for volatile organic analyses are obtained). The pump will not significantly affect the quality of the sampled water, except possibly strip volatile fractions. The water is pumped through chemically tubing (i.e. teflon), therefore, it does not come in contact with the air, nor is a strong vaccum applied to it. The major drawback of this pump is that it cannot be used to pump water from a depth greater than about 25 ft and that it pumps at a relatively low rate (100 ml/minute).

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4.4.1 Equipment

- o Peristaltic pump
- o 1 liter erlenmeyer flask
- o 6 mm I.D. teflon tubing
- o 6 mm O.D. glass tubing
- o 6 mm I.D. tygon tubing

4.4.2 Sampling Procedure

Figure 1 depicts the sampling system which shall be used to obtain samples by pumping.

Groundwater withdrawn through a precleaned 6 mm O.D. teflon tube and discharged into a clean, calibrated one-liter heavy-wall erlenmeyer flask with a peristalic pump on the outlet side of the sampling flask.

The sampled water contacts only teflon and precleaned glass is then carefully transferred to appropriate glass sample containers for shipment to the laboratory. This system shall not be used for samples to be analyzed for volatile organics, because of possible



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stripping of highly volatile constituents from the sample under the reduced occurring in these systems. It may, however, be used for non-volatile constituents such as metals or other organics.

4.5 Positive Pressure Sampling (for greater than 25 feet sampling depth)

A gas-lift sampler can be used in wells where the ground water surface may be greater than 25 ft. below ground surface. The sample pump should be made of glass, PVC, Teflon, or stainless steel, depending on the constituents of interest. For the toxic pollutants, PVC or Teflon is best due to their inertness and ruggedness. Care should be excercised in selecting the pressurizing gas so the water quality is not significantly affected due to the gas-water contact. Note that sample times are typically installed for each sample station.

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4.5.1 Equipment

- o Gas-lift sample pump utilizing tubing and materials lined with glass, PVC, Teflon, or stainless steel.
- o Ultra high purity compressed nitrogen (99.999% pure) (New England Cyrogenics, Newton, MA).
- o Reagent grade methanol.

4.5.2 Sampling Procedure

Compressed nitrogen is regulated into an approximate 1/2-inch diameter nylon tube connected to the sampler in the well. Groundwater that has permeated the sampler is forced up through an approximate 1/4-inch concentric nylon tube and sampled. The pressure and flow of nitrogen will be controlled with the regulator in order that the groundwater sample exists slowly and with a minimum of "spurting" at the end. One volume of groundwater will be flushed out and discarded to clean the tubes and obtain newly permeated groundwater. All sample bottles will be filled directly from the 1/4-inch tubing except in the case of VOA vials where less than 47 ml is released with each sampling. In this situation, a clean transfer



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bottle is filled first and then transferred to the VOA vial, filling carefully and capping tightly so that no air bubbles remain inside. This avoids the introduction of bubbles that would occur from filling directly from a "spurting" groundwater flow.

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# SAMPLING OF ORGANIC VAPORS AND AIRBORNE PARTICULATES

## 1.0 INTRODUCTION

This procedure shall be followed to collect organic vapors and particulates present in ambient air. A known volume of air is drawn through a three-stage sampler consisting of a teflon filter followed by a two-stage Tenax-GC sorbent tube to trap the organic vapors/particulates present. The filter is used to collect pollutants in a solid state or adsorbed on particulate matter and is analyzed separately after sampling. The sorbent is used to collect vaporous analytes. The organics are desorbed from the filter and Tenax thermally, and the sample is analyzed using a coupled gas chromatograph/mass spectrometer.

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## 2.0 EQUIPMENT

### 2.1 Sampling Pump

A calibrated personal sampling pump whose flow can be determined to an accuracy of ± 5% at a low rate of 1.0 to 1.5 l/min is required. The pump is calibrated with a representative sampling assembly in line.

### 2.2 Organic Sampling Filters

The filter assembly consists of a two piece 37 mm filter cassette packed with a teflon coated glass fiber filter (Pallflex Products, Inc. T60A20 or equivalent).

### 2.3 Organic Sampling Tubes

The sampling tube used to collect the sample consists of a glass tube, 10-cm long with a 6-mm I.D. and a 8-mm O.D. packed with two sections of Tenax-GC$^R$. The two sections include a front adsorbing section (100 mg) and a backup section (50 mg). The two sections are separated by a portion of silylated glass wool. A plug of silylated glass wool is placed at each end of the sorbent tube. The pressure drop across the tube must be less than



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one inch of mercury at a flow rate of 1.0 liter per minute. (SKC Inc., CAT #226-35-03 or equivalent).

3.0 PROCEDURE

3.1 A sample size of 150-300 liters is recommended. Sample at a known flow rate of 1.0 liters per minute.

3.2 Immediately before sampling, break open the ends of the tubes.

3.3 The section containing 50 mg of Tenax-GC$^R$ is used as a backup and should be positioned nearest the sampling pump. The tube should be placed in a vertical position during sampling to avoid channeling and subsequent premature breakthrough of the analyte.

3.4 Air sampled should be passed through a teflon coated glass fiber filter before entering the front section of the Tenax-GC$^R$ tube to trap any analyte in particulate form present in the atmosphere.

3.5 Set the flow rate of the pump as accurately as possible using the manufacturer's directions. Record the information necessary to determine flow rate, and also record the initial and final sampling times. Record the temperature and pressure of the atmosphere being sampled.

3.6 The tubes should be firmly sealed with plastic caps immediately after sampling. The filter cassette with the teflon coated glass fiber filter must also be sealed at both ends with caps provided by the manufacturer.

3.7 One Tenax-GC$^R$ tube and teflon filter should be handled in the same manner as the sample tubes except for the taking of an air sample. This sample should be labeled as a blank. Submit one blank for every ten samples, for any batch or partial batch of fewer then ten samples.



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3.8 At least one blind duplicate should be prepared for each sampling set taken per day. A blind duplicate is generated by collecting duplicate field samples (other than a blank) simultaneously at one location and labeling each of the two duplicates with a unique field code, consistent with the field sample coding system, as if they were independent samples.

3.9 A minimum of six unused Tenax-GC[R] tubes and filters should be available for use in desorption efficiency studies in conjunction with these samples, because desorption efficiency may vary from one batch or sorbent to another. Record the batch number of the Tenax-GC and filters used.

4.0 SPECIAL CONSIDERATIONS

4.1 Where two or more compounds are known or suspected to be present in the air, such information, including their suspected identities, should be transmitted with the sample, if possible.

4.2 Due to the high flow resistance of the sampling assembly, this sampling method places a heavy load on the sampling pump. Therefore, no more than five hours of sampling should be done without first recharging the battery.

5.0 SHIPPING INSTRUCTIONS

Capped sample[2] tubes and filter samples should be packed tightly and padded before they are shipped to minimize breakage or leakage during shipping.

6.0 REFERENCES

Pellizari, E.D., "Analysis of Organic Air Pollutants by Gas Chromatography and Mass Spectrometry", EPA-600/2-77-100; U.S. EPA p. 114.



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