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SKINNER LANDFILL

West Chester, Butler County, Ohio

Remedial Design

Final Design (100%)
Phase I Report

Volume IV of IV

May 20, 1996

RUST

SUPPORT PLAN C
SKINNER LANDFILL REMEDIAL ACTION
HEALTH AND SAFETY PLAN

WEST CHESTER, BUTLER COUNTY, OHIO

Rust Environment & Infrastructure of Ohio Inc.
PROJECT NO. 72680.800

May 20, 1996

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1.0 INTRODUCTION

This site specific Health and Safety Plan (HASP) has been prepared for the Skinner Landfill Site in accordance with the regulatory requirements of 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response", 29 CFR 1926.59 for construction, and with the Administrative Order on Consent, dated March 29, 1994, between the United States Environmental Protection Agency (USEPA) and the Potentially Responsible Parties (PRP). This HASP covers field activities being performed as part of the remedial action of the selected remedy for the Skinner Landfill Site.

The purposes of this HASP are to summarize the project organization and responsibilities; establish Standard Operating Procedures (SOPs) for preventing accidents, injuries, and illnesses; identify hazards; discuss the personal protective equipment that may be used at the site; identify personnel health and safety training requirements; summarize the monitoring techniques to be used; establish emergency procedures; describe the medical surveillance program; identify that appropriate first aid equipment is available; provide for accident recordkeeping; and establish a schedule for safety inspections.

The HASP will be implemented by the Site Safety Officer (SSO) as appointed by the Project Manager during site work. Compliance with this HASP is required of all personnel who enter this site. Assistance in implementing this plan can be obtained from the Project Manager and the contractors' Health and Safety Director (s).

Using the HASP Field Modification Form presented in Appendix II, the content of this HASP may change or undergo revision based upon additional information made available to health and safety personnel, monitoring results, or changes in the technical scope of work. Any changes proposed must be approved by the SSO.

The scope of work to be addressed during site remediation activities at the Skinner Landfill includes:

- Earth Moving;
- Cap Installation;
- Interceptor System Installation;
- Installation of Groundwater Extraction Wells, Piezometers and Gas Probes;
- Surface Water Sampling;
- Excavation and Soil Sampling;
- Groundwater Sampling; and
- Surveying.

Project personnel responsible for site activities include:

Name/Affiliation	Title	Work Phone	Home Phone
To Be Named	Project Manager		
To Be Named	Construction Manager		
To Be Named	Construction Quality Assurance Health & Safety Representative		
To Be Named	Prime Contractor Health & Safety Representative		
To Be Named	CQA Consultant Health & Safety Precautions		
To Be Named	Representative of Group Implementing Remedy		
Jamey Bell U.S. EPA	Remedial Project Manager	(312) 886-6436	
Greg Youngstrom Ohio EPA	Site Coordinator	(513) 285-6065	

2.0 SITE LOCATION AND DESCRIPTION

The Skinner Landfill is located approximately 15 miles north of Cincinnati, Ohio near West Chester, Butler County, Ohio in Township 3, Section 22, Range 2. The site is located along Cincinnati-Dayton Road as shown on Figure 1. The site is bordered on the south by the East Fork of Mill Creek, on the north by wooded land, on the east by a Consolidated Railroad Corporation (Conrail) railroad right-of-way, and on the west by the Skinner Creek.

Though the Skinner property is comprised of approximately 78 acres of hilly terrain, only a portion of the site is subject to remedial action. As per the Statement of Work, the remedial action area is generally limited to a fenced area established under the December 9, 1992, Unilateral Administrative Order (UAO) relating to the first operable unit for the site. Throughout this report the remedial action work will refer to this fenced portion of the site.

The site is located in a highly dissected area that slopes from a till-mantled bedrock upland to a broad, flat-bottomed valley that is occupied by the main branch of Mill Creek. Elevations on the

site range from a high of nearly 800 feet above mean sea level (MSL) in the northeast, to a low of 645 feet MSL near the confluence of the Skinner Creek and the East Fork of Mill Creek. Both Skinner Creek and the East Fork of Mill Creek are small, shallow streams. Both of these streams flow to the southwest from the site toward the main branch of Mill Creek. A third on-site stream, Dump Creek, borders the landfill on the east. Dump Creek is intermittent and flows south into the East Fork of Mill Creek. Three shallow ponds are also located on the site.

In general, the site is underlain by relatively thin glacial drift over interbedded shales and limestones of Ordovician age. The composition of the glacial drift ranges from intermixed silt, sand and gravel, to silty, sandy clays; and its thickness ranges from zero to over 40 ft on the site. The sand and gravel deposits comprise the hills and ridges and are encountered near the surface of the central portion of the site. The silts and clays usually occur as lenses in the sands and gravel or directly overlie bedrock.

2.1 Site History and Background

The property was originally developed as a sand and gravel mining operation, and was subsequently used as a landfill from 1934 to 1990. According to U.S. EPA studies, materials deposited at the site include demolition debris, household refuse and a wide variety of chemical wastes. The waste disposal areas include a now-buried waste lagoon near the center of the site and a landfill. According to U.S. EPA studies, the buried waste lagoon was used for the disposal of paint wastes, ink wastes, creosote, pesticides, and other chemical wastes. The landfill area, located north and northeast of the buried lagoon, received predominantly demolition and landscaping debris.

In 1976, the Ohio EPA (OEPA) initiated an investigation of the site in response to reports of a black oily liquid that was observed during a fire call to the site. Before the OEPA could complete the investigation, the landfill owners, the Skinners, covered the lagoon with a layer of demolition debris. Mr. Skinner further dissuaded the OEPA from accessing the site by claiming that nerve gas, mustard gas, and explosives were buried in the landfill. The OEPA requested the assistance of the U.S. Army after obtaining this information. Mr. Skinner later retracted his statements concerning buried ordnance, and an U.S. Army records review performed in 1992 did not reveal any evidence of munitions disposal at the site.

In 1982, the site was placed on the National Priority List by the U.S. EPA based on information obtained during a limited investigation of the site. The investigation indicated groundwater contamination had occurred as a result of the buried wastes. In 1986, a Phase I Remedial Investigation was conducted that included sampling of groundwater, surface water and soil, as well as a biological survey of the East Fork of Mill Creek and Skinner Creek. A Phase II Remedial Investigation was conducted from 1989 to 1991 and involved further investigation of groundwater, surface water, soils and sediments. A Baseline Risk Assessment and Feasibility Study (FS) were completed in 1992.

The Phase II Remedial Investigation revealed that the most contaminated media at the site is the soil from the buried waste lagoon. Lower levels of contamination were also found in soils on other portions of the site and in the groundwater, and very low levels were found in the sediments of the Mill Creek, the Skinner Creek, the Duck Pond, and the Diving Pond. Migration of the landfill constituents has been limited, and the Phase II Remedial Investigation concluded that there had been no off-site migration of landfill constituents via groundwater flow.

3.0 ASSIGNMENT OF HASP RESPONSIBILITY

The following describes the health and safety designations and general responsibilities that will be implemented for the Skinner Landfill remedial activities.

3.1 Potentially Responsible Parties

The USEPA or Group implementing the remedy will have authority over approval of workplans and proposed field work. The PRP Technical Committee has conducted a review of this document and other portions of the work plan. Representatives of the Group implementing the remedy may be present on-site to review site work as it progresses. They will be kept informed of any major health and safety or emergency issues during the site activities.

3.2 Regulatory Agencies

The United States Environmental Protection Agency (USEPA) and the Ohio Environmental Protection Agency (OEPA) are the regulatory agencies who will have the authority to conduct site visits and inspections during field activities. The agencies will be informed of major health and safety issues or emergencies that occur at the site.

3.3 Site Safety Officers and Site Coordinators

A Site Safety Officer (SSO) will be appointed by each of the contractors to provide health and safety oversight for their own personnel. In addition, a primary SSO will report to and be appointed by the Project Manager. The primary SSO will be responsible for implementing the HASP. The SSOs may direct or participate in on-site activities as appropriate when this does not interfere with primary SSO responsibilities. The primary SSO has stop-work authorization which he/she will execute upon determination of an imminent safety hazard, emergency situation, or other potentially dangerous situations, such as detrimental weather conditions. Authorization to proceed with work will be issued by the SSO in conjunction with the appropriate contractor health and safety personnel and the Project Manager.

3.4 Contractor Health and Safety Personnel

It is anticipated that the contractors will have a Health and Safety chain-of-command within their company structure. It will be the contractor's responsibility to communicate this chain-of-command to field personnel and to coordinate health and safety activities with the Site Coordinator.

3.5 Subcontractors

It is anticipated that subcontractors will be utilized for this project to perform on-site activities. Some activities will involve heavy equipment. On-site subcontractors will comply with the requirements outlined in this HASP and in accordance with OSHA 29 CFR 1910 and 29 CFR 1926; but, in all cases, subcontractors will be responsible for site safety related to and affected by their own field operations (i.e. heavy equipment operations). Two weeks prior to entry onto the site, contractors will provide the Site Coordinator with proof of their training, medical qualifications, and respirator fit test results.

3.6 Drillers

Prior to the start of site activities, the lead driller along with the primary SSO will "clear" and locate utilities before intrusive activities begin. The lead driller will be responsible for site safety related to or affected by field operations. Presented in Appendix V are additional safety protocols for working with drilling equipment.

4.0 HAZARD ASSESSMENT

This section describes the potential hazards associated with activities at the Skinner Landfill. Chemical and physical hazards are described.

4.1 Waste Description/Characterization

The following chemical information is presented to identify the types of materials that may be encountered at the Skinner Landfill Site. The detailed information on these materials was obtained from:

- ACGIH, Threshold Limit Values and Biological Exposure Indices
- Chemical Data Sheets
- NIOSH Pocket Guide to Chemical Hazards
- Merck Index
- 29 CFR1910 OSHA Standards for General Industry
- 29 CFR 1926 OSHA Standards for Construction

Presented in Table 1 is a list of chemicals and compounds that have been identified in media on-site in previous investigations. Exposure limits for the materials of concern are presented in Table 1. Chemical Data Sheets for the most prevalent of these compounds, providing information such as the chemical's characteristics, health hazards, protection exposure limits, and first aid procedures are presented in Appendix III. The general characteristics of on-site chemicals include:

Waste Types:	Liquid__X____	Solid_____X___	Gas_____
	Sludge__X____	Semi-Solid_X____	Other___X___
Characteristics:	Corrosive_____	Flammable_X____ (landfill gas including methane)	
	Explosive_____	Volatile___X___	
	Radioactive____	Inert_____	
	Other_____	Toxic_____X___	

The Skinner Landfill site could pose a number of potential health and safety concerns during the activities covered by this HASP. These concerns are based on site-specific sampling information and general hazard information applicable to most landfills:

- Volatile organic compounds
- Semivolatile/Base-neutral organics
- Herbicides/Pesticides/PCBs
- Inorganics/Metals
- Oxygen deficiency
- Landfill gas (methane gas/hydrogen sulfide)
- Leachate seeps
- Physical hazards associated with landfills and project trenching, and excavation operation activities.
- Physical and chemical hazards associated with drilling through/near landfill material.

A hazard assessment of each of these health and safety concerns is provided below:

Volatile Organic Compounds

Volatile organic compounds (VOCs) present in the landfill material, the contaminated groundwater, and in the landfill gas may require respiratory protection. VOCs detected at the Skinner Landfill are listed in Table 1. These substances can enter the unprotected body by inhalation, skin absorption, or ingestion. Exposures are generally divided into two categories, acute and chronic. Symptoms from acute exposures usually occur shortly after exposure to a high concentration of a contaminant. The concentration required to produce effects varies from chemical to chemical. Some exposures to these contaminants may cause symptoms such as burning, coughing, nausea, eye irritation, or rashes. Chronic effects may include organ damage and in some cases cancer.

Semivolatile/Base-Neutral Organics

Semivolatile organics identified on the site include a number of coal tar pitch volatiles such as benzo(a)pyrene, phthalates, napthlanene, and phenol. Under typical site conditions, these materials are not anticipated to volatilize into the breathing zone. Exposure to these materials is more likely via dermal contact or incidental ingestion. Coal tar pitch volatiles are suspect carcinogens. Other effects include skin irritation or dermatitis and irritation to the mucus membranes.

Herbicides/Pesticides/PCBs

Other organic material detected on the site include PCBs, DDT, aldrin and dieldrin. These compounds are typically not volatile and potential exposure is via inhalation of contaminated dust, dermal contact or incidental ingestion. Exposure effects include central nervous system effects such as dizziness, headaches, trembling etc. Chronic exposure to PCBs and pesticides include organ damage and cancer.

Inorganics/Metals

Inorganics identified at the site include: arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, nickel, vanadium, zinc, and cyanide. Some of the heavy metals identified were at or near levels expected in background soils and bedrock. Cyanide detections have been limited. In general, exposures to heavy metals can cause respiratory and central nervous system effects when inhaled or ingested. Some metals are suspected carcinogens and have the potential to impact organs such as the liver, kidneys and brain. The most likely route of exposure on the site of these chemicals is via inhalation and incidental ingestion of contaminated dust. Surficial contamination of the site is limited. Cyanide exposure can lead to central nervous system effects and organ damage. Higher concentrations of cyanide can lead to asphyxiation.

Oxygen Deficiency

Microbial activity in a landfill which produces methane gas uses available oxygen, thus producing an oxygen deficient air or atmosphere. Effects of oxygen deficiency in humans are impaired attention, drowsiness, nausea and vomiting, brain damage, unconsciousness and death. Concentrations of less than 19.5 percent oxygen are consisted to be oxygen deficient.

Landfill Gas

Methane gas which is produced by microbial activity in a landfill may act as a hazardous compound in two ways. First, methane is a flammable gas and may combust when ambient concentrations are between 5 and 15 percent. Second, methane displaces the oxygen normally breathed in the air and is therefore a simple asphyxiant. There is no smell to methane, and it is not irritating to eyes, nose, or throat; however, methane in landfill gas is easily detected by the indicative odor of decomposing

refuse. If inhaled in large quantities, dizziness, difficulty in breathing, and loss of consciousness may occur.

Hydrogen sulfide has a strong rotten egg odor; however, exposure over time desensitizes the sense of smell, therefore, the worker cannot be relied upon to provide warning to the degree of exposure. Hydrogen sulfide affects the respiratory system, lungs and eyes, and causes dizziness, headache, and fatigue.

Leachate Seeps

Leachate seeps are common around landfills; however, on the Skinner site, large areas of leachate outbreaks have not been identified. Leachate can irritate skin and may have an odor. It is commonly 10 to 100 times more polluted than raw wastewater. Any liquid either ponded on or seeping from a waste fill is leachate. Personnel should avoid contact with leachate.

Other Potential Hazards

The contaminants of concern at the site can affect the body if they are inhaled, come in contact with the eyes or skin, or are ingested. These compounds may be released during earth moving, excavation or drilling activities. The primary concern is for skin exposure to contaminated soils and water and potential inhalation of organic vapors or dust released during soil intrusive activities. Atmospheric monitoring will be conducted during all phases of on-site field activities to determine the need for upgrading to appropriate levels of respiratory protection. Exposure by skin absorption is a low to moderate possibility, but can be prevented by use of proper protective equipment and good hygiene practices.

Construction and drilling activities provide potential for encountering buried hazards such as utilities. Clearance will be obtained from the local utility company regarding underground cables before digging is initiated as appropriate. Overhead electrical lines will also be identified. Drilling activities that go through fill material will be at an increased risk due to the relative unknown nature of the fill material in specific locations. Historical site information indicates that drums were buried on the site; however, based on information gathered during previous investigations it is not anticipated that buried drums will be encountered during these field activities.

Physical hazards that may be encountered at the site during field activities include overhead utility lines and tripping hazards. Physical hazards at the site may include:

- Slope stability is a concern due to the heterogeneous nature of solid waste. Beware of all but the most gentle of slopes.

- Open holes may result from differential settlement, trenching activities or excavations from the installation of environmental controls.

- Confined space is a concern due to landfill gas, toxic vapors, and low oxygen levels. Any low area, manhole, or vault is likely to contain landfill gas and/or low oxygen content.

- Protruding objects are common on the surface of landfills - Puncture Hazard.

- Open trenches, trenching and excavation activities. The SSO will establish safe distances for personnel working on the ground near open trenches or trenching activities. Under no circumstances should personnel enter open trenches or excavations. If samples must be collected from trenches, a remote sampling device or equipment bucket will be used to retrieve the sample.

Depending on seasonal weather conditions, there is potential for workers on-site to be affected by heat stress if site activities are scheduled for the summer months or cold exposure if activities are conducted during winter months. A discussion of adverse weather conditions is described in the Contingency Plan, provided as Support Plan F.

Noise related to construction and drilling operations is expected to be minimal; however, as a precaution, hearing protection will be available when working near heavy equipment. Contractors will be responsible for assessing the noise exposures of their workers.

If dusty conditions exist during site activities, the work zone area may be sprayed with a water mist in order to provide dust control. Water use should be kept to a minimum to prevent accumulation or run-off of surface water. Dust control methods are discussed further in the Air Monitoring Plan, provided as Support Plan E.

5.0 TRAINING REQUIREMENTS

5.1 Basic Training Required

Personnel who are required to work in areas where the potential for toxic exposure exists will complete training or have site experience conforming to the requirements of 29 CFR 1910.120(e). Personnel working outside the limits of waste where there is limited potential for exposure and no intrusive work is planned are not required to have full training; however, these personnel may only enter the site under the direction and approval of the SSO.

The 40-hour course describes procedures for working at hazardous waste sites. These procedures include a health and safety program, medical surveillance, decontamination, site characterization and analysis, protective clothing and monitoring equipment, site control work documentation, emergency response, engineering and administrative control to reduce exposure, and site safety evacuation procedures. Personnel will have had refresher training, as required and at least one on-site person will hold a supervisor's training certificate. Training certificates will be maintained on-site by the SSO either in the field office trailer or in the SSO support vehicle.

Contractors/subcontractors will provide written documentation that these training/experience requirements have been met. All personnel will also be trained in the contents of Appendix IV, "Respirator Program for Skinner Landfill Investigation."

5.2 Site-Specific Training

Site-specific training will be provided to employees to minimize on-site hazards. This training will address the activities, procedures, monitoring, and equipment for the field operations, and will include identifying the names of personnel and alternate personnel responsible for site safety, and facility layout.

At a minimum, this training, will include the following:

1. Site description and history
2. Project activities, including project goals and coordination with other contractors
3. Hazard evaluation
4. On-site safety responsibilities
5. Site control and work zones (WZ)
6. Personnel training
7. Medical monitoring
8. Atmospheric monitoring
9. Personnel protection, clothing, and equipment
10. Decontamination procedures
11. Emergency procedures
12. Review of site-specific material safety data sheets (MSDS's)
13. Safe work practices
14. Other elements covered in this site-specific HASP

This training will also allow field workers to clarify anything they do not understand and to reinforce their responsibilities regarding safe operations. Training must include emergency preparedness, location of assembly areas, proper entry and exit procedures for exclusion zone (EZ), warning systems, location of emergency equipment, and route to hospital. Site safety meetings will be documented using the Site Safety Meeting Form presented in Appendix II (HASP Field Forms).

5.3 Safety Briefings

Project personnel will be given briefings by the SSO on a daily basis to further assist site personnel in conducting their activities safely. Briefings will be provided when new operations are to be conducted, changes in work practices must be implemented due to new information made available, or if site or environmental conditions change. Briefings will also be given to facilitate conformance with prescribed safety practices when performance deficiencies are identified during routine daily activities or as a result of safety audits.

5.4 Safety Audits

The contractor safety personnel or Site Coordinator, as deemed necessary, may conduct regular safety audits of field operations and subcontractor performance to review for compliance with health and safety policies and procedures. Daily operations will adhere to the protocols outlined in this HASP and will be enforced by the SSO.

5.5 First Aid and CPR

At least two individuals working on the site will be trained and qualified to administer first aid and CPR. These courses will be consistent with requirements of the American Red Cross and/or American Heart Association.

6.0 MEDICAL SURVEILLANCE PROGRAM

All personnel and subcontractors performing field work at the site will be required to have passed a pre-assignment and/or periodic medical examination that is consistent with 29 CFR 1910.120(f). A release for work will be confirmed by the Site Coordinator before an employee can begin hazardous site activities.

Additional medical testing may be required in consultation with the company physician if an overt exposure or accident occurs, or if other site conditions warrant further medical surveillance.

Contractors/subcontractors will maintain the medical records for their own employees, but will also provide written documentation certifying that each employee at the site has met the requirements of the Medical Surveillance Program. This documentation will be provided before the first day of work for each employee assigned to the site. The pre-assignment and annual examinations are essentially the same in content and will include:

- An updated medical and occupational history
- A screening physical examination
- Blood and urine laboratory tests
- Chest x-ray
- Electrocardiogram
- Pulmonary function tests
- Audiometry
- Visual acuity test

The physician has the authority to include other tests.

6.1 Emergency Medical Treatment

Provisions for emergency medical treatment will be integrated with the overall Site Emergency and Contingency Plan and will include:

- At least two individuals per shift qualified to render first aid and CPR
- First aid kits and portable eye wash stations in compliance with OSHA requirements and emergency first aid stations in the immediate work vicinity
- Conspicuously posted phone numbers and procedures for contacting ambulance services, fire department, police, and medical facilities
- Maps and directions to Mercy Hospital, Fairfield.

7.0 SITE CONTROL MEASURES

The purpose of the site control measures discussed in this section are to maintain order at the site and to minimize chemical and physical hazards to on-site personnel, visitors, and the public. Site control zones (CZ) will include an exclusion zone (EZ), a contamination reduction zone (CRZ), and a support zone (SZ). In addition, temporary activity-specific work zones (WZs) will be established at specific locations.

7.1 Exclusion Zone

The EZ is the area containing or suspected of containing contaminated materials. At Skinner, Landfill, the EZ will include all areas within the limits of waste. Access to the site is controlled via a locking gate.

Personnel who will be working within the fenced area but outside the limits of waste and who do not have the full 40-hour training must be accompanied by the SSO or a designee while on-site.

7.2 Work Zones (WZs)

Temporary activity-specific WZs may be established at each work location or drilling location at the discretion of the SSO. During the activity, each specific WZ will be established and marked by safety rope or tape. A CRZ will be placed at the WZ perimeter at an upwind location. A portable eye wash unit, first aid kit, fire extinguisher, towels, plastic garbage bags, and decontamination supplies will be placed in this CRZ.

Work Zone Entry and Exit Logs are to be completed on a daily basis. An example of this log is presented in Appendix II.

7.3 Personnel Decontamination

Personnel decontamination areas will be established on-site. Personnel will decontaminate and/or dispose of soiled protective clothing (i.e. disposable boots and gloves, etc.) in the CRZ established next to the temporary WZ. Refer to Section 10.0 for further decontamination procedures.

7.4 Equipment Decontamination Area

To prevent off-site transport of contamination, drill rigs, heavy equipment and associated equipment and vehicles will be decontaminated at a fixed decontamination area before exiting the EZ. A decontamination pad will be constructed on-site. In addition, some decontamination may occur immediately adjacent to the work zone in the CRZ. Drill equipment (augers, rods, etc.) will be steam-cleaned at the fixed decontamination area, as necessary. Decontamination liquids will be collected at the decontamination area within the EZ and allowed to percolate into the landfill material prior to emplacement of the cap. If decontamination liquids are generated after emplacement of the cap, these will be collected and containerized for off-site disposal. Refer to Section 10.1 for further decontamination procedures.

7.5 Support Zone

The SZ is considered the uncontaminated area and will be identified by the SSO and Project Manager when field activities begin. It will contain the Command Post which will provide for team communications and emergency response. A mobile telephone will be located in this area. The Support Zone will be located outside the limits of waste but may be located within the fenced area.

7.6 Site Visitors

Visitors are required to report to the SSO or Project Manager prior to accessing the site. The SSO or Project Manager will determine the purpose of individual visits, and will document decisions regarding their access to the site. If granted limited access, visitors must sign in and out under the SSO or Project Manager's direction daily for the duration of their approved visit. A copy of the Daily Sign-In/Out Log is provided in Appendix II. Under no circumstances will visitors be allowed to interfere with or participate in operations within the scope of the field investigation.

As needed, the SSO will establish a designated Level D area as an observation point for visitors during intrusive activities. This designated area will be located to offer proximate viewing of site operations, and positioned such that visitors in no way may inhibit site access, logistics, or general operations. Further, the Site Coordinator will locate the viewing areas such that visitors present are at minimal risk of exposure to site hazards.

Prior to gaining access to designated viewing areas described above, visitors must provide the SSO with documented compliance with Section 5 (Training) of the HASP, comply with other applicable

sections, and satisfy additional conditions placed on them, as deemed appropriate by the SSO to assure visitor safety. Site visitors will be escorted throughout the site by the Project Manager or SSO.

8.0 PERSONAL PROTECTIVE EQUIPMENT

8.1 General

Personal protective equipment (PPE) for general operations will be consistent with the requirements of 29 CFR 1910 Subpart I, "Personal Protective Equipment." Basic levels of protection for hazardous waste operations will be selected in accordance with the provisions of 29 CFR 1910.120(g)(3), "Personal Protective Equipment Selection," and 1910.120 Appendix D, "General Description and Discussion of the Levels of Protection and Protective Gear". Modification to basic PPE ensembles may be necessary for specific operations. In these cases, further definition will be provided by review of specific hazards, conditions, and proposed operational requirements and by conducting monitoring at the particular operation may be upgraded or downgraded, as deemed appropriate by the SSO.

8.2 Anticipated Levels of Protection for Site Operations

• Heavy Equipment Operation	Initiated in Level D
• Construction Activities Involving Soil Contact	Initiated in Modified Level D
• Surveying	Initiated in Level D
• Groundwater Extraction Well, Piezometer Installation and Gas Probe Installation	Initiated in Modified Level D
• Groundwater and Surface Water Sampling	Initiated in Level D
• Soil Sampling from excavations	Initiated in Level D

Level D personal protective clothing and equipment includes:

- Long sleeve shirt and pants or work coveralls.
- Tyvek disposable coveralls - required for Modified Level D.
- Polycoated disposable tyvek coveralls - required for Modified Level D in sampling areas when splashing by contaminated soils or water is a possibility and for leachate/sediment sampling.
- Hardhat required during drilling and when other overhead hazards exist.
- Safety glasses or goggles - required.

- Steel toe, steel shank boots - required.
- Disposable latex gloves - required when handling and collecting soil, water and leachate.
- Outer nitrile gloves - required when handling and collecting soil, water and leachate.
- Disposable outer boots - required for Modified D.
- Noise protection - as warranted.

Level C protective clothing and equipment includes:

- Full-face air-purifying respirator or full-face powered air-purifying respirator (NIOSH/Mine Safety Health Administration (MSHA) approved) fitted with acid gas/organic vapor/High Efficiency Particulate Air (filter) (HEPA) cartridges.
- Hart hat required during drilling and when other overhead hazards exist.
- Disposable tyvek coveralls - required.
- Polycoated disposable tyvek coveralls - required in areas where splashing by contaminated soils or water is a possibility.
- Disposable latex inner gloves.
- Nitrile outer gloves.
- Steel toe, steel shank boots.
- Disposable outer boots.

Level B PPE, includes the above Level C clothing with the addition of a self-contained breathing apparatus (SCBA) or supplied air-line respirator in place of an air-purifying respirator. Based on previous site activities, it is not anticipated that Level B will be required for these field activities. If action levels are exceeded, and based on evaluation of the conditions, Level B respiratory protection is deemed necessary, work activities will be halted and the contractor safety representative(s) will be contacted immediately before upgrading the levels of protection.

The use and care of respiratory protection will be in accordance with the protocols described in Appendix IV. If Level B is required for an extended period of time, the SSO will set up and monitor the cascade system for the supplied air-line.

Action levels used to determine the need to upgrade or downgrade the levels of protection are described in Section 9.8 of this HASP.

9.0 AIR MONITORING

9.1 General

It will be necessary to monitor the atmospheric conditions during on-site field sampling activities to determine the possible need to upgrade the personal protection of on-site workers. Atmosphere in the breathing zone (BZ), at the sample extraction point, and soil cuttings will be monitored. Instrument readings will be documented using the Atmospheric Monitoring Data Record presented in Appendix II.

9.2 Construction Activities with Soil, Groundwater or Waste Contact

These activities will be initiated in Modified Level D protection with the contingency to downgrade or upgrade the level of protection based on the action levels.

Monitoring will be performed continuously during the excavation and drilling activities. A Flame Ionization Detector (FID) or photoionization detector (PID) will be used to monitor the BZ. If a FID is used, methane detection will be screened out so other volatile organic detections are not masked. A Combustible Gas Indicator (CGI) equipped with an oxygen alarm and hydrogen sulfide detector will be used to monitor for the presence of combustible gases. (If action levels are exceeded, direct-read colormetric tubes may also be used to screen for the presence of benzene and vinyl chloride to determine if the action level can be raised). A beta/gamma radiation detector will be used to screen soil at the discretion of the SSO. Prior to use of this instrument, background will be established at several local offsite locations.

9.3 Heavy Equipment Operation

These activities will be initiated in Level D protection with the contingency to downgrade or upgrade the level of protection based on the action levels. If these activities involve movement of landfill waste and equipment operators have the potential to come in contact with waste materials, then personnel will upgrade to Modified Level D PPE.

Monitoring will be performed at the initiation of the activity. A Flame Ionization Detector (FID) or photoionization detector (PID) will be used to monitor the BZ. A radiation detector for beta and gamma radiation will be used to screen these activities.

9.4 Surveying, and other Non-Intrusive Activities

These activities will be initiated in Level D protection with the contingency to upgrade the level of protection based on the action levels.

The PID or FID will be used to monitor the general BZ of workers. Monitoring will be performed at the initiation of each day's field activity and at approximate intervals established by the primary SSO thereafter. Should elevated levels of compounds be encountered, the SSO will increase the frequency of monitoring. If surveying involves the removal of a well cap, the well will be allowed to vent prior to the initiation of activities and the well will be screened using the PID or FID prior to the survey work.

9.5 Groundwater Extraction Well, Piezometer Installation and Gas Probe Installation

These activities will be initiated in Modified Level D protection with the contingency to downgrade or upgrade the level of protection based on the action levels.

Monitoring will be performed continuously during the drilling activities. A Flame Ionization Detection (FID) or photoionization detector (PID) will be used to monitor the BZ, the borehole, and all geological samples upon their retrieval. If a FID is used, methane detection will be screened out so other volatile organic detections are not masked. Drill cuttings and fluids produced during drilling will also be monitored. A Combustible Gas Indicator (CGI) equipped with an oxygen alarm and hydrogen sulfide detector will be used to monitor the borehole for the presence of combustible gases. Any soil cutting or fluids produced during drilling will also be monitored using a PID and/or FID. (If action levels are exceeded, direct-read colormetric tubes may also be used to screen for the presence of benzene and vinyl chloride to determine if the action level can be raised). A beta/gamma radiation detector will be used to screen soil samples obtained from the borings. At least one soil sample from each boring will be screened with this instrument. Prior to use of this instrument, background will be established at several local offsite locations.

9.6 Groundwater and Surface Water Sampling

These activities will be initiated in Level D protection with the contingency to downgrade or upgrade the level of protection based on the action levels. Monitoring will be performed at the initiation of the sampling activity at each sampling location. For groundwater sampling, the well cap will be removed and the well will be permitted to vent approximately 5 minutes prior to the initiation of sample collection. An FID or PID will be used to monitor the BZ and the well opening.

9.7 Soil Sampling from Excavation

These activities will be initiated in Level D protection with the continency to downgrade or upgrade the level of protection based on the action levels. At no time during the sampling should personnel

enter the excavation. Samples will be obtained using the equipment bucket or other remote sampling device.

Monitoring will be performed continuously during the trenching or excavation activities. A Flame Ionization Detector (FID) or photoionization detector (PID) will be used to monitor the BZ, the trench/pit and all samples upon their retrieval. If an FID is used, methane detection will be screened out so other volatile organic detections are not masked. Soil removed from excavation will also be monitored periodically. A Combustible Gas Indicator (CGI) equipped with an oxygen alarm and hydrogen sulfide detector will be used to monitor the trench for the presence of combustible gases. (If action levels are exceeded direct-read colormetric tubes may also be used to screen for the presence of benzene and vinyl chloride to determine if the action level can be raised).

9.8 Action Levels

Instrumentation will include the PID and/or an Organic Vapor Analyzer (OVA) FID. A CGI equipped with an oxygen, hydrogen sulfide and lower explosive level will be used to monitor the WZs and BZs at each site. The action levels in this HASP will apply to all site work during the duration of activities at the site. If action levels are exceeded then direct-read colormetric tubes may be used to monitor for the presence of benzene and vinyl chloride. Action levels for direct-reading instruments in the BZ are as follows:

Instrument	Action Levels	Levels of Respiratory Protection/Action
PID (11.7 Ev)/OVA	Continuous readings of background to 1 ppm in BZ (can increase to 3 ppm if no benzene or vinyl chloride is detected with direct-read tubes)	Level D
PID (11.7 Ev)/OVA*	Continuous readings of 1 ppm above background to 5 ppm in BZ	Level C (based on identification of contaminant)
PID (11.7 Ev)/OVA*	Continuous readings of 5 to 250 ppm above background in BZ	Level B (if Level C is not appropriate for contaminant identified)
CGI	10% LEL	Proceed with caution
CGI	Greater than 20% LEL	Halt work, ventilate, begin work only after levels are below 20%
Oxygen	Less than 19.5%	Halt work, ventilate, begin work only after levels maintain 19.5%-21.0%
Hydrogen Sulfide**	Greater than 10 ppm	Halt work, ventilate, begin work only after levels fall below 10 ppm

Instrument	Action Levels	Levels of Respiratory Protection/Action
Radiation Detector (Beta & Gamma)	Greater than 2 times established background	Halt work in area of radiation detection. Contact Site Coordinator.

* In the event action levels are exceeded, work activities will be halted and an attempt will made to identify the contaminants present using colorimetric indicator tubes. Colorimetric-tubes will be available for benzene, and vinyl chloride so that correct respiratory protection can be selected. The primary SSO will notify the Project Manager immediately and prior to upgrading the level of respiratory protection.

** Typical landfill gas, not detected previously on-site.

If visible dust is detected while working in Level D, upgrading to Level C PPE is required. However, site controls such as wetting down the work zone with water to control dust can be implemented. In the event atmospheric concentrations exceed accepted levels, ventilating the work area may also be attempted to continue working in Level D or other methods for controlling dust are described in the Air Monitoring Plan, included in Support Plan E.

9.6 Exposure Monitoring/Air Sampling Program

It is not anticipated that migration of contaminants off-site will be of concern due to the low concentrations of contaminants found on-site. However, to ensure contaminants are not released off the site during field activities, limited perimeter monitoring will be conducted in accordance with the Air Monitoring Plan (Support Plan E). It will be left to the discretion of each contractor as to the applicability of personnel monitoring for their employees. Procedures for personnel monitoring are also described in the AMP.

9.7 Instrument Calibration & Maintenance

Instrument calibration and maintenance will be performed according to manufacturer's specifications which will be maintained on-site and documented on Field Instrument Calibration Logs. PID/FID calibration will be completed on a daily basis or more frequently by the primary SSO or other designated personnel. Combustible gas/oxygen/hydrogen sulfide meter will be calibrated according to the manufacturer's recommended frequency (i.e., daily or weekly).

10.0 DECONTAMINATION PROCEDURES

The primary SSO will determine the level of decontamination necessary based on the evaluation of specific work activities and the potential degree of contamination encountered. Temporary contamination reduction zones (CRZs) will be established at the same work locations.

10.1 Equipment

Heavy equipment, drill rigs and associated equipment and vehicles will be decontaminated at the designated decontamination area within the exclusion zone (EZ). Drilling equipment will be steam-cleaned between each well location and prior to leaving the site. Prior to leaving the site, trucks and heavy equipment will pass through a wheel wash. Decontamination rinse waters will be handled in accordance with Section 7.4 and SOP-3 of the FSP.

Hand tools and other small equipment will be decontaminated by the following procedure:

- Remove soil by scraping
- Washing equipment with potable water and a non-phosphate detergent
- Rinse with clean potable water
- Rinse with organic-free deionized water
- Air dry

10.2 Personnel

Personnel will perform decontamination in the personnel decontamination area upon leaving an established work zone or leaving the project site. The personnel decontamination areas will be established by the primary SSO at the exit of the work zones. Decontamination of personnel in Level D will consist of removal and disposal of coveralls (when worn), disposable boots, and gloves. Decontamination of personnel using Level C protective equipment will consist of:

- Removal and disposal of boot covers.

- Removal and disposal of coveralls.

- Removal and disposal of outer gloves.

- Removal, cleaning and storage of respiratory equipment.

- Washing boots or other nondisposable protective equipment (i.e., hard hat, safety glasses/goggles, etc.) suspected of being contaminated using soap solution followed by potable or distilled water rinse.

- Removal and disposal of inner gloves.

10.3 Contamination Prevention

One of the most important aspects of decontamination is the prevention of contamination. Good contamination prevention should minimize worker exposure and help ensure valid sample results by precluding cross-contamination. Procedures for contamination avoidance include:

Personnel

- Know the limitations of all PPE being used.
- Do not walk through areas of obvious or known contamination.
- Do not handle or touch contaminated materials directly. Do not sit or lean on potentially contaminated surfaces.
- Make sure all PPE has no cuts or tears prior to donning.
- Fasten all closures on suits, covering with tape, if necessary.
- Take particular care to protect any skin injuries.
- Stay upwind of airborne contaminants.
- Do not carry cigarettes, gum, food, or candy into contaminated area.
- Do not smoke, eat, or drink in contaminated area.
- Shower at the hotel or home at the end of the work day.

Sampling/Monitoring

- Cover instruments with clear plastic, leaving openings for sampling ports, sensor points, as required by site conditions.
- Bag sample containers prior to placement of sample material into containers, as required by site conditions.

Heavy Equipment

- Limit the surface area of equipment that comes into contact with contamination.

General

- If contaminated tools are to be placed on noncontaminated equipment for transport to the decontamination pad, use plastic to keep the noncontaminated equipment clean.

- Keep drill cuttings shoveled out of the way of workers. Direct liquids generated during the drilling out of the way to limit the amount of mud created around the rig.

10.4 Disposal Procedures

Discarded materials, waste materials, or other field equipment and supplies will be handled in such a way as to preclude the potential for spreading contamination, creating a sanitary hazard, or causing litter to be left on-site. Potentially contaminated materials, e.g., clothing, gloves, etc., will be bagged or drummed with appropriate labeling affixed as regulated, and segregated for disposal. Noncontaminated materials will be collected, bagged, and disposed of as normal domestic waste. Decontamination water from personnel decontamination activities will be collected and then either added to equipment decontamination water which will be allowed to percolate into the landfill material.

11.0 GENERAL SAFE WORK PRACTICES AND COMMUNICATIONS

11.1 Safety Equipment

Basic emergency and first aid equipment will be available at the SZ and/or the CRZ, as appropriate. This will include communications equipment, first aid kit, emergency eye wash, fire extinguisher, and other safety-related equipment.

11.2 Communications

Telephones - A mobile telephone will be located in the SZ for communication with emergency support services/facilities. This telephone will be kept in the site trailer.

Hand Signals - Hand signals will be used by downrange field teams in conjunction with the buddy system. These signals are very important when working with heavy equipment. They will be known by the entire field team before operations commence and reviewed during site-specific training.

Signal	Meaning
• Hand gripping throat	Out of air; can't breathe
• Grip partner's wrist	Leave area immediately; no debate
• Hands on top of head	Need assistance
• Thumbs up	OK; I'm all right, I understand
• Thumbs down	No; negative

11.3 Safe Work Practices

The following safe work practices will be implemented during site operations:

- Only properly trained and equipped personnel will be allowed to work in potentially contaminated areas.
- The number of personnel and equipment in the sampling areas will be kept to a minimum, consistent with safe site operations.
- Workers will adhere to the "buddy system" while working downrange and in designated exclusion areas. Radio contact will be maintained between pairs on-site in order to assist each other in case of emergencies when working in anything but Level D PPE.
- Workers will not exit exclusion areas until soiled equipment and clothing have been removed and decontaminated or properly disposed of.
- Eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth transfer; ingestion, and inhalation of potentially contaminated materials is prohibited.
- As necessary, personnel will thoroughly wash their hands and faces upon leaving the investigation areas.
- Contact with potentially contaminated materials and surfaces will be avoided. Personnel will comply with contamination control measures.
- Personnel with facial hair or other facepiece seal obstructions will not be permitted to work where respirators are required.

- Work will only be conducted if adequate illumination is provided, i.e, visual observation is not impaired due to loss of daylight conditions.

- Sampling personnel will not work near rotating augers. Drillers will inform personnel working with drilling activities of the emergency stop device.

12.0 EMERGENCY PREPAREDNESS

The Contingency Plan, Support Plan F, provides a description of emergency situations that may arise on-site. This plan covers community contacts, fire and explosions, first-aid, hazardous material release, and adverse weather conditions.

12.1 Emergency Service Contacts

The Emergency Coordinator will verify appropriate emergency service contacts within the community and communicate with these contacts before beginning work on-site. The Emergency Coordinator will inform the emergency service contacts about the nature and duration of work expected on the site and the type of contaminants and possible health or safety effects of emergencies involving these contaminants. Also at this time, the Emergency Coordinator and the emergency response contacts will make arrangements to handle any emergencies that might be anticipated.

EMERGENCY PHONE NUMBERS:

Police Department	911 (513) 777-5126 (Union Twsp. Non-emergency)
Fire Department	911 (513) 777-5216 (Union Twsp. Non-emergency)
Hospital	(513) 870-7000 Mercy Hospital Fairfield
Hospital Address	3000 Mack Road
National Response Center	(800) 424-8802
Project Manager	
Site Safety Officer	
Construction Quality Assurance Consultant Health & Safety Representative(s)	
Prime Contractor Health & Safety Representative(s)	

Implementor's Representative	
U.S. EPA Representative	Jamey Bell (312) 886-6436
OEPA Representative	Greg Youngstrom (513) 285-6065
OEPA - Emergency Spills	(800) 282-9378
National Response Center Releases	(800) 424-8802
Butler County Emergency Management Agency	(513) 887-3472
Union Township Trustees	Nell Kilpatrick-Administrative Assistant (513) 777-5900
West Chester Coalition on Skinner Cleanup	(513) 779-4424
Union Elementary School	(513) 777-2201
Butler County Planning Commission	(513) 887-3413

HOSPITAL ROUTE:

From the site, turn right (north) on Cincinnati-Dayton Road to the I-75 intersection and take I-75 South. Proceed on I-75 to I-275 West. Take I-275 West to the Winton Road Exit (at Forest Fair Mall) and take the north exit. Travel north on Gilmore Road (Winton Road south of the freeway) to Mack Road. Turn right (east) on Mack Road and the Mercy Hospital Fairfield will be on the left (north) side of the road at 3000 Mack Road. A map to the hospital is provided on Figure 2. Approximate travel time is estimated to be 15 to 20 minutes from the site to the hospital.

12.2 Evacuation and Communication

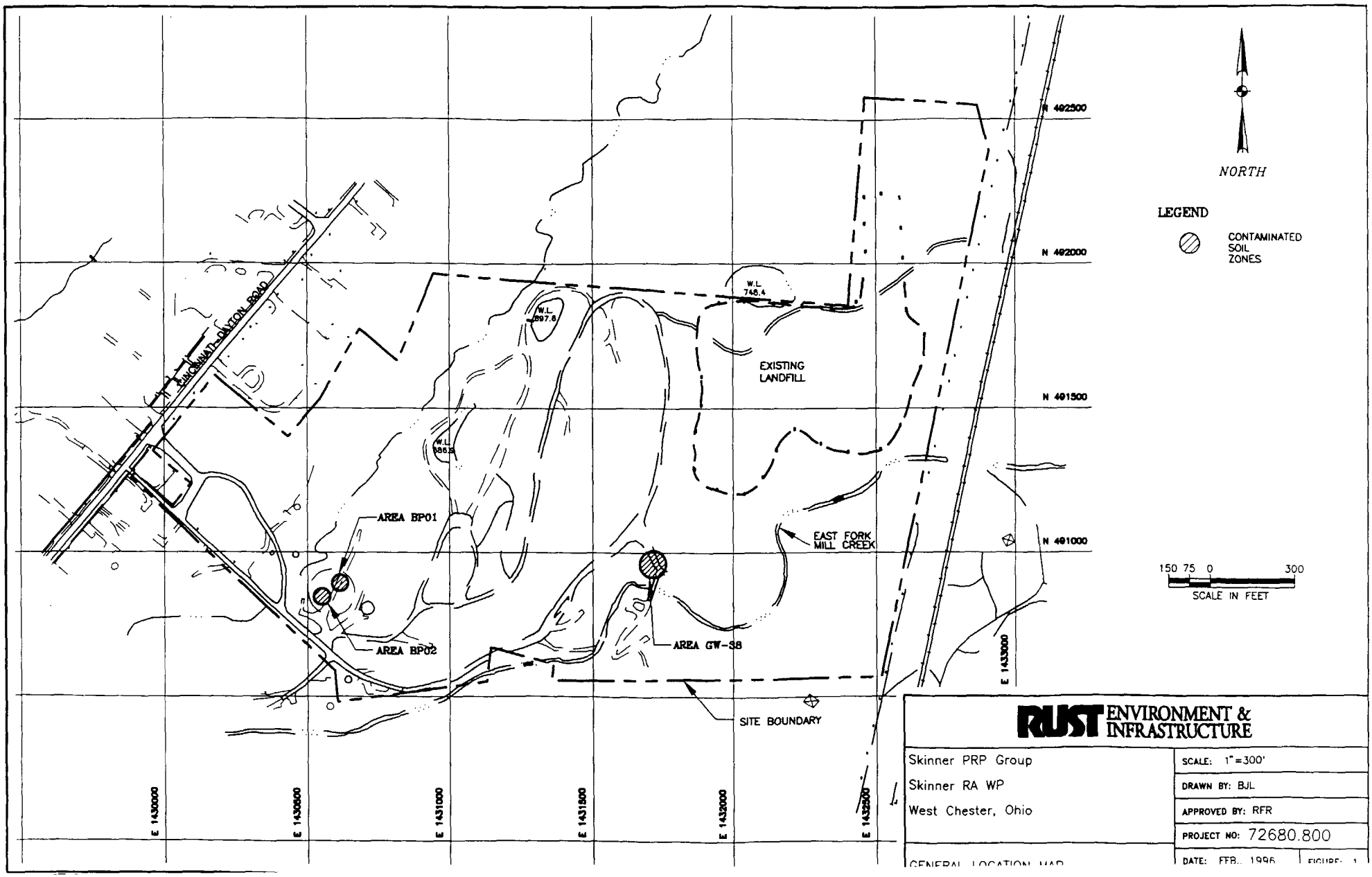
Site Vehicles will be equipped with mobile telephones. Personnel can contact local emergency assistance and appropriate project personnel via the mobile telephones. This list of emergency service contacts will be maintained in each site vehicle. Should the SSO determine that evacuation is required, a single, long horn blast will be utilized to signal workers to move to the site exit gate.

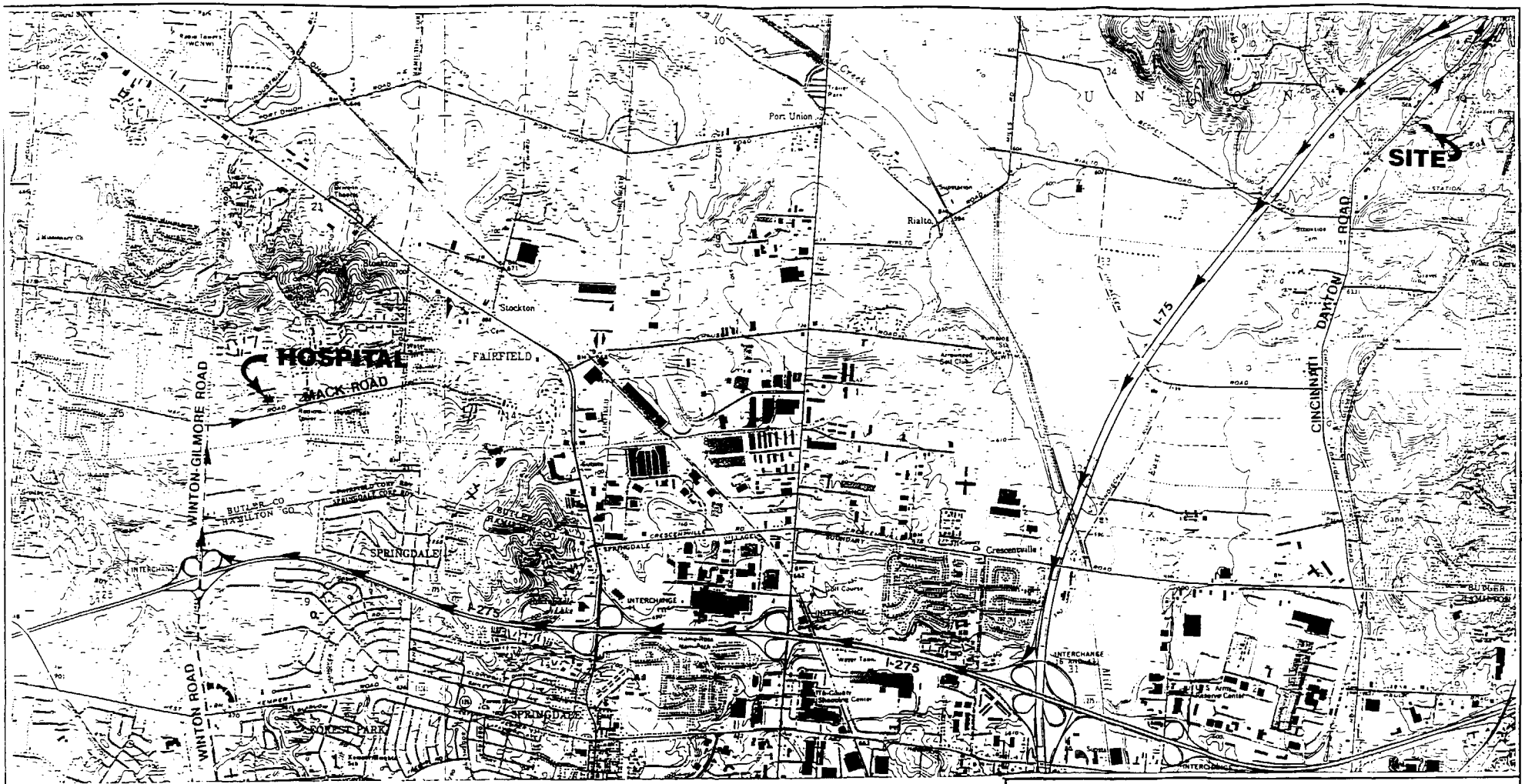
13.0 RECORDKEEPING

The following records and reports will be established and kept in the site trailer as appropriate for the (Skinner Landfill) remedial activities:

- Accident/Incident Reports
- Daily Sign In/Sign Out Log
- Air Monitoring Records
- Sample Manifest/Transmittal (Chain of Custody Form)
- Employee Training Certificates
- Employee Exposure Record
- Site-Safety Orientation Log
- Health and Safety Audit Reports
- Instrumentation Calibration Logs
- Material Safety Data Sheets/Chem Data Sheets or Hazardlines
- Medical Data Sheets (to be sent with injured personnel to hospital)
- Medical Examination Reports (Physician's Written Opinion)
- Respirator Fit Test Records
- Respirator Inspection Records
- Site Safety Meeting Form
- Work Zone Entry and Exit Logs

Figures


NORTH
LEGEND
CONTAMINATED SOIL ZONES
150 75 0 300
SCALE IN FEET
N 492500
N 492000
N 491500
N 491000
E 1430000
E 1430500
E 1431000
E 1431500
E 1432000
E 1432500
E 1433000
CINCINNATI-DAYTON ROAD
W.L. 897.6
W.L. 748.4
W.L. 886.9
EXISTING LANDFILL
EAST FORK MILL CREEK
AREA BP01
AREA BP02
AREA GW-38
SITE BOUNDARY
RUST ENVIRONMENT & INFRASTRUCTURE
Skinner PRP Group
Skinner RA WP
West Chester, Ohio
SCALE: 1"=300'
DRAWN BY: BJL
APPROVED BY: RFR
PROJECT NO: 72680.800
DATE: FEB., 1996
FIGURE: 1
GENERAL LOCATION MAP



BASE MAP SOURCE USGS QUADRANGLES GLENDALE, OHIO AND GREENHILLS, OHIO PHOTOREVISED IN 1987 AND 1981 RESPECTIVELY

QUADRANGLE LOCATION

1/4 1/8 0 1/4 1/2 1

SCALE IN MILES
1" = 1/2 Mile

N

DIRECTIONS TO HOSPITAL: FROM THE SITE TURN RIGHT (NORTH) ON CINCINNATI-DAYTON ROAD. TURN LEFT (SOUTH) ONTO I-75. FOLLOW I-75 TO I-275 WEST. TAKE I-75 TO THE WINTON ROAD EXIT (EXIT 39). WINTON ROAD BECOMES GILMORE ROAD AT THE BUTLER COUNTY BORDER. TAKE THE NORTHERN EXIT AND TRAVEL NORTH ON GILMORE ROAD TO MACK ROAD. TURN RIGHT (EAST) ONTO MACK ROAD. THE HOSPITAL IS LOCATED ON THE LEFT (NORTH) SIDE OF THE ROAD AT 300 MACK ROAD.

RUST ENVIRONMENT & INFRASTRUCTURE

Skinner Landfill West Chester, Butler County, Ohio Health and Safety Plan	SCALE: 1" = 1/2 Mile
	DRAWN BY: BJL
	APPROVED BY: KSH
	PROJECT NO: 72680.200
HOSPITAL ROUTE MAP	DATE: MAY 1994 — FIGURE: 2

Tables

TABLE 1
EXPOSURE LIMITS
SKINNER LANDFILL

Compound	PEL	TLV	STEL	IDLH	Carcinogen	IP(eV)	LEL/UEL (%)
Arsenic	0.005 mg/m^3	0.01 mg/m^3	NE	100 mg/m^3	Y	NA	NA
Barium	0.5 mg/m^3	0.5 mg/m^3	NE	1100 mg/m^3	N	NA	NA
Cadmium	0.2 mg/m^3	0.01 mg/m^3	NE	50 mg/m^3	Y	NA	NA
Chromium	1 mg/m^3	0.5 mg/m^3	NE	NE	N	NA	NA
Cobalt	0.1 mg/m^3	0.05 mg/m^3	NE	20 mg/m^3	N	NA	NA
Copper	1 mg/m^3	1 mg/m^3	NE	NE	N	NA	NA
Lead	0.05 mg/m^3	0.15 mg/	NE	700 mg/m^3	N	NA	NA
Manganese	5 mg/m^3**	5 mg/m^3	NE	NE	N	NA	NA
Nickel	1 mg/m^3	1 mg/m^3	NE	NE	Y	NA	NA
Vanadium	0.5 mg/m^3**	0.05 mg/m^3	NE	70 mg/m^3	N	NA	NA
Zinc	15 mg/m^3	10 mg/m^3	NE	NE	N	NA	NA
Cyanide	5 mg/m^3	5 mg/m^3*	NE	50 mg/m^3	N	NA	NA
Acetone	100 ppm	750 ppm	1000 ppm	20,000 ppm	N	9.69	2.5/13
Benzene	10 ppm	10 ppm	NE	3,000 ppm	Y	9.24	1.3/7.9
2-Butanone	200 ppm	200 ppm	300 ppm	3,000 ppm	N	9.54	1.4/11.4
Carbon Tetrachloride	10 ppm	5 ppm*	10 ppm	300 ppm	Y	11.47	NA
Chlorobenzene	75 ppm	10 ppm	NE	2,400 ppm	N	9.07	1.3/9.6
Chloroethane	1000 ppm	1000 ppm	NE	20,000 ppm	N	10.97	3.8/15.4
Chloroform	50 ppm**	10 ppm	NE	1,000 ppm	Y	11.42	NA
1,1 - dichloroethane	100 ppm	100 ppm	NE	4,000 ppm	N	11.06	5.6/?
1,2 - dichloroethane	50 ppm	10 ppm	NE	1,000 ppm	Y	11.05	6.2/16
1,1 - dichloroethene	NE	5 ppm	20 ppm	NE	N	9.6	5.6/12.8
1,2 - dichloropropane	75 ppm	75 ppm	110 ppm	2,000 ppm	Y	10.87	3.4/14.5
Ethyl benzene	100 ppm	100 ppm	125 ppm	2,000 ppm	N	8.76	6.8/8.0
Methylene chloride	500 ppm	50 ppm	NE	5,000 ppm	Y	11.32	14/22
Styrene	100 ppm	50 ppm*	100 ppm	5,000 ppm	N	8.40	1.1/7.0
Tetrachloroethene	100 ppm	25 ppm	100 ppm	500 ppm	Y	9.32	NA

TABLE 1
EXPOSURE LIMITS
SKINNER LANDFILL - CONTINUED

Compound	PEL	TLV	STEL	IDLH	Carcinogen	IP(eV)	LEL/UEL (%)
1,1,2,2 - tetrachloroethane	5 ppm*	1 ppm*	NE	150 ppm	Y	11.10	NA
Toluene	200 ppm	50 ppm*	NE	2,000 ppm	N	8.82	1.2/7.1
1,1,1 - trichloroethane	350 ppm*	350 ppm	450 ppm	1,000 ppm	N	11.00	7.5/12.5
1,1,2 - trichloroethane	10 ppm*	10 ppm *	NE	500 ppm	N	11.00	NA
Trichloroethene	100 ppm	50 ppm	100 ppm	1,000 ppm	N	9.45	8/10.5
Vinyl Chloride	1 ppm	5 ppm	NE	NE	Y	9.99	3.6/33
Xylene	100 ppm	100 ppm	150 ppm	1,000 ppm	N	8.56	1.0/7.0
bis (2-chloroethyl) ether	15 ppm	5 ppm	10 ppm	250 ppm	Y	NA	NA
bis (2-ethyl hexyl) phthalate	5 mg/m^3	5 mg/m^3	10 mg/m^3	NE	Y	NA	0.3/?
Butyl benzyl phthalate	NE	NE	NE	NE	NE	NA	NA
Coal Tar Pitch Volatiles***	0.2 mg/m^3	0.2 mg/m^3	NE	700 mg/m^3	Y	NA	NA
Di-n-butyl phthalate	5 mg/m^3	5 mg/m^3	NE	9300 mg/m^3	N	NA	0/5/?
Diethyl phthalate	NE	5 mg/m^3	NE	NE	N	NA	NA
4-methyl phenol (cresol)	5 mg/m^3*	5 mg/m^3	NE	250 ppm	N	8.93	1.1/?
2-methyl naphthalene	NE	NE	NE	NE	NE	NA	NA
Napthalene	10 ppm	10 ppm	15 ppm	500 ppm	N	8.12	0.9/5.9
Phenol*	5 ppm*	5 ppm*	NE	250 ppm	N	8.5	1.8/?
Aldrin	0.25 mg/m^3	0.25 mg/m^3*	NE	100 mg/m^3	Y	NA	NA
Arochlor 1254 (PCB)	0.5 mg/m^3*	0.5 mg/m^3*	NE	10 mg/m^3	Y	NA	NA
4,4' - DDD	NE	NE	NE	NE	Y	NA	NA
4,4' - DDE	NE	NE	NE	NE	NE	NA	NA
4,4' - DDT	1 mg/m^3*	1 mg/m^3	NE	NE	NA	NA	NA
Dieldrin	0.25 mg/m^3	0.25 mg/m^3*	NE	450 mg/m^3	Y	NA	NA
1,2-dichlorobenzene	50 ppm**	25 ppm	50 ppm	1000 ppm	N	9.06	2.2/9.2
1,4-dichlorobenzene	75 ppm	10 ppm	NE	1000 ppm	Y	8.98	NA
Endrin	0.1 mg/m^3	0.1 mg/m^3*	NE	2000 ppm	N	NA	NA
Hexachlorobenzene	NE	0.025 ppm	NE	NE	N	NA	NA

TABLE 1
EXPOSURE LIMITS
SKINNER LANDFILL - CONTINUED

Compound	PEL	TLV	STEL	IDLH	Carcinogen	IP(eV)	LEL/UEL (%)
Hexachlorobutadiene	0.02 ppm	0.02 ppm*	NE	NE	Y	NA	NA
Heptachloronorborene	NE	NE	NE	NE	NE	NA	NA
Methane	NE	NE	NE	NE	N	12.6	5/15
Hydrogen Sulfide	20 ppm	10 ppm	15 ppm	300 ppm	N	10.46	4.0/44

NOTE: NA - Not Applicable/Not Available
NE - Not Established
PEL - Permissible Exposure Limits (OSHA)
TLV - Threshold Limit Values (ACGIH)
STEL - Short-Term Exposure Limits (ACGIH)
IDHL - Immediately Dangerous to Life or Health (NIOSH)
IP - Ionization Potential
LEL/UEL - Lower Explosive Limit/Upper Explosive Limit
* Skin Notation: Potential for dermal absorption
** Ceiling Limit
*** Includes the following on-site chemicals: anthracene, benzo (a) anthracene, benzo (b) fluorathene, benzo (k) fluoranthene, benzo (a) pyrene, benzo (g,h,i) perylene, chrysene, fluoranthene, indeno (1,2,3-cd) pyrene, pyrene

APPENDIX I
AUTHORIZATIONS AND FIELD TEAM REVIEW

AUTHORIZED PERSONNEL

Personnel autnorized to enter the Skinner Landfill area while field activities are being conducted must be authorized by the RHSS. Authorization will involve completion of appropriate training courses and medical examination requirements as required by OSHA 29 CFR 1910.120, current fit-testing, and review and signing of this HASP. All personnel must be escorted by appropriately trained personnel, and check in with the Field Team Leader at the Command Post.

PERSONNEL AUTHORIZED TO PERFORM WORK ON-SITE:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

OTHER PERSONNEL AUTHORIZED TO ENTER SITE:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

FIELD TEAM REVIEW

Each field team member will sign this section after site-specific training is completed and before being permitted to work on site.

I have read and understand this Site Health and Safety Plan. I will comply with the provisions contained therein.

Site/Project: **Skinner Landfill**

Name Printed	Signature	Date

RUST ENVIRONMENT & INFRASTRUCTURE

Health and Safety Plan
Field Modification Form

Page No. _____ of _____

Project: _____

Project Location: _____

Project No.: _____

Site Safety Officer: _____

Field Modification To HASP: _____

Prepared By: _____
Site Safety Officer — Date

Accepted By: _____
RUST Environment & Infrastructure Field Manager — Date

Accepted By: _____
Contractor Representative (If Applicable) — Date

Approved By: _____
RUST Environment & Infrastructure Regional Health and Safety Specialist or Alternate HASP Reviewer — Date

NOTE: Field Modifications to HASPs must be discussed with the RUST Environment & Infrastructure RHSS or CHSM with subsequent written approval. Secure approval through fax.

RUST ENVIRONMENT & INFRASTRUCTURE

Respirator Fit Testing

NAME_____ SS#_____ DATE_____

TITLE _____ BRANCH _____ DEPT._____

TEST/HOOD ENCLOSURE USED: YES____ NO_____

Irritant Smoke Fit Testing:

No. of Squeezes	Activity	Reaction	
____	Initial	Yes____	No____
____	Head/Neck Motion	Yes____	No____
____	Motion/Talking	Yes____	No____
____	Motion/Deep Breathing	Yes____	No____
____ (Total Squeezes)			

Seal Obtained ____

Type of Cartridge Used _____

Type of Respirator _____

Size of Respirator _____

Testing Performed By _____ Date _____

Employee Signature _____ Date _____

xc: Branch
Corporate File

RUST ENVIRONMENT & INFRASTRUCTURE

Supervisor's Incident Report

Date of this report: ____/____/____

Fax this report within 24 hours to RUST International Inc.: 708-947-3781 *Telephone: 708-947-3525*
Attention: Claims Management Department

Group: G01 (RUST E&I) **Region:** _____ **Office/Division:** _____

TYPE OF INCIDENT: Inspection:____ Accident:____ Injury:____ Spill:____ Fire:____ Other:____
Agency: _____ Inspector's Name: _____ Type Inspection: _____
Agency Address: _____ Phone: _____

EMPLOYEE INFORMATION:
Employee's Name: _____ Social Security No: _____
Address: _____ Phone: _____
Date of Birth: _____ Number of Minor Dependents:____ Marital Status: Single ____ Widowed ____ Married ____ Divorced ____
Date of Hire: _____ Wage Rate: $_____ Hourly: ____ Annually: ____ Job No.: _____
Employee Hours on Date of Incident: ____ Employee Hrs. on Project: ____ Days/Wk.: ____ Hrs./Day: ____
Employees Occupation When Incident Occurred?: _____ Years of Experience in This Occupation?: _____

INCIDENT INFORMATION:
Date of Incident: _____ Time: _____ Witness(s): _____
Date Reported to Supervisor: _____ Was Incident Believed to be Result of Employment?: Yes ____ No ____
If on Job Site, Name of Job: _____ Location on Job Site Where Incident Occurred: _____
Address Where Incident Occurred: _____
If First Aid Applied, by Whom: _____
Type of Injury and Part of Body Affected?: _____
Name/Address Medical Provider: _____
Brief Description of Incident: _____

Employee Activity at Time of Incident: _____

Description of Property Damaged: _____

OSHA 200 LOG INFORMATION:

Is incident OSHA recordable?: Yes ☐ No ☐
Does incident involve fatality?: Yes ☐ No ☐
Does incident involve lost time/restricted activity?: Yes ☐ No ☐
Does incident involve medical treatment?: Yes ☐ No ☐
Does incident involve first aid only?: Yes ☐ No ☐
Current Status: _____

Employee's Supervisor: _____ Project Manager: _____

RUST ENVIRONMENT & INFRASTRUCTURE

Chain of Custody Record

Custody Seal #	RUST E&I Cooler #

Project Number	Project Name/Client

Sample Custodian: (Signature)

Item No.	Sample Description (Field ID Number)	Date	Time	Grab	Comp.	PID Reading (ppm)	Label Number	Analysis Required												Matrix: Sample Type					Matrix: Sample Container				
1																													
2																													
3																													
4																													
5																													
6																													
7																													
8																													
9																													
10																													
11																													
12																													
13																													
14																													
15																													
16																													
17																													
18																													
19																													
20																													

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Disposed of by: (Signature)	Items:	Date/Time
Relinquished by: (Signature)	Date/Time	Received by: (Signature) [Laboratory]	Disposed of by: (Signature)	Items:	Date/Time

Send Lab Results To:	Remarks:	Check Delivery Method:	Laboratory Receiving Notes:
	Federal Express Airbill No.: Lab:	☐ Samples delivered in person ☐ Common carrier	Custody Seal Intact? Temp. of Shipping Container: Sample Condition:

RUST ENVIRONMENT & INFRASTRUCTURE

Air–Purifying Respirators
Assignment and Service Log

Respirator Type (Full-face Or Half-face): _____

Manufacturer: _____

Model Number: _____

Size: _____

Date Assigned: _____

Assigned To Whom: _____

Inspection And Maintenance Record (To Be Maintained By Employee)

Date	Serviced By

Note: After each project, submit completed form to your Division Safety Representative.

RUST **Rust Environment & Infrastructure**

Atmospheric Monitoring Log
Field Health and Safety

Page ____ of ____

Date ____/____/____

Circle: Sun Mon Tue Wed Thu Fri Sat

Site: _____ Project No.: _____

Site Safety Officer: _____

Action Levels: D ☐ → C ☐ → B ☐ → (stop work, call in for instructions on all upgrades)

(Check box and write in levels for upgrade)

Task/Equipment: _____

Weather: _____

Location	Time	O_2 %	LEL %	H_2S PPM	Circle one: HNu/OVA Readings (ppm)				Comments
					Back ground	Breathing Zone	Sample Location	Head Space	

Additional Comments: _____

Signature: _____

Checked by: _____ Date: ____/____/____

NOTE: Place in project files.

RUST ENVIRONMENT & INFRASTRUCTURE

Air Monitoring Data Record

Project: _____
Project No.: _____
Date: _____
Page No.: _____

LOCATION SKETCH

METEOROLOGICAL DATA

Estimated Wind Speed (MPH): _____

Wind Direction (Time): _____

Temp. (Min.): _____ (Max.) _____

General Weather Conditions: _____

_____

Pump No.	Flow Rate L/Min.	Location	Pump Start	Pump End	Total Min.	Total Volume	Taken By

Signature: _____

Comments:

RUST ENVIRONMENT & INFRASTRUCTURE

Instrument Calibration Log

INSTRUMENT: _____

Date Calibrated	Known Standard	Actual Instrument Reading	Adjustments Made	Calibrated By	Comments

COMMENTS: _____

RUST ENVIRONMENT & INFRASTRUCTURE

Record of Respiratory Wear (OSHA Record)

Page _____ of _____

Week Ending ___/___/___

Employee Name: _____ Employee No.: _____

Client/Project Site: _____

Date (1)	Project Number	Time in Respirator (Hours)	Instrument Reading (2) (HNU or OVA)	Type of Respirator (3)
Totals				

Comments: _____

Notes:

(1) Record on a daily basis
(2) If worn because of dusty conditions – Note "Dusty Conditions"
(3) Level C or B

_____
Site Safety Officer Approval

Submit to your Office/Division Safety Representative (SR) on a Weekly basis

RUST ENVIRONMENT & INFRASTRUCTURE

Site Safety Meeting

Page _____ of _____

Project: _____ Date: _____

Project Number: _____ Time: _____

Meeting Conducted By: _____ _____

Name Signature

Summary Of Items Discussed: _____

_____

_____

_____

_____

Personnel Present

	Name	Representing	Signature
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			

RUST ENVIRONMENT & INFRASTRUCTURE

Work Zone Entry And Exit Log (Job Exposure Report)

Note: Complete this form when action levels are exceeded in the Breathing Zone (BZ).

Project: _____
Project No.: _____
Site Safety Officer: _____
Date: _____

Time In	Time Out	Name/Firm	Site Location	HNU/OVA Readings (In Breathing Zone)	Level PPE (D/C/B)

Note: This form is to be completed on a daily basis by all on-site personnel working within a work zone when action levels are exceeded in the BZ.
Submit this log to your Regional Health and Safety Specialist on a weekly basis.

RUST ENVIRONMENT & INFRASTRUCTURE

Daily Sign–In/Out Log

Project: _____
Project Location: _____
Project No.: _____
Site Safety Officer: _____
Date: _____
Page No.: _____

Time In	Time Out	Name	Firm	Purpose On–Site

Note: This form is to be completed on a daily basis by all personnel working on the site.

CHEMICAL NAME
ARSENIC

FORMULA
AS

SYNONYMS
UN 1558
ARSENIC, SOLID
COLLOIDAL ARSENIC
ARSENIC BLACK
GREY ARSENIC
METALLIC ARSENIC
ARSENIC, METALLIC
ARSENICALS
ARSENIC-75
OHS01980

PERMISSIBLE EXPOSURE LIMIT
10 UG(AS)/M3 OSHA TWA
200 UG(AS)/M3 ACGIH TWA
2 UG(AS)/M3 NIOSH RECOMMENDED 15 MINUTE CEILING
POSITIVE HUMAN CARCINOGEN (IARC, NTP)
INDEFINITE ANIMAL CARCINOGEN (IARC, NTP)
REPRODUCTIVE EFFECTS DATA (RTECS)
MUTAGENIC DATA (RTECS)
TUMORIGENIC DATA (RTECS)
SURVEILLANCE INDEX CLASSIFICATION I: HIGH HEALTH HAZARD
CERCLA HAZARD RATING - TOXICITY 3 - IGNITABILITY 0 - REACTIVITY 0 - PERSISTENCE 3

TOXICOLOGY: ARSENIC IS AN EYE, SKIN AND MUCOUS MEMBRANE IRRITANT AND A SKIN SENSITIZER. IT IS A NEUROTOXIN. POISONING MAY AFFECT THE HEART, GASTROINTESTINAL SYSTEM, KIDNEYS, AND LIVER. CHRONIC EXPOSURE TO ARSENIC COMPOUNDS MAY CAUSE A GENERALIZED MUSCULAR WEAKNESS, BRONZING OF THE SKIN, MEE'S LINES IN THE FINGERNAILS, AND A FEELING OF PINS AND NEEDLES IN THE EXTREMITIES. EVIDENCE FOR CARCINOGENICITY OF ARSENIC COMPOUNDS IN ANIMALS IS CONSIDERED INADEQUATE. THERE IS SUFFICIENT EVIDENCE THAT SKIN CANCER IN HUMANS IS CAUSALLY ASSOCIATED WITH EXPOSURE TO INORGANIC ARSENIC COMPOUNDS IN DRUGS, DRINKING WATER, AND THE OCCUPATIONAL ENVIRONMENT. THE RISK OF LUNG CANCER WAS INCREASED 4 TO 12 TIMES IN CERTAIN SMELTER WORKERS WHO INHALED HIGH LEVELS OF ARSENIC TRIOXIDE. HOWEVER, THE INFLUENCE OF OTHER CONSTITUENTS OF THE WORKING ENVIRONMENT CANNOT BE EXCLUDED. CASE REPORTS HAVE SUGGESTED AN ASSOCIATION BETWEEN EXPOSURE TO ARSENIC COMPOUNDS AND BLOOD DISEASES AND LIVER TUMORS.

THE THRESHOLD LIMIT VALUE WAS SET BASED ON THE PROBABILITY THAT SOME ARSENIC COMPOUNDS, OR THE METAL ITSELF, IS CHRONICALLY LESS TOXIC THAN ARSENIC TRIOXIDE.

THERE IS EVIDENCE THAT ARSENIC MAY CROSS THE PLACENTAL BARRIER.

IPR-GPG LDLO: 10 MG/KG
SCU-GPG LDLO: 300 MG/KG
SCU-RBT LDLO: 300 MG/KG
ORL-MAN TDLO: 7857 MG/KG/55 YEARS

IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONCENTRATION
NONE SPECIFIED

PHYSICAL DESCRIPTION
SILVER-GRAY BRITTLE, CRYSTALLINE SOLID THAT DARKENS IN MOIST AIR

CHEMICAL AND PHYSICAL PROPERTIES
MOLECULAR WEIGHT: 74.9
BOILING POINT AT 1 ATM, F: SUBLIMES AT 1135 F
SOLUBILITY IN WATER, G/100 G WATER AT 20C: INSOLUBLE
FLASH POINT, CLOSED CUP, F (OR OPEN CUP IF 0C): NONFLAMMABLE
VAPOR PRESSURE @ 20 C, MMHG: 0 MM
MELTING POINT, F: 1503 F AT 28 ATM
UPPER EXPLOSIVE LIMIT IN AIR, % BY VOLUME: NONFLAMMABLE
LOWER EXPLOSIVE LIMIT IN AIR, % BY VOLUME: NONFLAMMABLE
SPECIFIC GRAVITY: 5.727 AT 57 F

INCOMPATIBILITIES
OXIDIZERS
BROMATES
CHLORATES
CHROMIUM TRIOXIDE
SILVER NITRATE
SODIUM PEROXIDE
NITROGEN TRIFLUORIDE
ACIDS
HALOGENS (BROMINE, CHLORINE, IODINE, FLUORINE)
ALKALI METALS (SODIUM, POTASSIUM, LITHIUM)
ACETYLIDES
ZINC
PALLADIUM
PLATINUM
HYDROGEN GAS
THERMAL DECOMPOSITION PRODUCTS ARE HAZARDOUS AND/OR TOXIC
METAL IN POWDERED FORM IS EXPLOSIVE

PERSONAL PROTECTIVE EQUIPMENT
29CFR1910.1018 INORGANIC ARSENIC
(J) PROTECTIVE WORK CLOTHING AND EQUIPMENT
(1) PROVISION AND USE. WHERE THE POSSIBILITY OF SKIN OR EYE IRRITATION FROM INORGANIC ARSENIC EXISTS, AND FOR ALL WORKERS WORKING IN REGULATED AREAS, THE EMPLOYER SHALL PROVIDE AT NO COST TO THE EMPLOYEE AND ASSURE THAT EMPLOYEES USE APPROPRIATE AND CLEAN PROTECTIVE WORK CLOTHING AND EQUIPMENT SUCH AS, BUT NOT LIMITED TO:
(I) COVERALLS OR SIMILAR FULL-BODY WORK CLOTHING;
(II) GLOVES, AND SHOES OR COVERLETS;
(III) FACE SHIELDS OR VENTED GOGGLES WHEN NECESSARY TO PREVENT EYE IRRITATION, WHICH COMPLY WITH THE REQUIREMENTS OF 29CFR1910.133(A)(2)-(A)(6); AND
(IV) IMPERVIOUS CLOTHING FOR EMPLOYEES SUBJECT TO EXPOSURE TO ARSENIC TRICHLORIDE.
(2) CLEANING AND REPLACEMENT.
(I) THE EMPLOYER SHALL PROVIDE THE PROTECTIVE CLOTHING REQUIRED IN PARAGRAPH (J)(1) OF THIS SECTION IN A FRESHLY LAUNDERED AND DRY CONDITION AT LEAST WEEKLY, AND DAILY IF THE EMPLOYEE WORKS IN AREAS WHERE EXPOSURES ARE OVER 100 UG/M3 OF INORGANIC ARSENIC OR IN AREAS WHERE MORE FREQUENT WASHING IS NEEDED TO PREVENT SKIN IRRITATION.
(II) THE EMPLOYER SHALL CLEAN, LAUNDER, OR DISPOSE OF PROTECTIVE CLOTHING REQUIRED IN PARAGRAPH (J)(1) OF THIS SECTION.
(III) THE EMPLOYER SHALL REPAIR OR REPLACE THE PROTECTIVE CLOTHING AND EQUIPMENT AS NEEDED TO MAINTAIN THEIR EFFECTIVENESS.
(IV) THE EMPLOYER SHALL ASSURE THAT ALL PROTECTIVE CLOTHING IS REMOVED AT THE COMPLETION OF A WORK SHIFT ONLY IN CHANGE ROOMS PRESCRIBED IN PARAGRAPH (M)(1) OF THIS SECTION.

(V) THE EMPLOYER SHALL ASSURE THAT CONTAMINATED PROTECTIVE CLOTHING TO BE CLEANED, LAUNDERED, OR DISPOSED OF, IS PLACED IN A CLOSED CONTAINER IN THE CHANGE-ROOM WHICH PREVENTS DISPERSION OF INORGANIC ARSENIC OUTSIDE THE CONTAINER.
(VI) THE EMPLOYER SHALL INFORM IN WRITING ANY PERSON WHO CLEANS OR LAUNDERS CLOTHING REQUIRED BY THIS SECTION, OF THE POTENTIALLY HARMFUL EFFECTS INCLUDING THE CARCINOGENIC EFFECTS OF EXPOSURE TO INORGANIC ARSENIC.
(VII) THE EMPLOYER SHALL ASSURE THAT THE CONTAINERS OF CONTAMINATED PROTECTIVE CLOTHING AND EQUIPMENT IN THE WORKPLACE OR WHICH ARE TO BE REMOVED FROM THE WORKPLACE ARE LABELLED AS FOLLOWS:

CAUTION: CLOTHING CONTAMINATED WITH INORGANIC ARSENIC; DO NOT REMOVE DUST BY BLOWING OR SHAKING. DISPOSE OF INORGANIC ARSENIC CONTAMINATED WASH WATER IN ACCORDANCE WITH APPLICABLE LOCAL, STATE OR FEDERAL REGULATIONS.

(VIII) THE EMPLOYER SHALL PROHIBIT THE REMOVAL OF INORGANIC ARSENIC FROM PROTECTIVE CLOTHING OR EQUIPMENT BY BLOWING OR SHAKING.

GOGGLES
29CFR1910.1018 INORGANIC ARSENIC
(J) PROTECTIVE WORK CLOTHING AND EQUIPMENT
(1)(III) FACE SHIELDS OR VENTED GOGGLES WHEN NECESSARY TO PREVENT EYE IRRITATION, WHICH COMPLY WITH THE REQUIREMENTS OF 29CFR1910.133(A)(2)-(A)(6)

WASHING CHEMICALS FROM THE SKIN
29CFR1910.1018 INORGANIC ARSENIC
(M) HYGIENE FACILITIES AND PRACTICES
(2) SHOWERS. (I) THE EMPLOYER SHALL ASSURE THAT EMPLOYEES WORKING IN REGULATED AREAS OR SUBJECT TO THE POSSIBILITY OF SKIN OR EYE IRRIATION FROM INORGANIC ARSENIC SHOWER AT THE END OF THE WORK SHIFT.
(II) THE EMPLOYER SHALL PROVIDE SHOWER FACILITIES IN ACCORDANCE WITH 29CFR1910.141(D)(3).
(2) LUNCHROOMS. (II) THE EMPLOYER SHALL ASSURE THAT EMPLOYEES WORKING IN THE REGULATED AREA OR SUBJECT TO THE POSSIBILITY OF SKIN OR EYE IRRITATION FROM EXPOSURE TO INORGANIC ARSENIC WASH THEIR HANDS AND FACE PRIOR TO EATING.

ROUTINE CHANGING OF WORK CLOTHING
29CFR1910.1018 INORGANIC ARSENIC
(M) HYGIENE FACILITIES AND PRACTICES
(1) CHANGE ROOMS. THE EMPLOYER SHALL PROVIDE FOR EMPLOYEES WORKING IN REGULATED AREAS OR SUBJECT TO THE POSSIBILITY OF SKIN OR EYE IRRITATION FROM INORGANIC ARSENIC, CLEAN CHANGE ROOMS EQUIPPED WITH STORAGE FACILITIES FOR STREET CLOTHES AND SEPERATE STORAGE FACILITIES FOR PROTECTIVE CLOTHING AND EQUIPMENT IN ACCORDANCE WITH 29CFR1910.141(E).

CLOTHING REMOVAL FOLLOWING ACCIDENTAL CONTAMINATION
29CFR1910.1018 INORGANIC ARSENIC
(J) PROTECTIVE WORK CLOTHING AND EQUIPMENT
(2)(IV) THE EMPLOYER SHALL ASSURE THAT ALL PROTECTIVE CLOTHING IS REMOVED AT THE COMPLETION OF A WORK SHIFT ONLY IN CHANGE ROOMS PRESCRIBED IN PARAGRAPH (M)(1) OF THIS SECTION

SPECIFIC EMERGENCY PROVISIONS
29CFR1910.1018 INORGANIC ARSENIC

(K) HOUSEKEEPING (1) SURFACES. ALL SURFACES SHALL BE MAINTAINED AS FREE AS PRACTICABLE OF ACCUMULATIONS OF INORGANIC ARSENIC.
(2) CLEANING FLOORS. FLOORS AND OTHER ACCESSIBLE SURFACES CONTAMINATED WITH INORGANIC ARSENIC MAY NOT BE CLEANED BY THE USE OF COMPRESSED AIR, AND SHOVELING AND BRUSHING MAY BE USED ONLY WHERE VACUUMING OR OTHER RELEVANT METHODS HAVE BEEN TRIED AND FOUND NOT TO BE EFFECTIVE.
(3) VACUUMING. WHERE VACUUMING METHODS ARE SELECTED, THE VACUUMS SHALL BE USED AND EMPTIED IN A MANNER TO MINIMIZE THE REENTRY OF INORGANIC ARSENIC INTO THE WORKPLACE.
(4) HOUSEKEEPING PLANS. A WRITTEN HOUSEKEEPING AND MAINTENANCE PLAN SHALL BE KEPT WHICH SHALL LIST APPROPRIATE FREQUENCIES FOR CARRYING OUT HOUSEKEEPING OPERATIONS, AND FOR CLEANING AND MAINTAINING DUST COLLECTION EQUIPMENT. THE PLAN SHALL BE AVAILABLE FOR INSPECTION BY THE ASSISTANT SECRETARY.
(5) MAINTENANCE OF EQUIPMENT. PERIODIC CLEANING OF DUST COLLECTION AND VENTILATION EQUIPMENT AND CHECKS OF THEIR EFFECTIVENESS SHALL BE CARRIED OUT TO MAINTAIN THE EFFECTIVENESS OF THE SYSTEM AND A NOTATION KEPT OF THE LAST CHECK OF EFFECTIVENESS AND CLEANING OR MAINTENANCE.
(M) HYGIENE FACILITIES
(3) LUNCHROOMS. (I) THE EMPLOYER SHALL PROVIDE FOR EMPLOYEES WORKING IN REGULATED AREAS, LUNCHROOM FACILITIES WHICH HAVE A TEMPERATURE CONTROLLED, POSITIVE PRESSURE, FILTERED AIR SUPPLY, AND WHICH ARE READILY ACCESSIBLE TO EMPLOYEES WORKING IN REGULATED AREAS.
(4) LAVARATORIES. THE EMPLOYER SHALL PROVIDE LAVATORY FACILITIES WHICH COMPLY WITH 29CFR1910.141(D)(1) AND (2).
(5) VACUUMING CLOTHES. THE EMPLOYER SHALL PROVIDE FACILITIES FOR EMPLOYEES WORKING IN AREAS WHERE EXPOSURE, WITHOUT REGARD TO THE USE OF RESPIRATORS, EXCEEDS 100 UG/M3 TO VACUUM THEIR PROTECTIVE CLOTHING AND CLEAN OR CHANGE SHOES WORN IN SUCH AREAS ENTERING CHANGE ROOMS, LUNCHROOMS OR SHOWER ROOMS REQUIRED BY PARAGRAPH (J) OF THIS SECTION AND SHALL ASSURE THAT SUCH EMPLOYEES USE SUCH FACILITIES.
(6) AVOIDANCE OF SKIN IRRITATION. THE EMPLOYER SHALL ASSURE THAT NO EMPLOYEE IS EXPOSED TO SKIN OR EYE CONTACT WITH ARSENIC TRICHLORIDE OR TO SKIN OR EYE CONTACT WITH LIQUID OR PARTICULATE INORGANIC ARSENIC WHICH IS LIKELY TO CAUSE SKIN OR EYE IRRITATION.
(O) EMPLOYEE INFORMATION AND TRAINING.
(1) TRAINING PROGRAM. (I) THE EMPLOYER SHALL INSTITUTE A TRAINING PROGRAM FOR ALL EMPLOYEES WHO ARE SUBJECT TO EXPOSURE TO INORGANIC ARSENIC ABOVE THE ACTION LEVEL WITHOUT REGARD TO RESPIRATOR USE, OR FOR WHOM THERE IS THE POSSIBILITY OF SKIN OR EYE IRRITATION FROM INORGANIC ARSENIC. THE EMPLOYER SHALL ASSURE THAT THOSE EMPLOYEES PARTICIPATE IN THE TRAINING PROGRAM.
(II) THE TRAINING PROGRAM SHALL BE PROVIDED BY OCTOBER 1, 1978, FOR EMPLOYEES COVERED BY THIS PROVISION, AT THE TIME OF INITIAL ASSIGNMENT FOR THOSE SUBSEQUENTLY COVERED BY THIS PROVISION, AND SHALL BE REPEATED AT LEAST QUARTERLY FOR EMPLOYEES WHO HAVE OPTIONAL USE OF RESPIRATORS AND AT LEAST ANNUALLY FOR OTHER COVERED EMPLOYEES THEREAFTER; AND THE THE EMPLOYER SHALL ASSURE THAT EACH EMPLOYEE IS INFORMED OF THE FOLLOWING:
(A) THE INFORMATION CONTAINED IN APPENDIX A;
(B) THE QUANTITY, LOCATION, MANNER OF USE, STORAGE, SOURCES OF EXPOSURE, AND THE SPECIFIC NATURE OF OPERATIONS WHICH COULD RESULT IN EXPOSURE TO INORGANIC ARSENIC AS WELL AS WELL AS ANY NECESSARY PROTECTIVE STEPS;
(C) THE PURPOSE, PROPER USE, AND LIMITATION OF RESPIRATORS;
(D) THE PURPOSE AND A DESCRIPTION OF THE MEDICAL SURVEILLANCE PROGRAM AS REQUIRED BY PARAGRAPH (N) OF THIS SECTION;

(E) THE ENGINEERING CONTROLS AND WORK PRACTICES ASSOCIATED WITH THE EMPLOYEE'S JOB ASSIGNMENT; AND

(F) A REVIEW OF THIS STANDARD.

(2) ACCESS TO TRAINING MATERIALS. (I) THE EMPLOYER SHALL MAKE READILY AVAILABLE TO ALL AFFECTED EMPLOYEES A COPY OF THIS STANDARD AND ITS APPENDICES.

(II) THE EMPLOYER SHALL PROVIDE; UPON REQUEST, ALL MATERIALS RELATING TO THE EMPLOYEE INFORMATION AND TRAINING PROGRAM TO THE ASSISTANT SECRETARY AND THE DIRECTOR.

(P) SIGNS AND LABELS

(1) GENERAL. (I) THE EMPLOYER MAY USE LABELS OR SIGNS REQUIRED BY OTHER STATUTES, REGULATIONS, OR ORDINANCES IN ADDITION TO, OR IN COMBINATION WITH, SIGNS AND LABELS REQUIRED BY THIS PARAGRAPH.

(II) THE EMPLOYER SHALL ASSURE THAT NO STATEMENT APPEARS ON OR NEAR ANY SIGN OR LABEL REQUIRED BY THIS PARAGRAPH WHICH CONTRADICTS OR DETRACTS FROM THE MEANING OF THE REQUIRED SIGN OR LABEL.

(2) SIGNS. (I) THE EMPLOYER SHALL POST SIGNS DEMARKING REGULATED AREAS BEARING THE LEGEND;

DANGER
INORGANIC ARSENIC
CANCER HAZARD
AUTHORIZED PERSONNEL ONLY
NO SMOKING OR EATING
RESPIRATOR REQUIRED

(II) THE EMPLOYER SHALL ASSURE THAT SIGNS REQUIRED BY THIS PARAGRAPH ARE ILLUMINATED AND CLEANED AS NECESSARY SO THAT THE LEGEND IS READILY VISIBLE.

(3) LABELS. THE EMPLOYER SHALL APPLY PRECAUTIONARY LABELS TO ALL SHIPPING AND STORAGE CONTAINERS OF INORGANIC ARSENIC, AND TO ALL PRODUCTS CONTAINING INORGANIC ARSENIC EXCEPT WHEN THE INORGANIC ARSENIC IN THE PRODUCT IS BOUND IN SUCH A MANNER SO AS TO MAKE UNLIKELY THE POSSIBILITY OF AIRBORNE EXPOSURE TO INORGANIC ARSENIC. (POSSIBLE EXAMPLES OF PRODUCTS NOT REQUIRING LABELS ARE SEMICONDUCTORS, LIGHT EMITTING DIODES AND GLASS). THE LABEL SHALL BEAR THE FOLLOWING LEGEND:

DANGER
CONTAINS INORGANIC ARSENIC
CANCER HAZARD
HARMFUL IF INHALED OR SWALLOWED
USE ONLY WITH ADEQUATE VENTILATION
OR RESPIRATORY PROTECTION

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED)

100 UG(AS)/M3
- POWERED AIR-PURIFYING PARTICULATE RESPIRATOR
  WITH A HIGH-EFFICIENCY FILTER
- HALF-MASK SUPPLIED-AIR RESPIRATOR

500 UG(AS)/M3
- POWERED AIR-PURIFYING RESPIRATOR
  WITH A FULL FACE-PIECE
  WITH A HIGH-EFFICIENCY FILTER

10 MG(AS)/M3
- POWERED AIR-PURIFYING RESPIRATOR
  WITH A HIGH-EFFICIENCY FILTER

20 MG(AS)/M3
- SUPPLIED-AIR RESPIRATOR
  WITH A FULL FACE-PIECE, HELMENT, OR HOOD
  OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS
  WITH A FULL FACE-PIECE
  OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

ROUTE OF ENTRY INTO BODY
INHALATION
SKIN ABSORPTION
INGESTION

SYMPTOMS
SKIN IRRITATION
EYE IRRITATION
MUCOUS MEMBRANE IRRITATION
SKIN SENSITIZATION
HYPERACTIVITY
DYSPNEA
CYANOSIS
DYSPHAGIA
COUGHING
FROTHY SPUTUM
NAUSEA
VOMITING
ABDOMINAL CRAMPS
DIARRHEA
SALIVATION
WEIGHT LOSS
DERMATITIS
CORNEAL NECROSIS
EDEMA OF THE EYELIDS
VISUAL DISTURBANCE
BRONZING OF THE SKIN
ALOPECIA
BRITTLE FINGERNAILS
DIZZINESS
FEVER
IRRITABILITY
PARALYSIS
HEMATURIA
PERIPHERAL NEUROPATHY
OPTIC NEURITIS
ANESTHESIA
PARESTHESIA
ATAXIA
TREMORS
INCOORDINATION
CONFUSION
EMPHYSEMA
EDEMA
TRACHEOBRONCHITIS
NASAL ULCERATION

NASAL INFLAMMATION
PHARYNGEAL INFLAMMATION
LARYNX INFLAMMATION
ANEMIA
NEPHRITIS
CIRRHOSIS
CARDIAC FAILURE
TUMORS
LUNG CANCER
SKIN CANCER

FIRST AID PROCEDURES FOLLOWING EXPOSURE

IF THIS CHEMICAL GETS INTO THE EYES, IMMEDIATELY WASH THE EYES WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING THE LOWER AND UPPER LIDS. GET MEDICAL ATTENTION IMMEDIATELY. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS CHEMICAL.

IF THIS CHEMICAL GETS ON THE SKIN, IMMEDIATELY WASH CONTAMINATED SKIN WITH SOAP OR MILD DETERGENT & WATER. IF THIS CHEMICAL SOAKS CLOTHING, IMMEDIATELY REMOVE CLOTHING & WASH SKIN WITH SOAP OR MILD DETERGENT & WATER. GET MEDICAL ATTENTION PROMPTLY.

IF A PERSON BREATHES IN LARGE AMOUNTS OF THIS CHEMICAL, 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.

INGESTED ARSENIC:
EMERGENCY TREATMENT - REMOVE BY GASTRIC LAVAGE OR EMESIS. FOLLOW WITH SALINE CATHARTIC.
ANTIDOTE - GIVE DIMERCAPROL FOR TWO DAYS, THEN PENICILAMINE. DISCONTINUE WHEN URINE ARSENIC FALLS BELOW 50 UG/24 HOURS. (ANTIDOTES MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL)
FURTHER TREATMENT - GIVE 5% GLUCOSE IN NORMAL SALINE INTRAVENOUSLY TO TREAT DEHYDRATION. TREAT SHOCK, PULMONARY EDEMA, ANURIA, AND LIVER DAMAGE. FOR SEVERE POISONING, USE HEMODIALYSIS AFTER DIMERCAPROL THERAPY.
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

CIRCULATORY FAILURE/SHOCK - PLACE PATIENT IN SUPINE POSITION WITH FEET ELEVATED. ESTABLISH AND MAINTAIN AN ADEQUATE AIRWAY. MAINTAIN BODY WARMTH BY APPLICATION OF BLANKENTS, BUT DO NOT APPLY EXTERNAL HEAT. RELIEVE PAIN WITH MORPHINE SULFATE, 10 MG/70 KG SUBCUTANEOUSLY OR INTRAVENOUSLY, FOR OTHERWISE UNCONTROLLABLE PAIN. DO NOT GIVE MORPHINE TO CHILDREN UNDER 5 YEARS OF AGE OR TO UNCONSCIOUS OR STUPOROUS PATIENTS. PATIENTS WITH DEPRESSED RESPIRATION SHOULD NOT BE GIVEN MORPHINE UNLESS PERSONNEL AND EQUIPMENT TO MAINTAIN RESPIRATION ARE IMMEDIATELY AVAILABLE. RESTORE AND MAINTAIN ADEQUATE BLOOD VOLUME. GET FURTHER MEDICAL TREATMENT IMMEDIATELY.
(MEDICATION MUST BE GIVEN BY QUALIFIED MEDICAL PERSONNEL)
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

PULMONARY EDEMA - RELIEVE ANXIETY. GIVE MORPHINE SULFATE, 10 MG, TO DECREASE RATE OF RAPID, INEFFICIENT RESPIRATION. GIVE 40% OXYGEN BY FACE MASK. USE INTERMITTENT POSITIVE-PRESSURE OXYGEN RESUSCITATOR FOR SHORT PERIODS. GIVE AMINOPHYLLINE, 0.5 G, INTRAVENOUSLY, TO RELIEVE ASSOCIATED BRONCHIAL CONSTRICTION. TREAT

EDEMA CAUSED BY MORPHINE OR MORPHINE ANALOGS BY GIVING NALOXONE AND OXYGEN.
(MEDICATION MUST BE GIVEN BY QUALIFIED MEDICAL PERSONNEL)
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

ACUTE RENAL FAILURE - TREAT SHOCK. FOR HEMOLYTIC REACTIONS, GIVE SODIUM BICARONATE, 5 G EVERY 1-2 HOURS AS NECESSARY TO MAINTAIN AN ALKALINE URINE.
(MEDICATION MUST BE GIVEN BE QUALIFIED MEDICAL PERSONNEL)
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

LIVER DAMAGE - REMOVE FROM EXPOSURE TO ALL CHEMICALS AND DRUGS. MAINTAIN COMPLETE BED REST. AVOID ANESTHESIA OR SURGICAL PROCEDURES. AVOID DEHYDRATION OR OVERHYDRATION. IF VOMITING SEVERE AND ORAL FLUIDS NOT RETAINED, REPLACE VOMITUS WITH AN EQUAL QUANTITY OF 100% DEXTROSE IN NORMAL SALINE. IN RENAL FUNCTION ADEQUATE, GIVE 1 LITER OF 5% DEXTROSE OR INVERT SUGAR IN NORMAL SALINE PLUS 1-3 LITERS OF 10% DEXTROSE OR INVERT SUGAR IN DISTILLED WATER INTRAVENOUSLY EVERY TWENTY-FOUR HOURS.
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

GASTRIC LAVAGE - GIVE PATIENT GLASS OF WATER PRIOR TO PASSING OF STOMACH TUBE. LAY PATIENT ON ONE SIDE, WITH HEAD LOWER THAN WAIST. IMMOBILIZE A STRUGGLING PATIENT WITH A SHEET OR BLANKET. MEASURE DISTANCE ON TUBE FROM MOUTH TO EPIGASTRIUM, MARK TUBE WITH INDELIBLE MARKING OR TAPE. REMOVE DENTURES AND OTHER FOREIGN OBJECTS FROM MOUTH. OPEN MOUTH, USE GAG IF NECESSARY. EXTEND HEAD BY LIFTING THE CHIN. PASS TUBE OVER TONGUE AND TOWARD BACK OF THROAT WITHOUT EXTENDING HEAD OR NECK. IF OBSTRUCTION IS MET BEFORE THE MARK ON TUBE REACHES LEVELS OF TEETH, DO NOT FORCE, BUT REMOVE TUBE AND REPEAT PROCEDURE UNTIL TUBE PASSES TO MARK. PLACE END OF TUBE IN GLASS OF WATER. IF TUBE IS OBSTRUCTED WHEN INTRODUCED ABOUT HALFWAY TO THE MARK, IT MAY HAVE ENTERED TRACHEA.

AFTER TUBE IS PLACED IN STOMACH, ASPIRATE FIRST TO REMOVE STOMACH CONTENTS BY IRRIGATION SYRINGE. SAVE STOMACH CONTENTS FOR EXAMINATION, AND REPEAT INTRODUCTION AND WITHDRAWAL OF 100-300 ML WARM WATER UNTIL AT LEAST 3 LITERS OF CLEAR RETURN ARE OBTAINED. USE ACTIVATED CHARCOAL AT BEGINNING OF LAVAGE TO AID IN POISON INACTIVATION. LEAVE 50 GRAMS OF CHARCOAL SUSPENDED IN WATER IN THE STOMACH. IF INTRODUCTION AND REMOVAL OF LAVAGE FLUID BY GRAVITY REQUIRES MORE THAN FIVE MINUTES, ASSIST WITH ASEPTO SYRINGE. PREVENT ASPIRATION WITH CUFFED ENDOTRACHEAL TUBE. AVOID GIVING LARGE QUANTITIES OF WATER.

MASSAGE OF EPIGASTRIUM WHILE STOMACH TUBE IS BEING ASPIRATED MAY AID IN POISON REMOVAL.

IF PATIENT COMATOSE, INTUBATE TRACHEA WITH CUFFED ENDOTRACHEAL TUBE. SUCCINYLCHLORINE MAY BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL TO EASE INSERTION OF TRACHEAL CATHETER PRIOR TO PASSAGE OF STOMACH TUBE.
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

ORGANS
RESPIRATORY SYSTEM
SKIN

EYES
REPRODUCTIVE SYSTEM
CENTRAL NERVOUS SYSTEM
MUCOUS MEMBRANES
KIDNEYS
LIVER
BLOOD
PERIPHERAL NERVOUS SYSTEM

STATUS OF REGULATORY ENFORCEMENT
OSHA STANDARD 29CFR1910.1200 HAZARD COMMUNICATION
REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS HAVING WORKPLACES IN THE MANUFACTURING DIVISION, STANDARD INDUSTRIAL CLASSIFICATION CODES 20 THROUGH 39, TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF HAZARD COMMUNICATION PROGRAMS INCLUDING LABELS, MATERIAL SAFETY DATA SHEETS, TRAINING, AND ACCESS TO WRITTEN RECORDS
48FR53280 11/25/83

FOLLOWING OSHA STANDARDS APPLICABLE TO SUBSTANCES LISTED 29CFR1910, OTHERWISE ADVISE:

OSHA STANDARD 29CFR1910.1000 AIR CONTAMINANTS
TABLE Z-2

OSHA STANDARD 29CFR1910.1018 INORGANIC ARSENIC
APPLIES TO ALL OCCUPATIONAL EXPOSURES TO INORGANIC ARSENIC EXCEPT TO EMPLOYEE EXPOSURES IN AGRICULTURE OR RESULTING FROM PESTICIDE APPLICATION, THE TREATMENT OF WOOD WITH PRESERVATIVES OR THE UTILIZATION OF ARSENICALLY PRESERVED WOOD

OSHA STANDARD 29CFR1910.94 VENTILATION

OSHA STANDARD 29CFR1910.134 RESPIRATORY PROTECTION

OSHA STANDARD 29CFR1910.20 ACCESS TO EMPLOYEE EXPOSURE AND MEDICAL RECORDS

OSHA STANDARD 29CFR1910.132 PERSONAL PROTECTIVE EQUIPMENT

OSHA STANDARD 29CFR1910.141 SANITATION

OSHA STANDARD 29CFR1910.151 MEDICAL SERVICES AND FIRST AID

OSHA STANDARD 29CFR1910.133 EYE AND FACE PROTECTION

40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT
REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT ALLEGED TO HAVE BEEN CAUSED BY A SUBSTANCE OR MIXTURE. EPA MAY INSPECT AND REQUIRE REPORTING OF SUCH RECORDS.
48FR38178 08/22/83

SUBSTANCE LISTED TOXIC SUBSTANCES CONTROL ACT INVENTORY

I. CHEMICAL IDENTITY

Common name: Cadmium dust (as cadmium)
Formula: Cadium metal dust: Cd; cadmium oxide dust: CdO; cadmium sulfide dust: CdS; cadmium chloride dust: $CdCl_2$
Synonyms: None, except for cadmium sulfide dust, which is known as Greenockite
CAS No.: 7440-43-9
Carcinogen: EPA, NTP (probable)

II. REGULATORY INFORMATION

Hazardous substance: EPA
Hazardous waste: EPA
DOT Hazard Class: N/A

III. PHYSICAL CHARACTERISTICS

Boiling point: Cadmium metal dust: 767 C (1412 F); cadmium oxide dust: 900 C (1652 F) (sublimes and decomposes); cadmium sulfide dust: sublimes at 980 C (1796 F); cadmium chloride dust: 960 C (1760 F)
Specific gravity: Cadmium metal dust: 8.642; cadmium oxide dust: 6.95 or 8.15; cadmium sulfide dust: 4.82; cadmium chloride dust: 4.047
Vapor density: N/A
Melting point: cadmium metal dust: 321 C (609 F); cadmium oxide dust: 900 C (1652 F); 1750 C (3182 F); 568 C (1054 F)
Vapor pressure: Essentially zero
Solubility in water: Cadmium metal dust: insoluble; cadmium oxide dust: 0.0005; cadmium sulfide dust 0.0001; cadmium chloride dust: 140
Evaporation rate: N/A
Appearance and odor: Odorless gray powder; brown or blue-black solid; yellow-orange solid; white solid

IV. PHYSICAL HAZARDS

Flash point: N/A
Autoignition temperature: Cadmium metal dust: 250 C (482 F) (layer)
Flammable limits in air (% by vol.): N/A
Extinguishants: Dry powder for metal fires

V. HEALTH HAZARDS

Can affect the body if inhaled or swallowed.
Short-term exposure can cause irritation of the nose and throat; overexposure can cause delayed cough, chest pain, sweating,

chills, shortness of breath, weakness, and death. Ingestion causes nausea, vomiting, diarrhea, and abdominal cramps.
Long-term exposure may cause loss of sense of smell, ulceration of the nose, emphysema, kidney damage, and mild anemia. Cadmium has been reported to increase incidence of prostate cancer.

VI. EMERGENCY FIRST AID

Eyes: Irrigate immediately
Skin: Wash with soap
Breathing: If in large amounts, move to fresh air at once and perform artificial respiration.
Swallowing: Get medical attention. Give large quantities of water and induce vomiting unless victim is unconscious.

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA TWA: 0.2 mg/m^3, with a ceiling level of 0.6 mg/m^3
ACGHIH TWA: 0.5 mg/m^3

VIII. PRECAUTIONS FOR USE AND SAFE HANDLING

Conditions contributing to instability: None
Incompatibilities: Contact of cadmium metal dust with strong oxidizers or with elemental sulfur, selenium, and tellurium could cause fires and explosions.
Hazardous decomposition products: Toxic gases and vapors (such as cadmium oxide fume) may be released in a fire.
Special precautions: None

IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

Wear protective clothing. If released in hazardous concentrations, remove all ignition sources, ventilate, collect released material in the most convenient and safe manner for reclamation or for disposal in sealed containers in a secured sanitary landfill.

X. PROTECTIVE EQUIPMENT

Respirators–

1 mg/m^3: DXS
2 mg/m^3: DXSQ;HiEP;SA;SCBA
10 mg/m^3: HiEPF;SAF;SCBAF
40 mg/m^3: PAPHiE;SA:PD,PP,CF
Escape: DXS;SCBA

COBALT HYDROCARBONYL

Description: $HCO(CO)_4$ is a flammable and toxic gas which decomposes rapidly at room temperature.

Code Numbers: CAS 16842-03-8 RTECS GG0900000

DOT Designation: –

Potential Exposure: Those involved in manufacture and use of this material as a catalyst.

Permissible Exposure Limits in Air: ACGIH (1983/84) has adopted 0.1 mg/m^3 as a TWA value but has set no STEL value.

Permissible Concentration in Water: No criteria set.

Harmful Effects and Symptoms: The 30-minute LD-50 in rats is 165 mg/m^3. The clinical effects are similar to nickel carbonyl and iron pentacarbonyl but it has about one-half the toxicity of nickel carbonyl.

References

(1) American Council of Governmental Industrial Hygienists, Inc., *Documentation of the Threshold Limit Values: Supplemental Documentation: 1981*, Cincinnati, OH (1981).

COKE OVEN EMISSIONS

See "Coal Tar Pitch Volatiles."

COPPER AND COMPOUNDS

- Hazardous substances (EPA) (some compounds)
  Copper compounds listed by EPA as hazardous substances include: Cupric acetate, cupric acetoarsenite, cupric chloride, cupric nitrate, cupric oxalate, cupric sulfate, cupric sulfate ammoniated, cupric tartrate.
- Hazardous waste (copper cyanide) (EPA)
- Priority toxic pollutant (EPA)

Description: Cu, copper, is a reddish-brown metal which occurs free or in ores such as malachite, cuprite, and chalcopyrite. It may form both mono- and divalent compounds. Copper is insoluble in water, but soluble in nitric acid and hot sulfuric acid.

Copper dusts and mists have been assigned the formula $CuSO_4 \cdot 5H_2O/CuCl$ by NIOSH. Copper fume has been designated as $Cu/CuO/Cu_2O$ by NIOSH.

Code Numbers: Copper metal: CAS 7440-50-8 RTECS GL5325000

DOT Designation: –

Synonyms: None.

Potential Exposures: Metallic copper is an excellent conductor of electricity and is widely used in the electrical industry in all gauges of wire for circuitry, coil, and armature windings, high conductivity tubes, commutator bars, etc.

It is made into castings, sheets, rods, tubing, and wire, and is used in wate and gas piping, roofing materials, cooking utensils, chemical and pharmaceutica equipment, and coinage. Copper forms many important alloys: Be-Cu alloy brass, bronze, gun metal, bell metal, German silver, aluminum bronze, silico bronze, phosphor bronze, and manganese bronze.

Copper compounds are used as insecticides, algicides, molluscicides, plan fungicides, mordants, pigments, catalysts, and as a copper supplement fo pastures, and in the manufacture of powdered bronze paint and percussion caps They are also utilized in analytical reagents, in paints for ships' bottoms, i electroplating, and in the solvent for cellulose in rayon manufacture.

Incompatibilities: Acetylene gas; magnesium metal is incompatible wit copper dusts and mists.

Permissible Exposure Limits in Air: The Federal standard for copper fume i 0.1 mg/m^3, and for copper dusts and mists, 1 mg/m^3. ACGIH, as of 1983/84, ha set a TWA of 0.2 mg/m^3 for copper fume. There are no STEL values or IDLH levels set.

Determination in Air: Copper dusts and mists are collected on a filte worked up with acid, measured by atomic absorption. See NIOSH Method Set M. See also reference (A-10). For copper fume: filter collection, acid dige tion, measurement by atomic absorption (A-10).

Permissible Concentration in Water: To protect freshwater aquatic lif 5.6 $\mu g/\ell$ as a 24-hour average, never to exceed $e^{[0.94 \ln(\text{hardness}) - 1.23]}$ $\mu g/\ell$. T protect saltwater aquatic life: 4.0 $\mu g/\ell$ as a 24-hour average, not to excee 23.0 $\mu g/\ell$. To protect human health: 1,000 $\mu g/\ell$.

Determination in Water: Total copper may be determined by digestion fo lowed by atomic absorption or by colorimetry (using neocuproine) or by I ductively Coupled Plasma (ICP) Optical Emission Spectrometry. Dissolve copper may be determined by 0.45 μ filtration followed by the precedi methods.

Routes of Entry: Inhalation of dust or fume, ingestion, or skin or ey contact.

Harmful Effects and Symptoms: *Local* – Copper salts act as irritants to t intact skin causing itching, erythema, and dermatitis. In the eyes, copper sal may cause conjunctivitis and even ulceration and turbidity of the cornea. Meta lic copper may cause keratinization of the hands and soles of the feet, but it not commonly associated with industrial dermatitis.

Systemic – Industrial exposure to copper occurs chiefly from fumes ge erated in welding copper-containing metals. The fumes and dust cause irritatio of the upper respiratory tract, metallic taste in the mouth, nausea, metal fum fever, and in some instances discoloration of the skin and hair. Inhalation dusts, fumes, and mists of copper salts may cause congestion of the nasal m cous membranes, sometimes of the pharynx, and on occasions ulceration wi perforation of the nasal septum. If the salts reach the gastrointestinal trac they act as irritants producing salivation, nausea, vomiting, gastric pain, hemo rhagic gastritis, and diarrhea. It is unlikely that poisoning by ingestion in i dustry would progress to a serious point as small amounts induce vomitin emptying the stomach of copper salts.

Chronic human intoxication occurs rarely and then only in individuals wi Wilson's disease (hepatolenticular degeneration). This is a genetic conditi caused by the pairing of abnormal autosomal recessive genes in which the

is abnormally high absorption, retention, and storage of copper by the body. The disease is progressive and fatal if untreated.

Points of Attack: For copper dusts and mists: respiratory system, lungs, skin, liver, including risk with Wilson's disease, kidneys. For copper fume: respiratory system, skin, eyes, and risk with Wilson's disease.

Medical Surveillance: Consider the skin, eyes, and respiratory system in any placement or periodic examinations.

First Aid: For copper dusts and mists: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, wash with soap promptly. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of water and induce vomiting. Do not make an unconscious person vomit.

For copper fume: If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration.

Personal Protective Methods: For copper dusts or mists: Wear appropriate clothing to prevent repeated or prolonged skin contact. Wear eye protection to prevent any reasonable probability of eye contact. Employees should wash promptly when skin is contaminated. Work clothing should be changed daily if clothing is contaminated. Remove nonimpervious clothing promptly if contaminated.

Respirator Selection:

Copper dusts and mists
- 50 mg/m³: HiEPF/SAF/SCBAF
- 2,000 mg/m³: SAF:PD,PP,CF

Copper fume
- 1 mg/m³: FuHiEP/SA/SCBA
- 5 mg/m³: HiEPF/SAF/SCBAF
- 100 mg/m³: PAPHiE/SA:PD,PP,CF
- 200 mg/m³: SAF:PD,PP,CF

Disposal Methods Suggested: Copper-containing wastes can be concentrated through the use of ion exchange, reverse osmosis, or evaporators to the point where copper can be electrolytically removed and sent to a reclaiming firm. Details of copper recovery from a variety of industrial wastes have been published (A-57). If recovery is not feasible, the copper can be precipitated through the use of caustics and the sludge deposited in a chemical waste landfill.

References

(1) U.S. Environmental Protection Agency, *Toxicology of Metals, Vol. II: Copper*, Report EPA-600/1-77-022, pp 206-221, Research Triangle Park, NC (May 1977).
(2) U.S. Environmental Protection Agency, *Copper: Ambient Water Quality Criteria*, Washington, DC (1980).
(3) National Academy of Sciences, *Medical and Biologic Effects of Environmental Pollutants: Copper*, Washington, DC (1977).
(4) See Reference (A-61). (Copper Dusts and Mists and Fume).
(5) Sax, N.I., Ed., *Dangerous Properties of Industrial Materials Report, 1*, No. 5, 48-49, New York, Van Nostrand Reinhold Co. (1981). (Copper).
(6) Sax, N.I., Ed., *Dangerous Properties of Industrial Materials Report, 1*, No. 8, 58-60, New York, Van Nostrand Reinhold Co. (1981). (Copper Chloride).
(7) Sax, N.I., Ed., *Dangerous Properties of Industrial Materials Report, 2*, No. 5, 35-39, New York, Van Nostrand Reinhold Co. (1982). (Copper Nitrate).
(8) Sax, N.I., Ed., *Dangerous Properties of Industrial Materials Report, 3*, No. 1, 45-47, New York, Van Nostrand Reinhold Co. (1983). (Copper Naphthenate).

(9) See Reference (A-60) for entries on Copper Acetate, Copper Chloride, Copper Sulfate, Cupric Carbonate, Cupric Hydroxide, Cupric Nitrate and Cuprous Chloride.
(10) Parmeggiani, L., Ed., *Encyclopedia of Occupational Health & Safety*, Third Edition, Vol. 1, pp 546-48, Geneva, International Labour Office (1983).
(11) United Nations Environment Programme, *IRPTC Legal File 1983*, Vol. I, pp VII/195-99, Geneva, Switzerland, International Register of Potentially Toxic Chemicals (1984).

COTTON DUST

Description: $(C_6H_{10}O_5)_n$. "Cotton dust," is defined as dust generated into the atmosphere as a result of the processing of cotton fibers combined with any naturally occurring materials such as stems, leaves, bracts, and inorganic matter which may have accumulated on the cotton fibers during the growing or harvesting period. Any dust generated from processing of cotton through the weaving of fabric in textile mills and dust generated in other operations or manufacturing processes using new or waste cotton fibers or cotton fiber by-products from textile mills is considered cotton dust.

Code Numbers: CAS: None RTECS GN2275000

DOT Designation: ORM-C.

Synonyms: None.

Potential Exposures: The Occupational Safety and Health Administration has estimated that 800,000 workers are involved in work with cotton fibers and thus are potentially exposed to cotton dust in the work place.

Incompatibilities: Strong oxidizers.

Permissible Exposure Limit in Air: The current Federal standard for cotton dust was promulgated by OSHA June 23, 1978 and is 200 $\mu g/m^3$ (mean concentration) in textile yarn manufacturing; 750 $\mu g/m^3$ (mean concentration) in textile slashing and weaving operations; and 500 $\mu g/m^3$ (mean concentration) in all other operations except that this standard does not apply to the harvesting of cotton, cotton ginning, the handling and processing of woven or knitted materials, or washed cotton. These concentrations are for lint-free samples averaged over an eight-hour period collected by the vertical elutriator or equivalent method (A-6). This standard is currently in litigation in the courts. The STEL is 0.6 mg/m^3 and the IDLH level is 500 mg/m^3.

Determination in Air: Collection on a filter and gravimetric analysis (A-1).

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation of dust, ingestion, eye and skin contact.

Harmful Effects and Symptoms: The processing of raw cotton is associated with byssinosis (or "brown lung"), a disease characterized by pulmonary dysfunction. There is evidence, but not proof, that cotton dust itself is not the cause of byssinosis but may carry materials into the respiratory tract, possibly foreign protein or proteolytic enzymes.

Points of Attack: Respiratory system, lungs, cardiovascular system.

Medical Surveillance: [See also reference (2).]
(a) Preplacement: A comprehensive physical examination shall be made

I. CHEMI . IDENTITY

Common name: Lead and inorganic compounds
Formula: Pb (lead)
Synonyms: None
CAS No.: 7439-92-1 (lead)
Carcinogen: N/A

II. REGULATORY INFORMATION

Lead metal and all its inorganic compounds (as well as a class of organic compounds known as lead soaps) are regulated under an OSHA standard (29 CFR 1910.1025), which sets permissible exposure limits and requires monitoring, compliance plans, protective clothing and equipment, blood testing of employees, and temporary medical removal and return of an employee to assigned work if elevated levels of lead are found in the blood. The standard does not apply equally to all segments of industry and should be consulted for details. The OSHA standard is published in BNA's **Occupational Safety & Health Reporter** service.

Hazardous substance: EPA lists the acetate, arsenate, chloride, fluoborate, fluoride, iodide, nitrate, stearate, sulfate, sulfide, and thiocyanate.

Hazardous waste: EPA lists the acetate, phosphate, and subacetate.

DOT Hazard Class: Poison B (arsenate, arsenite, cyanide); oxidizer (nitrate, peroxide); ORM-B (chloride, fluoborate, fluoride); ORM-E (acetate, iodide, stearate, sulfate).

III. PHYSICAL CHARACTERISTICS

Boiling point: 1620 C
Specific gravity: 11.337
Vapor density: N/A
Melting point: 327.5 C
Vapor pressure: N/A
Solubility in water: essentially insoluble
Evaporation rate: N/A
Appearance and odor: Dull gray metal

IV. PHYSICAL HAZARDS

Flash point: N/A
Autoignition temperature: N/A
Flammable limits in air (% by vol.): N/A
Extinguishants: N/A

V. HEAL HAZARDS

Lead is a powerful systemic poison that can cause seizures, coma, and that can lead to death. Chronic long-term exposure can result in severe damage to the blood-forming organs, and the nervous, urinary, and reproductive systems. Symptoms include metallic taste in mouth, anxiety, constipation, nausea, pallor, weakness, insomnia, headache, muscle pain, and possible severe abdominal pain.

VI. EMERGENCY FIRST AID

Eyes: Irrigate immediately
Skin: Wash with soap or mild detergent
Breathing: Move to fresh air and perform artificial respiration if needed.
Swallowing: Give large quantities of water and induce vomiting. Get medical attention.

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA TWA: 50 μ/m^3. The standard sets an action level of 30 μ/m^3; if this concentration is reached several requirements of the standards are triggered, including exposure monitoring, medical surveillance, and training and education.

VIII. PRECAUTIONS FOR USE AND SAFE HANDLING

Controlled by the OSHA standard.

IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

Controlled by the OSHA standard.

X. PROTECTIVE EQUIPMENT

Controlled by the OSHA standard.

Respirators–

<0.5 mg/m^3: HiEP
<2.5 mg/m^3: HiEPF
<50 mg/m^3: PAPHiE; SA:PD,PP,CF
<100 mg/m^3: SAF:PD,PP,CF
>100 mg/m^3: SCBAF:PD,PP,CF
Firefighting: SCBAF:PD,PP,CF

COMMON SYNONYMS:	FORMULA	CAS REG. NO.	NIOSH NO.	AIR W/V CONVERSION FACTORS at 25°C
Cyanide anion	CN	57-12-5	GS7175000	
Cyanide ion	HCN	74-90-8	MW6825000	
Hydrocyanic acid, ion	NaCN	143-33-9	VZ7525000	1.06 mg/m³ ≃ 1 ppm (CN)
	KCN	151-50-8	TS8760000	0.94 ppm ≃ 1 mg/m³ (CN)
				MOLECULAR WEIGHT: 26.02 (CN)

REACTIVITY	EPA compatibility charts indicate that reactions of cyanides with mineral acids or organic acids typically evolve toxic and flammable gases. Those with halogenated organics or ketones generally produce heat while those with nitrides or alkali or alkaline earth metals produce heat and flammable gases. Azo or diazo compounds or hydrazines generally evolve innocuous gases while isocyanates may additionally produce heat. Polymerizable compounds or epoxides may undergo violent exothermic polymerization. Reactions of cyanides with organic peroxides, organic hydroperoxides, or strong oxidizing agents may result in heat and toxic gas evolution as well as explosion. The NFPA indicates that violent explosions occur at 450°C if cyanide salts are melted with nitrite salt or a chlorate and further notes that a mixture of chlorates with cyanides may explode if subjected to heat, shock, or friction. Fluorine is said to attack cyanides vigorously in the cold. Magnesium reacts with incandescence when heated with cyanides of cadmium, cobalt, copper, lead, nickel or zinc. Addition of cyanides to a molten nitrate bath will result in an explosion, as may a mixture with nitric acid or potassium cyanide (505,511).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid (HCN)	(12)
	• Color: colorless (HCN)	(12)
	• Odor: bitter almonds (HCN)	(67)
	• Odor Threshold: 2-5 ppm (HCN)	(67)
	• Liquid Density (g/ml at 20°C): 0.687 (HCN)	(69)
	• Freezing/Melting Point (°C): -13.2 (HCN)	(12)
	• Boiling Point (°C): 25.7 (HCN)	(12)
	• Flash Point (°C): -17.8 closed cup (HCN); various salts are not combustible	(60,504, 506,507)
	• Flammable Limits in Air, % by Volume: 5.6-6 to 40-41 (HCN); various salts are not combustible	(60,504, 506,507)
	• Autoignition Temperature (°C): 538-540 (HCN); various salts are not combustible	(60,504, 506,507)
	• Vapor Pressure (mm Hg at 20°C): 620 (HCN)	(67)
	• Saturated Concentration in Air (mg/m³ at 20°C): 918,783 (HCN)	(calc)
	• Solubility in Water (mg/L at 20°C): miscible (HCN)	(12)

PHYSICO-CHEMICAL DATA (Continued)	• Viscosity (cp at 20°C): not pertinent ( ) • Surface Tension (dyne/cm at 20°C): not pertinent ( ) • Log (Octanol-Water Partition Coefficient), log K_{ow}: not pertinent ( ) • Soil Adsorption Coefficient, K_{oc}: not pertinent ( ) • Henry's Law Constant (atm•m³/mol at 25°C): 1.22×10^{-4} (1426) • Bioconcentration Factor: not pertinent ( )

PERSISTENCE IN THE SOIL-WATER SYSTEM	The cyanide ion is mobile in the soil/ground-water system due to the high solubility of most CN^- salts and the lack of anion retention by soils. At low concentrations however, the ion is biodegradable by almost all organisms, and in waters exposed to the atmosphere volatilization losses (as HCN) are expected to be significant.

PATHWAYS OF EXPOSURE	The primary exposure pathway of concern from soil/ground-water systems is the migration of cyanide to ground water drinking water supplies. Exposures through inhalation or the accumulation of cyanide by aquatic organisms or domestic animals are not likely to be significant exposure pathways.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (49): Exposure to hydrogen cyanide can result in symptoms within minutes which are characterized by constriction of the throat, nausea, vomiting, confusion, giddiness, staggering, headache, dilated pupils, hypotension, tachycardia and hyperpnea. This is followed by dyspnea, unconsciousness, convulsions and death.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral 8.5 [mouse] (HCN) (67) skin -- no data LC_{50} (mg/m³) inhalation [rat] (67) 158 (HCN)•30 minutes
	Long-Term Effects: Fatigue, nausea, headache and goiter
	Pregnancy/Neonate Data: Malformations at near lethal levels in one study
	Mutation Data: Inadequate to assess
	Carcinogenicity: No data

HANDLING PRECAUTIONS (54)	Handle chemical only with adequate ventilation. Vapor concentrations up to 50 mg/m^3: Supplied-air respirator <u>or</u> self-contained breathing apparatus • Escape: Gas mask with canister providing protection against cyanide compounds (chin-style or front- or back-mounted canister) with particulate filter <u>or</u> self-contained breathing apparatus • Chemical goggles to prevent contact with the eyes • Protective clothing and rubber gloves to avoid contact with skin.

EMERGENCY FIRST AID TREATMENT (507)	Rapid onset - Get medical attention immediately • <u>Ingestion</u>: Induce vomiting if victim is conscious. Get medical attention immediately • <u>Inhalation</u>: Move victim to fresh air. Give artificial respiration if necessary. Avoid mouth-to-mouth resuscitation. Get medical attention immediately • <u>Skin</u>: Remove contaminated clothing and wash skin with soap and water. Get medical attention immediately • <u>Eye</u>: Flush eye with water for 15 minutes. Get medical attention immediately.

56.2.4 Other Sources of Human Exposure

Although cyanide has been used in this country extensively, other sources of exposure appear to be limited. Cyanogenic glycosides are naturally occurring in some plant species and produce HCN upon hydrolysis (1423). These compounds are not generally thought to be part of the U.S. diet (1419). Both HCN and $Ca(CN)_2$ are registered as fumigants and tolerances have been established for these uses on some grains, citrus fruits, nuts, cucumbers, lettuce, radishes and tomatoes (1604). The extent to which cyanide is actually found in these foods is unknown.

Although cyanide has been found in ground water, the prevalence and levels of cyanide in drinking water are low (1419). A survey of 969 water supplies in 1970 showed an average concentration 0.09 μg/L and a maximum concentration of 8 μg/L (1419). Apparently, no nationwide monitoring for cyanide has taken place since that time.

Inhalation of cyanide may result from a variety of sources. It is produced in fires from burning urethanes, acrylonitriles, or polyamides in plastics. It is also released in automobile emissions (1423). Probably the most important source of exposure, however, is in cigarette smoke. Smokers may be exposed to from 0.01 - 40 mg/day in mainstream smoke depending on the type of cigarette smoked, the amount inhaled, and the number of cigarettes smoked (1423).

56.3 HUMAN HEALTH CONSIDERATIONS

56.3.1 Animal Studies

56.3.1.1 Carcinogenicity

No definitive data on the carcinogenicity of cyanide are available. Rats fed a diet fumigated with 300 μg/L HCN exhibited no indications of any carcinogenic effect after two years (1781). However, dietary levels varied and histopathology was conducted only for a limited number of animals. Therefore, no definitive conclusion can be drawn regarding the carcinogenicity of HCN.

An early experiment by Perry (1687) found that prolonged inhalation of cyanide arrested body growth in young rats and retarded the growth of Jensen sarcoma implants. However, the effective dose (not specified) was concluded to be too close to the lethal dose to be practical.

56.3.1.2 Mutagenicity

No definitive studies on the mutagenic effects of cyanide have been reported.

The cytotoxicity of cyanide was tested in Chlorella pyrenoidosa by Broda and Dombrowicz (1785). Cyanide in concentrations of 1.96-3.76 mμg/mL had minimal inhibitory effect.

These data on the mutagenicity of cyanide are inadequate to assess the mutagenic potential of cyanide.

56.3.1.3 Teratogenicity, Embryotoxicity and Reproductive Effects

Due to its acutely toxic effects, little data are available on the effects of cyanide in reproduction and fetal development.

The teratogenic potential of sodium cyanide was evaluated in the golden hamster by Doherty et al. (1782). Cyanide was administered continuously by slow infusion at a rate of 0, 0.126, 0.1275 or 0.1295 mmol/kg/hr on gestational days 6 through 9. A total dose equivalent to 30-40 times the acute sc LD_{50} dose was administered. A high incidence of malformations and resorptions were observed in offspring of all treatment groups with neural tube defects consisting of exencephaly (brain outside scull) and encephalocoele (hernia of the brain) being the most common. Hydropericardium and crooked tail were also observed, but to a lesser extent. Fetal crown rump length was also decreased. Administration of cyanide and sodium thiocyanate simultaneously protected against both the toxic and teratogenic effects of sodium cyanide. The significance of these findings in view of the high level, continuous exposure is unclear, and preclude extrapolation to human exposure situations.

Thiocyanate, (SCN) the primary metabolic product of cyanide detoxification, produced inhibitory effects at high concentrations on mesodermal and endodermal development of the chick embryo (1685). In view of the high dose and the large number of false positives generated in this closed system, little confidence can be placed on this finding. Furthermore, Kreutler et al. (1786) reported no indications of adverse effects in rat pups born to dams administered 160 μg SCN/mL in their drinking water (~6.4 mg SCN/rat/day), beginning on day 2 of pregnancy.

56.3.1.4 Other Toxicologic Effects

56.3.1.4.1 Short-term Toxicity

Death due to cyanide poisoning is attributed to an interference with the cytochrome oxidase system which prevents oxygen from reaching vital tissues resulting in tissue hypoxia and death. The oral LD_{50} value for HCN in the mouse is 8.5 mg/kg (67) while the LC_{50} in the rat is 142 ppm (HCN) for 30 minutes (67). Once absorbed, cyanide readily reacts with the trivalent iron of cytochrome oxidase in mitochondria. Respiration is stimulated in an attempt to bring oxygen to the tissue. A transient state of CNS stimulation with hyperpnea occurs. Hypoxic convulsions and death due to respiratory arrest result if treatment is not rapidly administered (16).

Inhalation of cyanide can lead to rapid acute toxicity and death (1691,1684). Sato (1691) placed groups of 10 mice in airtight chambers containing HCN gas in various concentrations. At 20 ppm, approximately 20% of the mice died after 4.5 hours. Death also occurred after 4 hours in the 15 ppm exposed group. Mobility became hindered and respiration was labored when mice were exposed to 10 ppm for 2 hours. And, at 5 ppm, a marked decrease in food intake was observed.

Haymaker et al. (1684) exposed six dogs to 165, 590, 620, 690, 700 and 700 mg/m^3 for 10, 2, 2, 2, 1.75 and 1.75 minutes, respectively. Four of the six dogs had convulsive seizures. Autopsy of the dog exposed to 620 mg/m^3 for 2 minutes revealed marked proliferation of histiocytes in the leptomeninges (membranes covering the brain) and in the perivascular spaces of the molecular layer of the cerebellum. Purkinje cells were barely visible. Some of the dogs suffered necrosis of gray matter. It is unclear if these lesions are related directly to cyanide, thiocyanate or general cytotoxic anoxia.

Cyanide is also readily absorbed through the skin. Guinea pigs, with their abdomens shaved, were fastened belly side down to a board with a one inch diameter circle through which the abdomen was exposed to 97% HCN vapor. Only percutaneous absorption was permitted. Within a few minutes, rapid respiration followed by twitching of muscles, convulsions, and death was observed (1692).

Vick and Froehlick (1456) have suggested that early death due to cyanide poisoning is due in part to cardiovascular-respiratory failure in addition to a block of the cytochrome oxidase system. This conclusion was based on the observation in dogs that artificial respiration with or without 100% oxygen was ineffective and treatment with amyl nitrite did not produce any appreciable increase in methemoglobin until after restoration of cardiovascular function.

Johnson et al. (1682) investigated the effect of cyanide on the accumulation of calcium in the brain and the relationship of changes in brain calcium levels to the CNS-mediated signs of toxicity. Male Swiss-Webster mice were subcutaneously injected with 10 mg/kg potassium cyanide. A significant decrease in whole-brain total calcium was seen within 5 minutes of the injection, which was followed by a significant increase within 15 minutes. The cyanide-induced rise in brain calcium levels corresponded to the induction of tremors. Subtremor doses (0.5-7 mg/kg KCN) were ineffective in altering the whole-brain total calcium concentrations. The initial drop in whole-brain calcium levels during the first 5 minutes of the study was thought to be due to a cyanide-induced release of calcium from intra-cellular organelles. The sudden increase in whole-brain total calcium within 15 minutes suggested that calcium accumulation occurred.

56.3.1.4.2 Chronic Toxicity

Howard and Hanzal (1781) conducted a 2-year-feeding study to determine chronic effects of cyanide in rats. Groups of 10 male and 10

female Carworth Farm rats were fed a diet fumigated with 0, 100 or 300 ppm hydrogen cyanide. The level of exposure, however, varied throughout the study and may have dropped to 80 ppm at intervals. No signs of toxicity were noted. Food consumption, growth rate, and survival of the treated animals were comparable with the controls. No pathological or histological abnormalities were observed in a representative number of rats that were examined. Elevated thiocyanate levels were noted in the plasma, liver and kidney of the cyanide treated rats at termination. In view of the limited data and the uncertainties with regard to exact dosage, the only conclusion that can be drawn is that 80 to 300 ppm HCN in the diet presented no apparent hazard to rats.

Hertting et al. (1689) administered 0.5 to 2 mg/kg sodium cyanide to dogs once or twice a day for 15 months. Acute toxic signs were usually observed following ingestion with complete recovery occurring within half an hour. No evidence of physiological changes in organ function or permanent alterations in intermediary metabolism were observed.

Beagle dogs were fed 150 ppm sodium cyanide in the diet for 30 days with no effect on food consumption, hematologic parameters, behavioral characteristics or microscopic changes in organs or tissues (1690). These data indicate that substantial but sublethal doses of cyanide can be tolerated for long periods of time without any permanent damage.

Occasionally blindness has been reported in cyanide intoxicated laboratory animals due to optic tract demyelination. Lessell (1680) injected rats subcutaneously with increasing doses of sodium cyanide (0.4-1.7 mg/100 g) three times a week for 3 months. Seventy percent of the treated rats developed demyelinative and necrotic lesions in the corpus callosum and 20% of the animals had lesions in the optic nerve. All rats with a demyelinative optic neuropathy had a marked corpus callosal lesion. The vulnerability of both these tracts is most likely due to the low cytochrome oxidase levels in these tissues. Impairment of this already low level by cyanide results in histotoxic anoxia and the observed damage to the corpus callosal and the optic nerve.

56.3.2 Human and Epidemiologic Studies

56.3.2.1 Short-term Toxicologic Effects

Acute intoxication from HCN results in a sense of suffocation, tachycardia with palpitations, vertigo, buzzing in the ear, headache, epigastric burning, vomiting, general weakness, tremors, sensory obtusion, dyspnea and loss of consciousness (1683). Cyanide binds to metallic cofactors and inhibits 42 enzyme systems with cytochrome oxidase being especially sensitive; concentration of 3.3×10^{-8} moles/mL of cyanide completely inhibits cytochrome oxidase (1423).

Cyanide is a fast-acting poison which can be inhaled, ingested and/or absorbed through the skin (1683). The human lethal dose of ingested HCN is believed to be 50-90 mg; this corresponds to about 1 mg/kg for a 70-kg person. The toxicity of cyanide salts is somewhat lower because of slower absorption, i.e., 200-250 mg or about 3 mg/kg for 70-kg man (1423). Death may be delayed for an hour.

Recoveries, however, from ingestion of up to 3-5 g KCN without therapy and up to 6 g KCN with therapy have been documented (1423,1799,1675). Results of oral intoxication with cyanide, however, must be interpreted with caution in that the presence of food in the digestive tract may retard absorption.

Cyanide is also readily absorbed through the skin and can be fatal by this route. Raestrup (1784) described a case in which a man accidentally dropped fused KCN into a puddle of water. The water-cyanide solution splashed into his face and he immediately lost consciousness. He died 3 hours later. Muller-Hess (1677) also reported a fatal accident in which a worker was splashed on the head and shoulders with an 80% NaCN solution. He died in less than one hour.

Numerous cases of acute cyanide intoxication via inhalation have been cited in the literature (1423,1683,1688). Inhalation of HCN concentrations above 90 $\mu g/L$ (~100 mg/m^3) is lethal in humans (1423).

Three men in protective masks, but no additional protective clothing, entered a 2% HCN atmosphere. All 3 men were overcome in 8 to 10 minutes but managed to escape before they collapsed. Symptoms of acute cyanide exposure were manifested followed by complete recovery within 3 days (1676).

Wexler et al. (1695) examined the cardiac function of four men executed by HCN inhalation (concentrations not reported). Within the first three minutes of exposure, all subjects had a marked decrease in heart rate accompanied by sinus irregularity and the complete disappearance of P waves. All subjects showed A-V dissociation with a secondary decrease in rates during the fifth minute. Death occurred by 13 to 14 minutes. These data indicate that cyanide exerts no specific effect on the myocardium but induces effects typical of hypoxia.

56.3.2.2 Chronic Toxicologic Effects

Few reports of ill effects associated with long-term exposure to small quantities of cyanide are cited in the literature. Some investigators (1693,1683) have observed weakness, vertigo, nausea, rapid pulse, headache, flushing of the face and gastric distress in individuals suspected of having chronic cyanide poisoning.

A goldsmith apprentice suspected of having chronic cyanide toxicity was described by Sandberg (1783). Five months after returning from a 13-month leave of absence, the individual developed headache,

general malaise, paresis of the left arm and left leg, grey skin, dilated left pupil, blindness in the left half of the visual field, and an altered EEG showing diffuse frontal theta activity. It was revealed that in addition to dermal exposure from the 1.5% aqueous KCN solution used to clean the gold, the man inhaled HCN which evolved from the solution when heated. Blood analysis showed CN levels at 10-12 μg/100 mL. All symptoms disappeared within 4 months and blood CN levels dropped to 2-3 μg/mL.

Permanent disability resulting from chronic dermal exposure to cyanide was reported by Collins and Martland (1686). Cyanide was absorbed through the skin of a 38-year-old hotel worker who polished silver for 2 years by dropping the silver into KCN solution and wiping it off without gloves. The workers hands and arms turned a brownish-red and his fingernails turned black. Itching, diarrhea, headache, pain and stiffness in the back, weakness in the arms and legs and urine retention developed. Eventually, clinical manifestations resembling acute anterior poliomyelitis developed. After six months of incapacitation, the patient could walk with braces and crutches. The role of cyanide in this case remains unclear.

Chronic cyanide toxicity bear a striking similarity to thiocyanate intoxication, and it has been suggested that the symptoms ascribed to chronic cyanide poisoning may, in fact, be due to the toxicity of its metabolic product, thiocynate. Heavy smoking and eating cabbage-type vegetables can exacerbate the symptoms of occupational cyanide exposure due to additional formation of thiocynate (1683).

Wuthrich (1693) described a clinical case involving a man exposed sporadically to cyanide vapor for six years. Symptoms included loss of appetite, nervousness, vertigo, headache, nausea and vomiting. After exposure to cyanide had ceased for 14 days, the patient was given a placebo of NaCl, iv, for 3 days. The man's condition improved dramatically. On the fourth day, 1.4 g of sodium thiocynate was substituted for the NaCl injection. Nausea, lack of appetite and nervousness returned. After 3 days of sodium thiocynate injections, the man's condition worsened and he stated that he felt exactly as he had in his work place. Injections with NaCl resulted in the disappearance of symptoms within 2 days.

An increased urinary excretion of thiocynate was observed in case hardeners exposed to 4-6 ppm cyanide vapor and possibly to cyanide salts over the years (1694). No signs of toxicity were reported. However, El Ghawabi et al. (1696) reported 20 cases of mild to moderate thyroid enlargement among 36 male electroplating workers exposed to an average of 6.5-10.4 ppm cyanide for up to 15 years. Blood thiocyanates resulting from chronic cyanide exposure compete with iodide for uptake by the thyroid gland resulting in the appearance of goiters.

Chronic cyanide toxicity has been implicated in various neuropathic disorders. These diseases include Nigerian nutritional neuropathy, Leber's optical atrophy, retrobulbar neuritis, pernicious

anemia, cretinism and ataxic tropical neuropathy. A common contributing factor found in each of these conditions was a diet high in cyanogenic glycosides (1683).

56.3.3 Levels of Concern

The USEPA (355) has established an ambient water quality criterion for cyanides of 200 μg/L for the protection of human health from the toxic properties of cyanide ingested through water and contaminated aquatic organisms.

For noncarcinogenic risk, the USEPA (992) has issued health advisories of 0.75 mg/L (1-10 days) for exposure to cyanide in drinking water. The WHO (666) recommends a level of 10 μg/L for drinking water.

Both OSHA (298) and the ACGIH (3) have set an occupational exposure limit of 5 mg/m^3 (as CN^-) for cyanide, with a notation of possible skin absorption.

Neither IARC nor NTP have classified this compound with regard to carcinogenic activity.

56.3.4 Hazard Assessment

Cyanide is a rapidly acting, chemical asphyxiant, which is readily absorbed from the alveolar membrane, intestinal mucosa and/or skin, and rapidly appears in the blood. The more quickly a critical concentration of cyanide is attained in the tissues, the more severe the effects. In sufficient doses, cyanide produces rapid death by inhibiting key respiratory enzymes and thereby preventing the body from utilizing available oxygen. At nonlethal doses, cyanide is detoxified to the relatively nontoxic thiocyanate ion. Thus, exposure to small but continuous doses of cyanide may produce no visible effects, while high doses of cyanide over a short time interval saturate normal detoxification mechanisms, which results in acute lethality. Minimum lethal doses of HCN for humans are approximately 50-90 mg by ingestion and approximately 100-150 mg/m^3 by inhalation (1423). With the ingestion of simple cyanide salts such as KCN, death may be delayed as long as an hour due to poor absorption (1423).

No indications of adverse effects were noted in long-term feeding studies available for cyanide (1781,1689). No data were available on the carcinogenic and mutagenic effects of cyanide. A single report noted malformations in hamsters exposed continuously to NaCN by infusion during gestation (1782). The significance of this study to the human situation is questionable.

The majority of available data deal with the effects of acute exposure to high levels of cyanide which leads either to death or complete recovery. Symptoms of cyanide exposure in humans include weakness, headache, confusion, nausea, vomiting, increased rate of respiration or slow, gasping respiration and eye and skin irritation. This is followed by collapse, coma, convulsions and death. Little is known about the effects of chronic exposure to low levels of cyanide

(1683). Studies have circumstantially implicated cyanide exposure as a factor in several neurological disorders such as Nigerian nutritional neuropathy, but the evidence is not conclusive. The ability of humans to detoxify cyanide rapidly at low exposure levels suggests that the risk of chronic low-level exposure to cyanide are minimal.

56.4 SAMPLING AND ANALYSIS CONSIDERATIONS

Determination of cyanide ion (as total cyanide) concentrations in soil and water requires collection of a representative field sample and laboratory analysis. Care is required to prevent losses and avoid contamination during sample collection. Samples may be collected in either glass or plastic containers of one liter or larger size. Sample preservation involves cooling and maintaining samples at 4°C with the addition of sodium hydroxide in the field until the pH of the sample is > 12; ascorbic acid should be added in the presence of residual chlorine. Samples should be analyzed as soon as possible after collection; maximum holding time is 14 days (24 hours when sulfide is present). In addition to the targeted samples, quality control samples such as field blanks, duplicates, and spiked matrices may be specified in the recommended methods.

EPA-approved procedures for the analysis of cyanide in aqueous samples include Methods 335.2 and 335.3 (1420), 9010 (63) and 412 (1422). In Methods 335.2, 9010, and 412B, the cyanide as hydrocyanic acid (HCN) is released from cyanide complexes by a reflux-distillation operation and absorbed in a scrubber containing a sodium hydroxide solution; the cyanide ion in the absorbing solution is then determined by volumetric titration (Methods 335.2, 9010, and 412C), colorimetrically (Method 335.2 and 412D) or potentiometrically (Method 412E). In Method 335.3, cyanide (as HCN) is released from cyanide complexes by UV digestion and distillation; cyanides are converted to cyanogen chloride by reactions with chloramine-T which subsequently reacts with pyridine and barbituric acid to yield a red-colored complex.

The EPA procedures recommended for determination of total cyanide concentrations in aqueous samples may also be applicable to the determination of cyanide in soil and waste samples. These procedures differ primarily in the preparation of the sample for analysis; cyanide ion must be solubilized and separated from the sample matrix prior to analysis.

Typical detections limits for cyanide that can be obtained in wastewaters are shown below; detection limits were not indicated for non-aqueous samples. The actual detection limit achieved in a given analysis will vary with instrument sensitivity and matrix effects.

Non-Aqueous Detection Limit

1 mg/L (Method 335.2/titration procedure)
0.02 mg/L (Method 335.2/colorimetric procedure)
5 μg/L (Method 335.3)
1 mg/L (Method 9010)
1 mg/L (Method 412C)
0.02 mg/L (Method 412D)
0.05 mg/L (Method 412E)

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (13)
2-Propanone Dimethyl ketone Pyroacetic ether Pyroacetic acid Methyl acetal Methyl ketone	67-64-1 NIOSH NO.: AL3150000	C_3H_6O	2.37 mg/m³ ≈ 1 ppm 0.422 ppm ≈ 1 mg/m³
	STRUCTURE: $CH_3-\overset{\overset{\large O}{\|}}{C}-CH_3$		MOLECULAR WEIGHT: 58.09

REACTIVITY	Reactions of ketones such as acetone with non-oxidizing mineral acids, caustics, cyanides, mercaptans, or other organic sulfides typically produce heat, while those with alkali or alkaline earth elemental metals, nitrides or strong reducing agents evolve heat and flammable gases. Reactions with oxidizing mineral acids or other strong oxidizing agents may generate heat, fires, and/or explosions. Those with azo or diazo compounds or hydrazines may generate heat and usually innocuous gases. Reactions with organic peroxides or hydroperoxides typically result in explosions, while those with chlorinated melamines may result in rapid reaction, fumes, fire, and explosion. Explosive reactions have also been reported with chloroform and a base and with nitrosyl chloride and a platinum catalyst in closed containers (505,511).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): volatile liquid	(45)
	• Color: colorless	(45)
	• Odor: sweet, pungent	(45)
	• Odor Threshold: 20 ppm	(13)
	• Liquid Density (g/ml at 20°C): 0.791	(21)
	• Freezing/Melting Point (°C): -95.3	(23)
	• Boiling Point (°C): 56.2	(13)
	• Flash Point (°C): -20 to -17 (cc); -15.6 to -9.4 (oc)	(23,51,60, 507)
	• Flammable Limits in Air, % by Volume: 2.15 or 2.6 - 12.8	(51,60, 506,507)
	• Autoignition Temperature (°C): 465, 538 or 560	(23,51, 506,514)
	• Vapor Pressure (mm Hg at 20°C): 186	(21)
	• Saturated Concentration in Air (mg/m³ at 20°C): 5.9×10^5	(ADL estim)
	• Solubility in Water (mg/L at 20°C): infinite	(21)
	• Viscosity (cp at 20°C): 0.33	(21)
	• Surface Tension (dyne/cm at 20°C): 23.7	(21)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: -0.24	(29)
	• Soil Adsorption Coefficient, K_{oc}: 0.28	(65)
	• Henry's Law Constant (atm•m³/mol at 25°C): 3.97×10^{-5}	(966)
	• Bioconcentration Factor: 0.03	(659)

PERSISTENCE IN THE SOIL-WATER SYSTEM	Acetone is expected to migrate freely through the soil/ground-water system. Volatilization may occur in near surface soils; however, vapor phase concentrations in soil are expected to be very low whenever water is present. Biodegradation of acetone has been demonstrated and persistence in environments with active microbial populations is not expected.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil/ground-water system is the migration of acetone to ground-water drinking water supplies. Inhalation may be important in some situations. Bioaccumulation of acetone is not likely to be an important exposure pathway.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (2,46): Dryness and irritation of eyes, nose and throat are usual signs of acute exposure to acetone vapor. Exposure to high concentrations of acetone can produce dizziness, nausea, narcosis and in extreme cases, coma.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral 9750 [rat] (51); skin 20,000 [rabbit] (51) — LC_{50} (mg/m^3) inhalation [mouse] (51) 110,000·62 min
	Long-Term Effects: Respiratory tract irritation, dermatitis
	Pregnancy/Neonate Data: Negative
	Mutation Data: Limited evidence
	Carcinogenicity Classification: IARC - none assigned; NTP - none assigned

HANDLING PRECAUTIONS (54)	Handle chemical only with adequate ventilation • Vapor concentrations of 750-5000 ppm: gas mask with organic vapor canister • Vapor concentrations of 5000-20,000 ppm: gas mask with organic vapor canister, any supplied air respirator or self-contained breathing aparatus with full facepiece • Butyl, natural rubber, neoprene, nitrile, PE, PVA or PVC gloves, apron and boots to prevent repeated or prolonged skin contact with the liquid • Chemical goggles if there is probability of eye contact.

EMERGENCY FIRST AID TREATMENT (59)	Ingestion: Give large quantities of water and induce vomiting if victim is conscious. Get medical attention • Inhalation: move victim to fresh air immediately and perform artificial respiration if necessary • Skin: Remove contaminated clothing immediately to avoid flammability hazard. Wash skin with soap and water • Eye: Irrigate with water copiously for at least 15 minutes. If irritation or pain persists, get medical attention.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Benzol Benzole Carbon oil Coal naphtha Phenylhydride Pyrobenzol	71-43-2 NIOSH NO.: CY1400000	C_6H_6	3.19 mg/m^3 ≅ 1 ppm 0.313 ppm ≅ 1 mg/m^3
	STRUCTURE:		MOLECULAR WEIGHT: 78.11

REACTIVITY	Benzene may generate heat, react vigorously, and possibly ignite or explode in contact with oxidizing mineral acids or other strong oxidizing agents (507,511,505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless to light yellow	(23)
	• Odor: aromatic	(23)
	• Odor Threshold: 4.68 ppm (15 mg/m^3)	(263)
	• Liquid Density (g/ml at 20°C): 0.8765	(68)
	• Freezing/Melting Point (°C): 5.5	(14)
	• Boiling Point (°C): 80.1	(23)
	• Flash Point (°C): -11 (closed cup)	(23)
	• Flammable Limits in Air, % by Volume: 1.3-7.9	(60,504,506)
	• Autoignition Temperature (°C): 560-592	(60,504,510)
	• Vapor Pressure (mm Hg at 20°C): 76	(67)
	• Saturated Concentration in Air (mg/m^3 at 20°C): 319,000	(67)
	• Solubility in Water (mg/L at 20°C): 1780	(67)
	• Viscosity (cp at 20°C): 0.6468	(21)
	• Surface Tension (dyne/cm at 20°C): 29	(23)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 2.13	(29)
	• Soil Adsorption Coefficient, K_{oc}: 65	(652)
	• Henry's Law Constant (atm·m^3/mol at 25°C): 5.43×10^{-3}	(74)
	• Bioconcentration Factor: 6.5 (estim)	(659)

PERSISTENCE IN THE SOIL-WATER SYSTEM	Benzene is expected to be fairly mobile in the soil/ground-water system. Transport with infiltration water is expected particularly in sandy soils and soils of low organic content. Volatilization of material near the surface or in the soil-air compartment may be important. Transformation processes such as hydrolysis and biodegradation are not expected to be significant in natural soils; however, biodegradation by acclimated populations has been reported.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is the migration of benzene to ground-water drinking water supplies. Migration has commonly occurred in the past. Inhalation resulting from volatilization from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (45,12): The primary effects of inhalation and ingestion are on the central nervous system. Symptoms include headache, dizziness, drowsiness and nausea which may progress to convulsions, respiratory paralysis and death with high vapor concentrations. Benzene causes irritation of the eyes and skin.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 3800 (59); skin -- no data; LC_{50} (ppm) inhalation [rat] (59) 10,000·7 hr
	Long-Term Effects: Pancytopenia, leukemia
	Pregnancy/Neonate Data: Negative
	Mutation Data: Mixed results
	Carcinogenicity Classification: IARC - category 1; NTP - clear evidence

HANDLING PRECAUTIONS (54,52)	Handle chemical only with adequate ventilation • Vapor concentrations of 10-50 ppm: supplied-air respirator or self-contained breathing apparatus • 50-1000 ppm: supplied-air respirator or self-contained breathing apparatus with full facepiece • 1000-2000 ppm: supplied-air respirator operated in pressure-demand, positive-pressure or continuous flow mode • Butyl, natural rubber, neoprene, nitrile, viton, PE, PVC or other protective clothing to prevent prolonged or repeated skin contact with the liquid • Chemical goggles if there is possibility of eye contact.

EMERGENCY FIRST AID TREATMENT (45,53)	Caution: Do not administer stimulants • Ingestion: Do not induce vomiting. Seek medical attention • Inhalation: Move victim to fresh air; give artificial respiration if necessary. Get medical attention • Skin: Remove contaminated clothing; wash skin with soap and water. If irritation persists after washing, get medical attention • Eye: Irrigate copiously with water. Get medical attention.

CHEMICAL NAME
BENZENE

FORMULA
C6H6

SYNONYMS
BENZOL
CYCLOHEXATRIENE
COAL TAR NAPHTHA
PHENYL HYDRIDE
NCI-C55276
BENZINE
BENZOLE
UN 1114
(6)ANNULENE
BENZIN
BENZOLENE
BICARBURET OF HYDROGEN
CARBON OIL
COAL NAPHTHA
MINERAL NAPHTHA
MOTOR BENZOL
NITRATION BENZENE
PHENE
PYROBENZOL
PYROBENZOLE
OHS02610

PERMISSIBLE EXPOSURE LIMIT
1 PPM OSHA TWA; 5 PPM OSHA 15-MIN STEL; 0.5 PPM OSHA ACTION LEVEL
10 PPM (30 MG/M3) ACGIH TWA
0.1 PPM NIOSH RECOMMENDED 8-HOUR TWA
1 PPM NIOSH RECOMMENDED 15-MINUTE CEILING
HUMAN CARCINOGEN (NTP, IARC, OSHA); SUSPECT HUMAN CARCINOGEN (ACGIH)
ANIMAL CARCINOGEN (IARC); POSITIVE CARCINOGEN IN RATS/MICE (NCI)
MUTAGENIC DATA (RTEC); TERATOGENIC DATA (RTEC)
AQUATIC TOXICITY RATING 2 (TLM96 10-100 PPM)
TLM96 - FATHEADS 32-33.47 PPM, BLUEGILLS 22.49 PPM, GUPPIES 36.60 PPM
TLM96 - GAMBUSIA AFFINIS 386; TLM - RAINBOW TROUT 15.4 PPM
KILL, 1HR - LEPOMIS HUMILIS 35-37 PPM
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 3 - REACTIVITY 0 - PERSISTENCE 1

TOXICOLOGY: BENZENE IS A CENTRAL NERVOUS SYSTEM DEPRESSANT, AND AN EYE AND SKIN IRRITANT. POISONING MAY CAUSE BLOOD DYSCRASIAS, HEMMORRHAGES, AND IMMUNOSUPPRESSION.

CASE REPORTS AND EPIDEMIOLOGICAL STUDIES HAVE ESTABLISHED A RELATIONSHIP BETWEEN PROLONGED BENZENE EXPOSURE AND LEUKEMIA.

THE THRESHOLD LIMIT VALUE WAS SET TO PREVENT BLOOD ABNORMALITIES AND OTHER TOXIC EFFECTS.

ORL-RAT LD50: 3400 MG/KG	ORL-MUS LD50: 4700 MG/KG
IHL-RAT LC50: 10000 PPM/7 H	IHL-MUS LC50: 9980 PPM
SKN-MUS LD50: 48 MG/KG	IPR-RAT LD50: 2890 UG/KG
IPR-MUS LD50: 990 UG/KG	IHL-HMN LCLO: 2 PPH/5 M
IHL-HMN LCLO: 65 MG/M3/5 YR	IHL-HMN LCLO: 20000 PPM/5 M
UHK-HMN LDLO: 194 MG/KG	ORL-HMN TDLO: 130 MG/KG
IHL-HMN TCLO: 100 PPM	IHL-HMN TCLO: 210 PPM

IHL-MAN TCLO: 150 PPM/1 YR INTERMITTENT
ORL-DOG LDLO: 2000 MG/KG IHL-DOG LCLO: 146000 MG/M3
IHL-CAT LDLO: 170000 MG/M3

IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONCENTRATION
2000 PPM
OSHA/NIOSH

PHYSICAL DESCRIPTION
COLORLESS TO LIGHT-YELLOW, MOBILE, NON-POLAR LIQUID; AROMATIC ODOR

CHEMICAL AND PHYSICAL PROPERTIES
MOLECULAR WEIGHT: 78.08
BOILING POINT AT 1 ATM, F: 176 F
SOLUBILITY IN WATER, G/100 G WATER AT 20C: 0.06
FLASH POINT, CLOSED CUP, F (OR OPEN CUP IF 0C): 12 F
VAPOR PRESSURE @ 20 C, MMHG: 75 MM HG
MELTING POINT, F: 42 F
UPPER EXPLOSIVE LIMIT IN AIR, % BY VOLUME: 7.5%
LOWER EXPLOSIVE LIMIT IN AIR, % BY VOLUME: 1/3%
AUTOIGNITION TEMPERATURE: 1076 F
SPECIFIC GRAVITY: 0.879
VAPOR DENSITY (AIR=1): 2.7
ODOR THRESHOLD: 1.5-5 PPM
OCTANOL/WATER PARTITION COEFFICIENT: 2.13

INCOMPATIBILITIES
STRONG OXIDIZERS
ZINC IN PRESENCE OF STEAM
CHLORINE TRIFLUORIDE
OZONE
SULFURIC ACID
POTASSIUM
CHROMIC ANHYDRIDE
DUST/VAPORS MAY FORM EXPLOSIVE MIXTURE WITH AIR

PERSONAL PROTECTIVE EQUIPMENT
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).

EMPLOYERS SHALL ENSURE THAT CLOTHING WET WITH THIS SUBSTANCE IS PLACED IN CLOSED CONTAINERS FOR STORAGE UNTIL IT CAN BE DISCARDED OR UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF THE CONTAMINANT FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE CONTAMINANT, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE CLEANING OPERATION OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.

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ACGIH "GUIDELINES FOR THE SELECTION OF CHEMICAL PROTECTIVE CLOTHING" INDICATES THE FOLLOWING PROTECTIVE RATINGS FOR MATERIALS COMMONLY USED FOR PROTECTIVE CLOTHING. THESE RATINGS ARE BASED PRIMARILY ON QUANTITATIVE TEST RESULTS AND QUALITATIVE RESISTANCE INFORMATION. (THE RECOMMENDATIONS APPLY TO THE PURE SUBSTANCE ONLY; BREAKTHROUGH-TIME MAY VARY FOR MIXTURES.) BENZENE:

EXCELLENT/GOOD:
VITON

GOOD/FAIR:
POLYVINYL ALCOHOL

FAIR/POOR:
BUTYL RUBBER
NATURAL RUBBER
NEOPRENE
NEOPRENE/NATURAL RUBBER
NITRILE
POLYETHYLENE
CHLORINATED POLYETHYLENE
POLYURETHANE
POLYVINYL CHLORIDE

FAIR/GOOD:
NEOPRENE/STYRENE-BUTADIENE
NITRILE/POLYVINYL CHLORIDE
STYRENE-BUTADIENE RUBBER
FLUORINATED ETHYLENE PROPYLENE POLYMER OR POLYTETRAFLUOROETHYLENE
CHLORINATED NATURAL RUBBER
SARANEX

GOGGLES
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE SPLASH-PROOF SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THIS LIQUID MAY CONTACT THE EYES.

WASHING CHEMICALS FROM THE SKIN
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE PROMPTLY WASH OR SHOWER WITH SOAP OR MILD DETERGENT AND WATER TO REMOVE ANY CONTAMINANT FROM THE SKIN.

ROUTINE CHANGING OF WORK CLOTHING
NOT REQUIRED

CLOTHING REMOVAL FOLLOWING ACCIDENTAL CONTAMINATION
EMPLOYERS SHALL ENSURE THAT ANY CLOTHING WHICH BECOMES WET WITH THIS FLAMMABLE LIQUID BE REMOVED IMMEDIATELY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

SPECIFIC EMERGENCY PROVISIONS
NONE REQUIRED

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED)

< OR = 10 PPM
- HALF-MASK AIR-PURIFYING RESPIRATOR
  WITH AN ORGANIC VAPOR CARTRIDGE

< OR = 50 PPM
- FULL FACE-PIECE AIR-PURIFYING RESPIRATOR
  WITH AN ORGANIC VAPOR CARTRIDGE

< OR = 100 PPM
- GAS MASK WITH AN ORGANIC VAPOR CANISTER (CHIN-STYLE OR FRONT- OR BACK-MOUNTED CANISTER)

< OR = 1,000 PPM
SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

> 1,000 PPM
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE

UNKNOWN
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE

ESCAPE
- GAS MASK WITH AN ORGANIC VAPOR CANISTER (CHIN-STYLE OR FRONT- OR BACK-MOUNTED CANISTER)
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

ROUTE OF ENTRY INTO BODY
INHALATION
SKIN ABSORPTION
INGESTION
SKIN OR EYE CONTACT

SYMPTOMS
ANEMIA
YELLOW DISCOLORATION
CEREBRAL EDEMA
THROMBOCYTOPENIA
MYDRIASIS
TINNITUS
RESPIRATORY IRRITATION
CONFUSION
ABDOMINAL CRAMPS
DYSPNEA
VISUAL DISTURBANCE
EUPHORIA
EXCITATION
BONE MARROW DEPRESSION

LYMPHOPENIA
ERYTHROCYTOPENIA
BLOOD CHANGES
PNEUMONIA
CARDIAC IMMUNOSUPPRESSION
VENTRICULAR FIBRILLATION
LIVER DAMAGE
KIDNEY DAMAGE
ERYTHROCYTOPENIA
BRAIN HEMORRHAGE
PETECHIAE
CONVULSIONS
COMA
TUMORS
LEUKEMIA

FIRST AID PROCEDURES FOLLOWING EXPOSURE

IF THIS CHEMICAL GETS INTO THE EYES, IMMEDIATELY WASH THE EYES WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING THE LOWER AND UPPER LIDS. GET MEDICAL ATTENTION IMMEDIATELY. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS CHEMICAL.

IF THIS CHEMICAL GETS ON THE SKIN, IMMEDIATELY WASH CONTAMINATED SKIN WITH SOAP OR MILD DETERGENT & WATER. IF THIS CHEMICAL SOAKS CLOTHING, IMMEDIATELY REMOVE CLOTHING & WASH SKIN WITH SOAP OR MILD DETERGENT & WATER. GET MEDICAL ATTENTION PROMPTLY.

IF A PERSON BREATHES IN LARGE AMOUNTS OF THIS CHEMICAL, 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.

WHEN THIS CHEMICAL HAS BEEN SWALLOWED, DO NOT INDUCE VOMITING.
REMOVE BY GASTRIC LAVAGE AND CATHARSIS.

BENZENE/TOLUENE/XYLENE EXPOSURE:

EMERGENCY TREATMENT - REMOVE FROM EXPOSURE. GIVE ARTIFICIAL RESPIRATION WITH OXYGEN. REMOVE BY GASTRIC LAVAGE. AVOID ASPIRATION.

FURTHER TREATMENT - CONTROL EXCITEMENT OR CONVULSIONS WITH DIAZEPAM, 0.1 MG/KG, SLOWLY INTRAVENOUSLY. KEEP PATIENT AT REST UNTIL RESPIRATION IS NORMAL. DO NOT GIVE EPINEPHRINE OR EPHEDRINE OR RELATED DRUGS. MONITOR ECG FOR VENTRICULAR ABNORMALITIES INDICATING CARDIAC ARREST.

SPECIAL TREATMENT - TREAT ANEMIA WITH REPEATED BLOOD TRANSFUSIONS. TREAT KIDNEY OR LIVER DAMAGE.

(MEDICATION MUST BE GIVEN BY QUALIFIED MEDICAL PERSONNEL)
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

GASTRIC LAVAGE - GIVE PATIENT GLASS OF WATER PRIOR TO PASSING OF STOMACH TUBE. LAY PATIENT ON ONE SIDE, WITH HEAD LOWER THAN WAIST. IMMOBILIZE A STRUGGLING PATIENT WITH A SHEET OR BLANKET. MEASURE DISTANCE ON TUBE FROM MOUTH TO EPIGASTRIUM, MARK TUBE WITH INDELIBLE MARKING OR TAPE. REMOVE DENTURES AND OTHER FOREIGN OBJECTS FROM MOUTH. OPEN MOUTH, USE GAG IF NECESSARY. EXTEND HEAD BY LIFTING THE CHIN. PASS TUBE OVER TONGUE AND TOWARD BACK OF THROAT WITHOUT EXTENDING HEAD OR NECK. IF OBSTRUCTION IS MET BEFORE THE MARK ON TUBE REACHES LEVELS OF TEETH, DO NOT FORCE, BUT REMOVE TUBE AND REPEAT PROCEDURE UNTIL TUBE PASSES TO MARK. PLACE END OF TUBE IN GLASS OF WATER. IF TUBE IS OBSTRUCTED WHEN INTRODUCED ABOUT HALFWAY TO THE MARK, IT MAY HAVE ENTERED TRACHEA.

AFTER TUBE IS PLACED IN STOMACH, ASPIRATE FIRST TO REMOVE STOMACH CONTENTS BY IRRIGATION SYRINGE. SAVE STOMACH CONTENTS FOR EXAMINATION, AND REPEAT INTRODUCTION AND WITHDRAWAL OF 100-300 ML WARM WATER UNTIL AT LEAST 3 LITERS OF CLEAR RETURN ARE OBTAINED. USE ACTIVATED CHARCOAL AT BEGINNING OF LAVAGE TO AID IN POISON INACTIVATION. LEAVE 50 GRAMS OF CHARCOAL SUSPENDED IN WATER IN THE STOMACH. IF INTRODUCTION AND REMOVAL OF LAVAGE FLUID BY GRAVITY REQUIRES MORE THAN FIVE MINUTES, ASSIST WITH ASEPTO SYRINGE. PREVENT ASPIRATION WITH CUFFED ENDOTRACHEAL TUBE.

AVOID GIVING LARGE QUANTITIES OF WATER.

MASSAGE OF EPIGASTRIUM WHILE STOMACH TUBE IS BEING ASPIRATED MAY AID IN POISON REMOVAL.

IF PATIENT COMATOSE, INTUBATE TRACHEA WITH CUFFED ENDOTRACHEAL TUBE. SUCCINYLCHLORINE MAY BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL TO EASE INSERTION OF TRACHEAL CATHETER PRIOR TO PASSAGE OF STOMACH TUBE.
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

CONVULSIONS - GIVE ARTIFICIAL RESPIRATION BY MOUTH-TO-MOUTH INSUFFLATION. RESTRAIN THE PATIENT DURING CONVULSIONS TO PREVENT INJURY. DO NOT ATTEMPT EMESIS OR GASTRIC LAVAGE WHILE THE PATIENT IS TWITCHING OR HYPERIRRITABLE UNLESS THE AIRWAY IS CONTROLLED AND REMOVAL OF DRUG IS IMPERATIVE.

ADMINISTER ANTICONVULSANTS. MAINTAIN HYDRATION BY ORAL OR INTRAVENOUS FLUID ADMINISTRATION. MAINTAIN AN ADEQUATE AIRWAY. TREAT HYPOGLYCEMIA BY GIVING GLUCOSE. REDUCE ELEVATED TEMPERATURE BY USING TEPID SPONGES. REMOVE SECRETIONS FROM THE PHARYNX BY SUCTION. GIVE POSITIVE-PRESSURE RESPIRATION WITH OXYGEN DURING CONVULSIONS.
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

ACUTE RENAL FAILURE - TREAT SHOCK. FOR HEMOLYTIC REACTIONS, GIVE SODIUM BICARONATE, 5 G EVERY 1-2 HOURS AS NECESSARY TO MAINTAIN AN ALKALINE URINE.
(MEDICATION MUST BE GIVEN BE QUALIFIED MEDICAL PERSONNEL)
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

LIVER DAMAGE - REMOVE FROM EXPOSURE TO ALL CHEMICALS AND DRUGS. MAINTAIN COMPLETE BED REST. AVOID ANESTHESIA OR SURGICAL PROCEDURES. AVOID DEHYDRATION OR OVERHYDRATION. IF VOMITING SEVERE AND ORAL FLUIDS NOT RETAINED, REPLACE VOMITUS WITH AN EQUAL QUANTITY OF 100% DEXTROSE IN NORMAL SALINE. IN RENAL FUNCTION ADEQUATE, GIVE 1 LITER OF 5% DEXTROSE OR INVERT SUGAR IN NORMAL SALINE PLUS 1-3 LITERS OF 10% DEXTROSE OR INVERT SUGAR IN DISTILLED WATER INTRAVENOUSLY EVERY TWENTY-FOUR HOURS.
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

ORGANS
BLOOD
CENTRAL NERVOUS SYSTEM
SKIN
BONE MARROW
EYES
RESPIRATORY SYSTEM

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (59)
2-Butanone MEK Ethyl methyl ketone Methyl acetone	78-93-3 NIOSH NO.: EL6475000	C_4H_8O	2.94 mg/m³ ≈ 1 ppm 0.340 ppm ≈ 1 mg/m³
	STRUCTURE: $CH_3-CH_2-\overset{\overset{\large O}{\|}}{C}-CH_3$		MOLECULAR WEIGHT: 72.10

REACTIVITY	Reactions of ketones such as methyl ethyl ketone with non-oxidizing mineral acids, caustics, cyanides, mercaptans, or other organic sulfides typically produce heat, while those with alkali or alkaline earth elemental metals, nitrides or strong reducing agents evolve heat and flammable gases. Reactions with oxidizing mineral acids or other strong oxidizing agents may generate heat and fire. Those with azo or diazo compounds or hydrazines may generate heat and usually innocuous gases. Reactions with organic peroxides or hydroperoxides typically result in explosions. Various manufacturers list oxidizing agents, chlorinated hydrocarbons in the presence of alkalies, alkanolamines, amines, pyridines, ammonia, caustics, inorganic acids, isocyanates, and halogens as incompatible materials (505,507,511).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless	(23)
	• Odor: acetone-like	(23)
	• Odor Threshold: 5.4 ppm, 10 ppm	(384,2)
	• Liquid Density (g/ml at 20°C): 0.805	(14)
	• Freezing/Melting Point (°C): -86.4	(23)
	• Boiling Point (°C): 79.6	(14)
	• Flash Point (°C): -5.6 to -1.1 (oc); -6.7 to -3.9 (cc)	(60,507, 514)
	• Flammable Limits in Air, % by Volume: 1.7 - 2.0 to 10 - 12	(51,60, 506,507)
	• Autoignition Temperature (°C): 404 or 516	(51,60, 506,510)
	• Vapor Pressure (mm Hg at 20°C): 70.6	(59)
	• Saturated Concentration in Air (mg/m³ at 20°C): 279,071	(ADL estim)
	• Solubility in Water (mg/L at 10°C): 353,000	(67)
	• Viscosity (cp at 25°C): 0.4	(23)
	• Surface Tension (dyne/cm at 20°C): no data	( )
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 0.29	(29)
	• Soil Adsorption Coefficient, K_{oc}: 0.94	(611)
	• Henry's Law Constant (atm•m³/mol at 20°C): 4.35×10^{-5}	(1138)
	• Bioconcentration Factor: 1.86, 0.09	(1137,659)

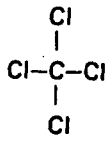
PERSISTENCE IN THE SOIL-WATER SYSTEM	Methyl ethyl ketone is expected to migrate in the soil/ground-water system with very little retardation. Volatilization from near-surface soils may occur; however, vapor concentrations in soil are expected to be very low whenever water is present. Biodegradation of methyl ethyl ketone has been demonstrated and persistence in environments with active microbial populations is not expected.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil/ground-water system is the migration of methyl ethyl ketone to ground-water drinking water supplies. Inhalation may be important in some situations. Bioaccumulation of methyl ethyl ketone is not likely to be an important exposure pathway.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (13): Eye, nose and throat irritation are usually the first symptoms to appear in methyl ethyl ketone exposure. At high concentrations, CNS depression and narcosis along with congestion of the lungs, liver and kidneys are observed.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg): oral 2737 [rat] (47); skin 13,000 [rabbit] (47). LC_{50} (mg/m^3): inhalation [mouse] 40,000·2 hr (47)
	Long-Term Effects: Dermatitis
	Pregnancy/Neonate Data: Fetotoxic at 3000 ppm
	Mutation Data: Conflicting data
	Carcinogenicity: No data

HANDLING PRECAUTIONS (54)	Handle chemical only with adequate ventilation • Vapor concentration of 200 - 1000 ppm: chemical cartridge respirator with organic vapor cartridge and full facepiece • 1000 - 30,000 ppm: gas mask with organic vapor canister, any supplied air respirator or self-contained breathing apparatus with full facepiece • Butyl, natural rubber, neoprene, nitrile, PE, PVA or PVC gloves, apron and boots to prevent repeated or prolonged skin contact with the liquid • Chemical goggles if there is probability of eye contact.

EMERGENCY FIRST AID TREATMENT (54)	Ingestion: Give large quantities of salt water and induce vomiting if victim is conscious. Get medical attention • Inhalation: Move victim to fresh air immediately and perform artifical respiration if necessary • Skin: Remove contaminated clothing. Wash skin with soap and water • Eye: Irrigate with large amounts of water immediately.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Tetrachloromethane Methane tetrachloride Perchloromethane Carbon chloride Tetrachlorocarbon	56-23-5 NIOSH NO.: FG4900000	CCl_4	6.29 mg/m³ ≅ 1 ppm 0.159 ppm ≅ 1 mg/m³
	STRUCTURE:		MOLECULAR WEIGHT: 153.84

REACTIVITY	Reactions of halogenated organic materials such as carbon tetrachloride with cyanides, mercaptans or other organic sulfides typically generate heat, while those with mineral acids, amines, azo compounds, hydrazines, caustics, or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases, and fires. Those with alkali or alkaline earth metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents, or strong reducing agents typically result in heat generation and explosions and/or fires (511). Known explosions have been caused by reactions with burning wax, calcium hypochlorite, plutonium, uranium, borane, allyl alcohol, certain aluminum compounds, barium, silanes, silver perchlorate and other substances listed above (505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless	(23)
	• Odor: sweet, pungent	(263)
	• Odor Threshold: 21-100 ppm	(263)
	• Liquid Density (g/ml at 20°C): 1.5947	(21)
	• Freezing/Melting Point (°C): -23	(23)
	• Boiling Point (°C): 76.74	(23)
	• Flash Point (°C): nonflammable	( )
	• Flammable Limits in Air, % by Volume: nonflammable	(507,504)
	• Autoignition Temperature (°C): nonflammable	(507,504)
	• Vapor Pressure (mm Hg at 20°C): 91.3	(23)
	• Saturated Concentration in Air (mg/m³ at 20°C): 754,000	(67)
	• Solubility in Water (mg/L at 20°C): 800	(38)
	• Viscosity (cp at 20°C): 0.965	(21)
	• Surface Tension (dyne/cm at 20°C): 26.77	(21)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 2.83	(29)
	• Soil Adsorption Coefficient, K_{oc}: 439	(33)
	• Henry's Law Constant (atm·m³/mol at 20°C): 0.02	(74)
	• Bioconcentration Factor: 30 (bluegill), 32 (estim)	(102,659)

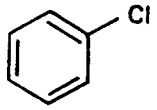
PERSISTENCE IN THE SOIL-WATER SYSTEM	Carbon tetrachloride is expected to be sorbed strongly onto surface soils, and less strongly in deep or sandy soils. Removal by volatilization may occur for near-surface carbon tetrachloride. Transformation processes such as hydrolysis and biodegradation are not expected to be significant in natural soils.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is the migration of carbon tetrachloride to ground-water drinking water supplies. There is extensive evidence that such migration has occurred in the past. Inhalation resulting from volatilization from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (38,54,46) Exposure may cause drowsiness, dizziness, incoordination and mental confusion; nausea, vomiting, diarrhea and abdominal pain are frequent. Delayed effects from short-term overexposure include damage to the heart, liver and kidneys. Repeated or prolonged skin contact with the liquid may cause irritation. Eye contact with the liquid causes pain and minimal injury to the conjunctiva.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) — oral [rat] 2800 (47); skin [rat] 5070 (47) LC_{50} (mg/m^3) — inhalation [mouse] (59) 59,920·8 hr
	Long-Term Effects: Liver and kidney injuries
	Pregnancy/Neonate Data: Fetotoxic
	Mutation Data: Suggestive evidence of mutagenicity
	Carcinogenicity Classification: IARC - category 2b; NTP - none assigned

HANDLING PRECAUTIONS (38,52)	Handle chemical only with adequate ventilation • Vapor concentrations of 10-100 ppm: any supplied-air respirator or self-contained breathing apparatus • 100-300 ppm: any supplied-air respirator or self-contained breathing apparatus with full facepiece • Above 300 ppm: self-contained breathing apparatus with full facepiece operated in positive pressure mode • Chemical goggles if there is probability of eye contact • Natural rubber, neoprene, nitrile, PE, PVA, PVC gloves/apron/boots and protective clothing to prevent repeated or prolonged skin contact with the liquid.

EMERGENCY FIRST AID TREATMENT (59)	Caution: Do not administer stimulants • Ingestion: If victim is conscious, induce vomiting. Get medical attention • Inhalation: Move victim to fresh air. Give artificial respiration if needed • Skin: Remove contaminated clothing. Wash skin with soap and water. If irritation persists, get medical attention • Eye: Irrigate copiously with water for 15 minutes. If pain or irritation persists, get medical attention.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Monochlorobenzene Chlorobenzol Phenyl chloride MCB CP27	108-90-7 NIOSH NO.: CZ0175000	C_6H_5Cl	4.60 mg/m³ ≅ 1 ppm 0.217 ppm ≅ 1 mg/m³
	STRUCTURE: 		MOLECULAR WEIGHT: 112.56

REACTIVITY	Reactions of halogenated organic materials such as chlorobenzene with cyanides, mercaptans or other organic sulfides typically generate heat, while those with mineral acids, amines, azo compounds, hydrazines, caustics or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases and fires. Those with alkali or alkaline earth metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents, or strong reducing agents typically result in heat generation and explosions and/or fires (511,505). Chlorobenzene is also known to form shock-sensitive solvated salts that are liable to explode when mixed with silver perchlorate, and to react violently with dimethyl sulfoxide (505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: clear	(23)
	• Odor: almond-like	(23)
	• Odor Threshold: 0.21 ppm	(263)
	• Liquid Density (g/ml at 20°C): 1.106	(14)
	• Freezing/Melting Point (°C): -55/-45	(69)
	• Boiling Point (°C): 132	(14)
	• Flash Point (°C): 28 (closed cup)	(69)
	• Flammable Limits in Air, % by Volume: 1.3-7.1	(60,513,504)
	• Autoignition Temperature (°C): 593-640	(60,38,506)
	• Vapor Pressure (mm Hg at 20°C): 8.8	(38)
	• Saturated Concentration in Air (mg/m³ at 20°C): 54,000	(67)
	• Solubility in Water (mg/L at 20°C): 490	(14)
	• Viscosity (cp at 20°C): 0.756	(21)
	• Surface Tension (dyne/cm at 20°C): 32.65	(21)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 2.84	(29)
	• Soil Adsorption Coefficient, K_{oc}: 333	(652)
	• Henry's Law Constant (atm·m³/mol at 25°C): 0.00346	(74)
	• Bioconcentration Factor: 10.3 (estim for edible aquatic organisms), 33 (estim)	(262,659)

PERSISTENCE IN THE SOIL-WATER SYSTEM	Chlorobenzene is expected to be fairly mobile in soil/ground-water systems, particularly in deep soils of low organic content. In general, chlorobenzene will persist in the soil/ground-water environment. However, volatilization from surface soils may be important and biodegradation by acclimated microbial populations has been observed.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is probably the migration of chlorobenzene to ground-water drinking water supplies, although it is moderately adsorbed and may be biodegraded. Inhalation resulting from volatilization from surface soils may also be important under some conditions.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (45,51): The symptoms of inhalation and ingestion include dizziness, drowsiness, headache, nausea and vomiting. The urine may be colored burgundy-red. Chlorobenzene will cause irritation of the eyes, nose and skin.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 2910 (47); skin -- no data; LCLo (mg/m^3) inhalation [mouse] (51) 15,000
	Long-Term Effects: Liver and kidney damage
	Pregnancy/Neonate Data: Negative teratogen; near-lethal levels linked to decreased spermatogenesis in dogs
	Mutation Data: Limited evidence is negative
	Carcinogenicity Classification: IARC - none assigned; NTP - some evidence

HANDLING PRECAUTIONS (38,54)	Handle chemical only with adequate ventilation • Vapor concentrations of 75-1000 ppm: chemical cartridge respirator with full facepiece and organic vapor cartridge • 1000-2400 ppm: any supplied-air respirator or self-contained breathing apparatus with full facepiece, or gas mask with organic vapor canister • Chemical goggles if there is probability of eye contact • Protective clothing to prevent repeated or prolonged skin contact.

EMERGENCY FIRST AID TREATMENT (38,54)	Ingestion: Do not induce vomiting. Seek medical attention immediately • Inhalation: Move victim to fresh air; administer artificial respiration if necessary; get medical attention • Skin: Remove contaminated clothing; wash skin with soap and water. If irritation persists after washing, get medical attention • Eye: Flush with copious amounts of water; get medical attention.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Ethyl chloride Monochloroethane Muriatic ether Hydrochloric ether	75-00-3 NIOSH NO.: KH7525000	C_2H_5Cl	2.64 mg/m³ ≈ 1 ppm 0.379 ppm ≈ 1 mg/m³
	STRUCTURE:	$Cl-CH_2-CH_3$	MOLECULAR WEIGHT: 64.52

REACTIVITY	Reactions of halogenated organic materials such as chloroethane with cyanides, mercaptans or other organic sulfides typically generate heat, while those with mineral acids, amines, azo compounds, hydrazines, caustics or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases and fires. Those with alkali or alkaline earth metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents, or strong reducing agents typically result in heat generation and explosions and/or fires (511,505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): gas; readily liquified under pressure	(23)
	• Color: colorless	(23)
	• Odor: ethereal	(23)
	• Odor Threshold: 4.2 ppm	(384)
	• Liquid Density (g/ml): 0.9214 at 0°C	(59)
	• Freezing/Melting Point (°C): -140.85	(23)
	• Boiling Point (°C): 12.5	(23)
	• Flash Point (°C): -50 (closed cup)	(23)
	• Flammable Limits in Air, % by Volume: 3.6-15.4	(60,51,504)
	• Autoignition Temperature (°C): 519	(510,23,506)
	• Vapor Pressure (mm Hg at 20°C): 1000	(23)
	• Saturated Concentration in Air (mg/m³ at 20°C): 3,537,300 (calc)	( )
	• Solubility in Water (mg/L at 20°C): 5700	(38)
	• Viscosity (cp at 20°C): no data	( )
	• Surface Tension (dyne/cm at 20°C): no data	( )
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 1.43	(29)
	• Soil Adsorption Coefficient, K_{oc}: 14.9	(33)
	• Henry's Law Constant (atm·m³/mol at 20°C): 0.011	(74)
	• Bioconcentration Factor: 1.3 (estim)	(659)

PERSISTENCE IN THE SOIL-WATER SYSTEM	Chloroethane is expected to be highly mobile in soil/ground-water systems. Limited sorption onto soils, particularly soils of low organic content, is anticipated. Volatilization and migration with soil pore water are thought to be important transport processes. Degradation in natural soil/ground-water systems is not expected to be significant.

PATHWAYS OF EXPOSURE	The primary pathway of concern from soil-water systems is the migration of chloroethane in ground-water drinking water supplies. The high volatility of the chemical suggests that inhalation resulting from volatilization from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (54): Chloroethane vapors are narcotic and produce depression of the central nervous system. Headache, dizziness, incoordination, stomach cramps and irritation of the respiratory tract have been noted. Deaths due to cardiac arrest have been recorded. Chloroethane is mildly irritating to the skin and eyes. In liquid form, frostbite can occur due to rapid evaporation.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral -- no data; skin -- no data. LCLo (mg/m^3) inhalation [rat] (47) 10,560·45 min
	Long-Term Effects: Liver and kidney damage
	Pregnancy/Neonate Data: No data
	Mutation Data: Negative data
	Carcinogenicity: No data; study in progress

HANDLING PRECAUTIONS (38)	Handle chemical only with adequate ventilation • Vapor concentrations of 1000-10,000 ppm: any supplied air respirator or self-contained breathing apparatus • 10,000-20,000 ppm: any supplied air respirator or self-contained breathing apparatus with a full facepiece • Chemical goggles if there is probability of eye contact • Impervious protective clothing and gloves should be used to prevent repeated or prolonged contact with liquid.

EMERGENCY FIRST AID TREATMENT (38,54)	Caution: Do not administer stimulants - may induce ventricular fibrillation • Ingestion: Induce vomiting if victim is conscious; get medical attention • Inhalation: Move victim to fresh air, give artificial respiration if necessary. Keep victim warm. Get medical attention • Skin: Remove wet/contaminated clothing immediately. Flush skin with water promptly. Do not use hot water • Eye: Irrigate immediately with large amounts of water; get medical attention.

I. CHEMICAL IDENTITY

Common name: Chloroform
Formula: $CHCl_3$
Synonyms: Trichloromethane
CAS No.: 67-66-3
Carcinogen: IARC animal suspected

II. REGULATORY INFORMATION

Hazardous substance: EPA
Hazardous waste: EPA
DOT Hazard Class: ORM-A, poison

III. PHYSICAL CHARACTERISTICS

Boiling point: 61 C (142 F)
Specific gravity: 1.49
Vapor density: 4.1
Melting point: −63.5 C (−82 F)
Vapor pressure:at 20 C, 160 mm Hg
Solubility in water: at 20 C, 0.8 g/100g water
Evaporation rate: 11.6
Appearance and odor: Colorless liquid with a pleasant sweet odor.

IV. PHYSICAL HAZARDS

Flash point: N/A
Autoignition temperature: N/A
Flammable limits in air (% by vol.): Not combustible.
Extinguishants: N/A

V. HEALTH HAZARDS

May cause headache, drowsiness, vomiting, dizziness, unconsciousness, irregular heart beat, and death. Vapor exposure may cause liver and kidney damage. In the eye, causes pain and irritation. Swallowing followed immediately by severe burning of mouth and throat, pain in chest and abdomen, and vomiting. Large amounts may cause loss of consciousness, and liver damage may follow.

VI. EMERGENCY FIRST AID

Eyes: Wash with large amounts of water, lifting the lids occasionally. Get medical attention as soon as possible. Do not wear contacts when working with the substance.
Skin: Wash with soap or mild detergent. Remove contaminated clothing. If there is skin irritation, get medical atten[illegible].

Breathing: Move patient to fresh air. Perform artificial respiration if needed. Keep patient warm and at rest. Get medical attention as soon as possible.
Swallowing: Get medical attention immediately. Induce vomiting mechanically with finger or with syrup of ipecac.

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA TWA: 50 ppm (240 mg/m^3)
ACGIH STEL: 50 ppm (225 mg/m^3)
IDLH: 1,000 ppm

VIII. PRECAUTIONS FOR USE AND SAFE HANDLING

Conditions contributing to instability: In the presence of air and light, slowly reacts to form phosgene and hydrochloric acid gases.
Incompatibilities: Reacts with strong caustics and chemically active metals such as aluminum, magnesium powder, sodium, or potassium.
Hazardous decomposition products: Toxic gases (such as hydrogen chloride, chlorine, phopsgene, and carbon monoxide) may be released on decomposition.
Special precautions: Will attack some forms of plastic, rubber, and coatings.

IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

Persons not wearing protective equipment and clothing should stay out of spill area. Ventilate area. Collect for reclamation or absorb in vermiculite, dry sand, or earth.

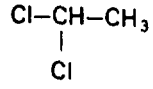
X. PROTECTIVE EQUIPMENT

Impervious clothing, gloves, face shields (eight-inch minimum) to prevent prolonged or repeated skin contact. Contaminated clothing should be placed in closed containers pending disposal or cleaning. Splash-proof safety goggles where there is danger of eye contact. Emergency eye-wash fountains should be provided in the workplace if there is a possibility of eye exposure.

Respirators–

<500 ppm: SA; SCBA
<1000 ppm: SAF; SCBAF
>1000 ppm: SCBAF:PD, PP; comb SAF:PD, PP,CF w/SCBA:PD, PP
Fire fighting: SCBAF:PD, PP
Escape: Any gas mask providing protection against organic vapors; escape[illegible]BA.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Ethylidene chloride Ethylidene dichloride Chlorinated hydrochloric ether Dichloromethylmethane	75-34-3 NIOSH NO.: KI0175000	$C_2H_4Cl_2$	4.05 mg/m³ ≅ 1 ppm 0.247 ppm ≅ 1 mg/m³
	STRUCTURE:		MOLECULAR WEIGHT: 98.97



REACTIVITY	Reactions of halogenated organic materials such as 1,1-dichloroethane with cyanides, mercaptans or other organic sulfides typically generate heat, while those with mineral acids, amines, azo compounds, hydrazines, caustics or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases and fires. Those with alkali or alkaline earth metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents or strong reducing agents typically result in heat generation and explosions and/or fires (511,505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless	(23)
	• Odor: chloroform-like	(12)
	• Odor Threshold: 200 ppm	(38)
	• Liquid Density (g/ml at 20°C): 1.175	(21)
	• Freezing/Melting Point (°C): -96.7	(21)
	• Boiling Point (°C): 57.3	(21)
	• Flash Point (°C): -12 (closed cup)	(21)
	• Flammable Limits in Air, % by Volume: 5.6-11.4	(60,506,12)
	• Autoignition Temperature (°C): 458-493	(60,12)
	• Vapor Pressure (mm Hg at 20°C): 182	(21)
	• Saturated Concentration in Air (mg/m³ at 20°C): 987,500	(ADL estim)
	• Solubility in Water (mg/L at 20°C): 5500	(21)
	• Viscosity (cp at 20°C): 0.377	(21)
	• Surface Tension (dyne/cm at 20°C): no data	( )
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 1.79	(29)
	• Soil Adsorption Coefficient, K_{oc}: 30	(33)
	• Henry's Law Constant (atm·m³/mol at 25°C): 0.0057	(33)
	• Bioconcentration Factor: 2.9 (estim)	(659)

PERSISTENCE IN THE SOIL-WATER SYSTEM	1,1-Dichloroethane is expected to be highly mobile in the soil/ground-water system. Limited sorption on soils, particularly soils of low organic content is expected. Volatilization and migration with soil pore water are thought to be significant transport pathways. Degradation in natural soil/ground-water systems is not expected to be significant.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is the migration of 1,1-dichloroethane to ground-water drinking water supplies. Inhalation resulting from volatilization from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (54,76): Toxic chemical hepatitis, kidney injury and lung irritation are associated with inhalation of 1,1-dichloroethane. It is also irritating to the eyes and skin. CNS depression is observed in laboratory animals.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 725 (47) skin -- no data LCLo (mg/m^3) inhalation -- no data
	Long-Term Effects: Liver and kidney toxicity
	Pregnancy/Neonate Data: Negative
	Mutation Data: Negative
	Carcinogenicity Classification: NTP - none assigned; IARC - none assigned

HANDLING PRECAUTIONS (38)	Handle chemical only with adequate ventilation • Vapor concentrations of 100-1000 ppm: any supplied-air respirator, self-contained breathing apparatus or chemical-cartridge respirator with an organic vapor cartridge • 1000-4000 ppm: any supplied-air respirator or self-contained breathing apparatus with full facepiece; gas mask with organic vapor canister • Chemical goggles if there is probability of eye contact • Impervious clothing and gloves should be used to prevent repeated or prolonged skin contact with liquid.

EMERGENCY FIRST AID TREATMENT (38,54)	Ingestion: Induce vomiting if victim is conscious; get medical attention immediately • Inhalation: Move victim to fresh air; give artificial respiration, if necessary. Keep victim warm. Get medical attention • Skin: Remove contaminated clothing. Wash skin with soap and water. If irritation persists after washing, get medical attention • Eye: Irrigate with large amounts of water; get medical attention.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Propylene dichloride Propylene chloride alpha, beta-Dichloropropane	78-87-5 NIOSH NO.: TX9625000	$C_3H_6Cl_2$	4.62 mg/m³ ≅ 1 ppm 0.2165 ppm ≅ 1 mg/m³
	STRUCTURE: $H_3C-\underset{\underset{Cl}{\vert}}{CH}-CH_2-Cl$		MOLECULAR WEIGHT: 112.99

REACTIVITY	Reactions of halogenated organic materials such as 1,2-dichloropropane with cyanides, mercaptans or other organic sulfides typically generate heat, while those with mineral acids, amines, azo compounds, hydrazines, caustics or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases and fires. Those with alkali or alkaline earth metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents, or strong reducing agents typically result in heat generation and explosions and/or fires (511,505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless	(23)
	• Odor: chloroform-like	(23)
	• Odor Threshold: 50 ppm	(38)
	• Liquid Density (g/ml at 20°C): 1.158	(23)
	• Freezing/Melting Point (°C): -80; -100	(23,38)
	• Boiling Point (°C): 96.3	(23)
	• Flash Point (°C): 16.1 (closed cup)	(23)
	• Flammable Limits in Air, % by Volume: 3.4-14.5	(60,51,506)
	• Autoignition Temperature (°C): 557	(60,51,506)
	• Vapor Pressure (mm Hg at 20°C): 39.5	(38)
	• Saturated Concentration in Air (mg/m³ at 20°C): 258,000	(67)
	• Solubility in Water (mg/L at 20°C): 2700	(12)
	• Viscosity (cp at 20°C):0.840	(48)
	• Surface Tension (dyne/cm at 20°C): 31.42	(14)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 2.02	(33)
	• Soil Adsorption Coefficient, K_{oc}: 51	(33)
	• Henry's Law Constant (atm·m³/mol at 25°C): 0.0036	(74)
	• Bioconcentration Factor: 4.1 (estim), 5.0 (estim)	(147,659)

PERSISTENCE IN THE SOIL-WATER SYSTEM	1,2-Dichloropropane is expected to be somewhat mobile in surface soils and highly mobile in deep or sandy soils. Volatilization may be important for the near surface material or the small portion expected to be in the soil-air phase. Transformation processes (hydrolysis, biodegradation) are not expected to be significant in natural soils.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is the migration of 1,2-dichlorobenzene to ground-water drinking water supplies. Inhalation resulting from volatilization from surface soils may also be important in some situations.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (54,46): Prolonged contact with liquid 1,2-dichloropropane may cause dermatitis by defatting the skin. Undiluted it is moderately irritating to the eyes, but does not cause permanent injury. Based on animal experiments, inhalation or ingestion of high levels of 1,2-dichloropropane can be expected to produce CNS depression.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 1900 (59); skin [rabbit] 8750 (47). LCLo (ppm) inhalation [rat] (47) 1600·7 hr
	Long-Term Effects: Liver and kidney toxicity
	Pregnancy/Neonate Data: No data
	Mutation Data: Limited data are positive
	Carcinogenicity Classification: IARC - none assigned; NTP - some evidence

HANDLING PRECAUTIONS (38)	Handle chemical only with adequate ventilation • Vapor concentrations of 75-400 ppm: any supplied-air respirator, self-contained breathing apparatus or chemical cartridge respirator with an organic vapor cartridge • 400-2000 ppm: any supplied-air respirator or self-contained breathing apparatus with full facepiece; any gas mask with an organic vapor canister • Chemical goggles if there is probability of eye contact • Impervious protective clothing and gloves to prevent repeated or prolonged skin contact with the liquid.

EMERGENCY FIRST AID TREATMENT (38)	Ingestion: Induce vomiting if victim is conscious; get medical attention • Inhalation: Move victim to fresh air; give artificial respiration if necessary. Get medical attention • Skin: Remove contaminated clothing; wash skin with soap and water. If irritation persists after washing, get medical attention • Eye: Flush with large amounts of water. If irritation persists after washing, get medical attention.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Ethylene dichloride Ethylene chloride Glycol dichloride Ethane dichloride EDC	107-06-2 NIOSH NO.: KI0525000	$C_2H_4Cl_2$	4.05 mg/m³ ≅ 1 ppm 0.247 ppm ≅ 1 mg/m³
	STRUCTURE:		MOLECULAR WEIGHT:
	$Cl-CH_2-CH_2-Cl$		98.96

REACTIVITY	Reactions of halogenated organic materials such as 1,2-dichloroethane with cyanides, mercaptans or other organic sulfides typically generate heat, while those with mineral acids, amines, azo compounds, hydrazines, caustics or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases and fires. Those with alkali or alkaline earth metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents or strong reducing agents typically result in heat generation and explosions and/or fires (511,505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless	(23)
	• Odor: chloroform-like	(23)
	• Odor Threshold: 88 ppm	(384)
	• Liquid Density (g/ml at 20°C): 1.253	(21)
	• Freezing/Melting Point (°C): -35.5	(23)
	• Boiling Point (°C): 83.5	(23)
	• Flash Point (°C): 13.3 (closed cup)	(23)
	• Flammable Limits in Air, % by Volume: 6.2-16.0	(51,506,504)
	• Autoignition Temperature (°C): 413	(51,506,504)
	• Vapor Pressure (mm Hg at 20°C): 63.7	(21)
	• Saturated Concentration in Air (mg/m³ at 20°C): 350,000	(67)
	• Solubility in Water (mg/L at 20°C): 8690	(21)
	• Viscosity (cp at 20°C): 0.84	(21)
	• Surface Tension (dyne/cm at 20°C): 31.38	(21)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 1.48	(29)
	• Soil Adsorption Coefficient, K_{oc}: 14	(33)
	• Henry's Law Constant (atm·m³/mol at 25°C): 0.0011	(74)
	• Bioconcentration Factor: 2 (bluegills), 1.4 (estim)	(123,659)

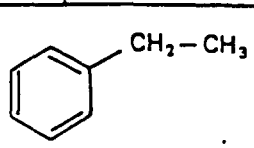
PERSISTENCE IN THE SOIL-WATER SYSTEM	1,2- Dichloroethane is expected to be highly mobile in the soil/ground-water system. Adsorption onto soil, particularly soil of <1% organic content, is low. Volatilization from surface soils and through soil air may be important transport processes. Microbial biodegradation in soil is not expected to be significant.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is the migration of 1,2-dichloroethane to ground-water drinking water supplies. Inhalation resulting from volatilization from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (54): Ingestion and inhalation may cause nausea, vomiting, mental confusion, dizziness and pulmonary edema. Liquid and vapor may cause eye and skin irritation. Acute exposures can lead to death from respiratory and circulatory failure.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 670 (47); skin [rabbit] 2800 (12); LCLo (ppm) inhalation [rat] (59) 1000·4 hr
	Long-Term Effects: Liver and kidney damage, neurologic changes
	Pregnancy/Neonate Data: Negative
	Mutation Data: Suggestive evidence of mutagenic potential
	Carcinogenicity Classification: IARC - category 2b; NTP - none assigned

HANDLING PRECAUTIONS (54,52)	Handle chemical only with adequate ventilation • Vapor concentrations up to 50 ppm: any supplied-air respirator or self-contained breathing apparatus • 50-250 ppm: any supplied-air respirator or self-contained breathing apparatus with full facepiece • Chemical goggles if there is probability of eye contact • Natural rubber, neoprene, PVC, PE, PVA gloves/apron/boots and appropriate clothing to prevent prolonged or repeated skin contact with liquid.

EMERGENCY FIRST AID TREATMENT (54,59)	Ingestion: Induce vomiting if victim is conscious. Get medical attention • Inhalation: Move victim to fresh air; give artificial respiration if necessary. Get medical attention • Skin: Remove contaminated clothing. Wash skin with soap and water. If pain or irritation persists after washing, get medical attention • Eye: Irrigate with large amounts of water for at least 15 minutes; if pain or irritation persists, get medical attention.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Ethyl benzol Phenyl ethane EB	100-41-4 NIOSH NO.: DA0700000	C_8H_{10}	4.34 mg/m³ ≅ 1 ppm 0.2304 ppm ≅ 1 mg/m³
	STRUCTURE: 		MOLECULAR WEIGHT: 106.16

REACTIVITY	Ethyl benzene may generate heat, react vigorously, and possibly ignite or explode in contact with oxidizing mineral acids or other strong oxidizing agents (507,51,54,511).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless	(23)
	• Odor: sweet, gasoline-like	(59)
	• Odor Threshold: 2.3 ppm	(384)
	• Liquid Density (g/ml at 20°C): 0.867	(23)
	• Freezing/Melting Point (°C): -95	(23)
	• Boiling Point (°C): 136.19	(21)
	• Flash Point (°C): 15 (closed cup)	(23)
	• Flammable Limits in Air, % by Volume: 1.0-6.7	(51,506,504)
	• Autoignition Temperature (°C): 432	(510,506,504)
	• Vapor Pressure (mm Hg at 20°C): 7	(67)
	• Saturated Concentration in Air (mg/m³ at 20°C): 40,000	(67)
	• Solubility in Water (mg/L at 20°C): 152	(67)
	• Viscosity (cp at 25°C): 0.64	(599)
	• Surface Tension (dyne/cm at 20°C): 31.5	(21)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 3.15	(29)
	• Soil Adsorption Coefficient, K_{oc}: 681	(652)
	• Henry's Law Constant (atm·m³/mol at 25°C): 0.0079	(74)
	• Bioconcentration Factor: 95 (estim), 68 (estim)	(211,659)

PERSISTENCE IN THE SOIL-WATER SYSTEM	Somewhat mobile in soil-water systems, especially in aqueous phase if sufficient water is present. Volatilization losses through air-filled pores may be a minor loss pathway. Chemical is resistant to hydrolysis, but will probably biodegrade easily if microbiological populations are sufficiently numerous and active. May persist for months to years (or more) if biodegradation is not possible.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is the migration of ethyl benzene to ground-water drinking water supplies. It is commonly found in ground water at NPL sites, illustrating the importance of this pathway. Inhalation from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (38,54): Ethyl benzene primarily causes irritation of the eyes, nose, throat and skin. Irritating effects are more pronounced at higher concentrations. Narcosis can occur with very high concentrations; dizziness, drowsiness and weakness may occur. Prolonged or repeated skin contact with the liquid is defatting and may cause dermatitis.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 3500 (47); skin [rabbit] 5000 (59). LCLo (ppm) inhalation [rat] 4000·4 hr (47)
	Long-Term Effects: Limited data suggest possible liver and kidney injury
	Pregnancy/Neonate Data: Negative
	Mutation Data: Limited evidence
	Carcinogenicity: No data

HANDLING PRECAUTIONS (38)	Handle chemical only with adequate ventilation • Vapor concentrations of 100-1000 ppm: chemical cartridge respirator with full facepiece and organic vapor canister • 1000-2000 ppm: any supplied-air respirator or self-contained breathing apparatus with full facepiece; gas mask with organic vapor canister • Chemical goggles if there is probability of eye contact • Impervious clothing and gloves should be used to prevent repeated or prolonged skin contact with liquid.

EMERGENCY FIRST AID TREATMENT (38,54)	Caution: Do not administer stimulants • Ingestion: Do not induce vomiting. Get medical attention immediately • Inhalation: Move victim to fresh air; give artificial respiration if necessary. Keep victim warm. Get medical attention • Skin: Remove contaminated clothing. Flush skin with water. If irritation persists after washing with soap and water, get medical attention • Eye: Irrigate immediately with large amounts of water, get medical attention.

ENVIRONMENTAL AND OCCUPATIONAL STANDARDS AND CRITERIA

AIR EXPOSURE LIMITS:

Standards

- OSHA PEL (8-hr TWA): 100 ppm
- AFOSH PEL (8-hr TWA): 100 ppm; STEL (15-min): 125 ppm

Criteria

- NIOSH IDLH (30-min): 2000 ppm
- ACGIH TLV® (8-hr TWA): 100 ppm
- ACGIH STEL (15-min): 125 ppm

WATER EXPOSURE LIMITS:

Drinking Water Standards

None established

EPA Health Advisories

None established

EPA Ambient Water Quality Criteria (355)

- Human Health
  - Based on ingestion of contaminated water and aquatic organisms, 1.4 mg/L.
  - Based on ingestion of contaminated aquatic organisms only, 3.28 mg/L.
- Aquatic Life
  - Freshwater species

    acute toxicity: no criterion, but lowest effect level occurs at 32,000 µg/L.

    chronic toxicity: no criterion established due to insufficient data.
  - Saltwater species

    acute toxicity: no criterion, but lowest effect level occurs at 430 µg/L.

    chronic toxicity: no criterion established due to insufficient data.

eventually reach surface waters by this mechanism, suggesting several other exposure pathways:

- Surface waters may be used as drinking water supplies, resulting in direct ingestion exposure;
- Aquatic organisms residing in these waters may bioaccumulate this chemical and be consumed, also resulting in ingestion exposures;
- Recreational use of these waters may result in dermal exposures;
- Domestic animals may consume or be dermally exposed to contaminated ground or surface waters; the consumption of meats and poultry could then result in ingestion exposures.

In general, exposures associated with surface water contamination can be expected to be lower than exposure from drinking contaminated ground water. The Henry's law constant for ethyl benzene suggests that it will volatilize upon reaching surface waters. However, if ethyl benzene is available, the bioconcentration factor for this compound suggests moderate bioaccumulation in aquatic organisms or domestic animals.

20.2.4 Other Sources of Exposure

The volatility of ethyl benzene suggests that it may be found in air. Brodzinsky and Singh (84) compiled all available atmospheric monitoring data for a number of volatile organics. For ethyl benzene, they had data for 861 locations. In rural and remote areas, the median concentration was 2.0 $\mu g/m^3$. In urban and suburban areas, the median concentration was 5.2 $\mu g/m^3$ and in source-dominated locations, the median concentration was 2.7 $\mu g/m^3$. These results suggest there are inhalation exposures to individuals, even in remote areas.

20.3 HUMAN HEALTH CONSIDERATIONS

20.3.1 Animal Studies

20.3.1.1 Carcinogenicity

No carcinogenicity data are available.

20.3.1.2 Mutagenicity

In the sole study available, ethyl benzene was found to be a weak inducer of sister chromatid exchange in human lymphocytes (209).

20.3.1.3 Teratogenicity, Embryotoxicity and Reproductive Effects

Hardin et al. (208) conducted teratogenicity tests in rats and rabbits. Both species were exposed to vapor concentrations of 100 or 1000 ppm ethyl benzene for 6 to 7 hours daily. Rats were exposed for 3 weeks prior to mating as well as on days 1 through 19 of gestation. Rabbits were exposed only on days 1 through 24 of gestation. No significant maternal or fetal toxicity was seen in rabbits. In rats, a possible reduction in fertility was noted at both exposure levels, but no dose-response was evident. Maternal toxicity in the form of increased spleen, liver and kidney weights was seen in the 1000 ppm group. In the fetuses, there was a significant increase in the incidence of extra ribs at both exposure levels.

20.3.1.4 Other Toxicologic Effects

20.3.1.4.1 Short-term Toxicity

Acute toxicity data on oral and dermal routes in both rats and rabbits indicate a low toxicity for ethyl benzene. An oral LD_{50} value in rats of 3500 mg/kg has been reported; dermal LD_{50} values in rabbits of 500 mg/kg (59) and 17,800 mg/kg (47) have been recorded.

Wolf et al. (210) evaluated the ability of ethyl benzene to produce injury to the eye and skin of rabbits. They found that two drops applied to the eye produced slight conjunctival irritation but no corneal injury. Ten to twenty applications to the ear and abdomen for 2 to 4 weeks produced moderate redness, swelling, superficial necrosis and blistering.

20.3.1.4.2 Chronic Toxicity

Chronic inhalation exposure of guinea pigs, monkeys, rabbits and rats at concentrations ranging from 400 to 2200 ppm for 7 to 8 hours per day, 5 days per week for 6 months produced no effects in guinea pigs, monkeys and rabbits; rats exhibited a slight increase in liver and kidney weights (210). The same investigators noted changes in the liver and kidney in rats administered 408 or 680 mg/kg/day ethyl benzene in olive oil, 5 days per week for 6 months. No effects on the bone marrow were observed (210).

20.3.2 Human and Epidemiologic Effects

Ethyl benzene is primarily an irritant to the skin, eyes and upper respiratory tract. Systemic absorption causes central nervous system depression (38). Inhalation of ethyl benzene might exacerbate the symptoms of obstructive airway diseases (e.g., emphysema) due to its irritant properties or reflex bronchospasm. Aspiration of small amounts causes extensive edema and hemorrhage of lung tissue (38).

No human ingestion data are available and inhalation data are limited. At 200 ppm (870 mg/m^3), the vapor has a transient irritant effect on the eyes. At 2000 ppm, eye irritation and lacrimation are immediate and severe and are accompanied by moderate nasal irritation. Tolerance to these effects develops after several minutes. Central nervous system effects begin after about 6 minutes at this level. At 5000 ppm, the irritation of the eyes, nose and throat becomes intolerable (19,2,211). Redness and inflammation may result from skin contact with the liquid (51). The rate of absorption through the skin of the hand and forearm is 22 to 33 mg/cm^2 per hour (46). Ethyl benzene is not known to be toxic to the liver or kidneys; however, concern for these organs has been expressed since they are the primary routes of metabolism and excretion, respectively (54).

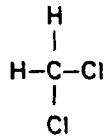
20.3.3.3 Levels of Concern

The USEPA (355) has established an ambient water quality criterion for the protection of human health for ethyl benzene of 1.4 mg/L. This criterion is based on the threshold limit value (100 ppm) for occupational exposure to vapors, which was set to prevent irritation rather than chronic effects. An uncertainty factor of 1000, 50% absorption (assumed), a bioconcentration factor of 37.5 for fish and consumption of two liters of water and 6.5 g of contaminated fish per day were also utilized to calculate the criterion.

Both OSHA (298) and the ACGIH (3) have set an occupational exposure limit of 100 ppm (435 mg/m^3) for ethyl benzene, based on preventing eye irritation.

20.3.3.4 Hazard Assessment

The extent and quality of health effects data available for ethyl benzene are inadequate. Available data deal primarily with the irritant properties of ethyl benzene. The limited nature of these studies, linked with the lack of information on chronic and subchronic toxicity, carcinogenic activity and mutagenicity make estimation of the hazards of long-term low-level human exposure to this compound difficult to define.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION
Dichloromethane Methylene dichloride Methylene bichloride Methane dichloride DCM	75-09-2 NIOSH NO.: PA8050000	CH_2Cl_2	FACTORS at 25°C (12) 3.48 mg/m³ ≅ 1 ppm 0.288 ppm ≅ 1 mg/m³
	STRUCTURE:		MOLECULAR WEIGHT: 84.94

REACTIVITY	Reactions of halogenated organic materials such as methylene chloride with cyanides, mercaptans or other organic sulfides typically generate heat, while those with mineral acids, amines, azo compounds, hydrazines, caustics, or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases and fires. Those with alkali or alkaline earth metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents, or strong reducing agents typically result in heat generation and explosions and/or fires (511,505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless	(23)
	• Odor: ether-like	(23)
	• Odor Threshold: 214 ppm	(263)
	• Liquid Density (g/ml at 20°C): 1.325	(12)
	• Freezing/Melting Point (°C): -96.7	(21)
	• Boiling Point (°C): 39.8	(21)
	• Flash Point (°C): nonflammable	
	• Flammable Limits in Air, % by Volume: 12-19	(506,504)
	• Autoignition Temperature (°C): 556-640	(506,504)
	• Vapor Pressure (mm Hg at 20°C): 350	(38)
	• Saturated Concentration in Air (mg/m³ at 20°C): 1,549,000	(67)
	• Solubility in Water (mg/L at 20°C): 13,200	(21)
	• Viscosity (cp at 20°C): 0.430	(23)
	• Surface Tension (dyne/cm at 20°C): 0.028	(21)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 1.25	(29)
	• Soil Adsorption Coefficient, K_{oc}: 8.8	(33)
	• Henry's Law Constant (atm·m³/mol at 25°C): 0.00257	(74)
	• Bioconcentration Factor: 0.8 (estim)	(659)

PERSISTENCE IN THE SOIL-WATER SYSTEM	Methylene chloride is expected to be highly mobile in the soil/ground-water system; little or no retardation is expected in deep or sandy soils. Volatilization is an important removal process for methylene chloride near the surface or in the soil-air phase. Transformation processes such as hydrolysis and biodegradation are not expected to be important in natural soil systems.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is the migration of methylene chloride to ground-water drinking water supplies. Data from NPL sites show that such migration has commonly occurred in the past. Inhalation resulting from volatilization from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (54): Methylene chloride is a mild narcotic. Effects from intoxication include headache, giddiness, stupor, irritability, numbness and tingling of the limbs. Irritation to the eyes and upper respiratory passages occur with both liquid and vapor. If held in contact with the skin, the liquid may cause burns. Exposure may cause elevated carboxyhemoglobin levels.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 2136 (59) skin -- no data; LC_{50} (mg/m^3) inhalation [rat] (59) 88,000·30 min
	Long-Term Effects: Possible liver damage, increase COHb levels
	Pregnancy/Neonate Data: Negative
	Mutation Data: Suggestive evidence of mutagenicity
	Carcinogenicity Classification: NTP - clear evidence; IARC - category 3 (NOTE: NTP data have not yet been reviewed by IARC.)

HANDLING PRECAUTIONS (38,52,54)	Handle chemical only with adequate ventilation • Vapor concentrations of 500-5000 ppm: any supplied-air respirator or self-contained breathing apparatus with full facepiece • Chemical goggles if there is probability of eye contact • Natural rubber, neoprene, nitrile, PE, PVC or other protective clothing to prevent repeated or prolonged skin contact with the liquid.

EMERGENCY FIRST AID TREATMENT (38,59)	Ingestion: If victim is conscious, induce vomiting. Get medical attention • Inhalation: Move victim to fresh air. If necessary, give artificial respiration. Get medical attention • Skin: Remove any contaminated clothing; wash skin with soap and water. If irritation persists after washing, get medical attention • Eye: Irrigate for 15 minutes with large amounts of water. If irritation persists after washing, get medical attention.

I. CHEMICAL IDENTITY

Common name: Styrene
Formula: $C_6H_5CH=CH_2$
Synonyms: Phenylethylene; vinylbenzene; cinnamene; styrene monomer
CAS No.: 100-42-5
Carcinogen: IARC

II. REGULATORY INFORMATION

Hazardous substance: EPA
Hazardous waste: N/A
DOT Hazard Class: Flammable liquid

III. PHYSICAL CHARACTERISTICS

Boiling point: 145 C (293 F)
Specific gravity: 0.90
Vapor density: 3.6
Melting point: −30.6 C (−23 F)
Vapor pressure: 4.5 mm Hg
Solubility in water: 0.03
Evaporation rate: 0.49
Appearance and odor: Colorless liquid with a sweet aromatic odor at low concentrations, becoming a sharp, penetrating, and disagreeable odor at higher concentrations.

IV. PHYSICAL HAZARDS

Flash point: 32 C (92 F)
Autoignition temperature: 490 C (914 F)
Flammable limits in air (% by vol.): Lower: 1.1; upper: 6.1
Extinguishants: Dry chemical, foam, or carbon dioxide

V. HEALTH HAZARDS

Effects of short-term overexposure: May irritate the eyes, nose, throat, and skin. High concentrations may cause a person to become sleepy or unconscious. Effects of long-term overexposure: Repeated skin contact may produce a skin rash.

VI. EMERGENCY FIRST AID

Eyes: Wash with large amounts of water, lifting the lids occasionally. Get medical attention as soon as possible. Do not wear contacts when working with the substance.
Skin: Flush with water. Remove contaminated clothing. If there is skin irritation, get medical attention.

Breathing: Mo patient to fresh air. Perform artificial piration if needed. Keep patient warm and at rest. Get medical attention as soon as possible.
Swallowing: Do not induce vomiting. Get medical attention immediately.

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA TWA: 100 ppm

VIII. PRECAUTIONS FOR USE AND SAFE HANDLING

Conditions contributing to instability: Stabilized by a polymerization inhibitor (often tertbutylcatechol). If this is not present in adequate concentrations, styrene can polymerize and explode its container. The polymerization is also speeded up by temperatures above 66 C (150 F).
Incompatibilities: Avoid contact with oxidizing agents and catalysts for vinyl polymerization, such as peroxides, strong acids, and aluminum chloride.
Hazardous decomposition products: Toxic gases (such as carbon monoxide) may be released in a fire. Styrene fumes are very acrid.
Special precautions: Will corrode copper and copper alloys and dissolve rubber.

IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

Persons not wearing protective equipment and clothing should stay out of spill area. Remove all ignition sources. Ventilate area. Small quantities may be absorbed on paper towels and evaporated in a hood. Burn paper towels in a location away from combustible materials. Collect large quantities and atomize in a suitable combustion chamber. Combustion may be improved by mixing with a more flammable liquid.

X. PROTECTIVE EQUIPMENT

Impervious clothing, gloves, face shields (eight-inch minimum) to prevent prolonged or repeated skin contact should be provided and used. Contaminated clothing should be placed in closed containers pending disposal or cleaning. Splash-proof safety goggles where there is danger of eye contact.

Respirators–

400 ppm: CCROV;SA;SCBAF
1,000 ppm: CCROVF
5,000 ppm: GMOV;SAF;SCBAF
Escape: GMOV;SCBA

PERSISTENCE IN THE SOIL-WATER SYSTEM	Relatively mobile in soil-water systems, including transport of vapor through air-filled pores as well as transport in solution. Chemical is resistant to hydrolysis and to biodegradation (except by acclimated mixed cultures); it may thus persist for months to years (or longer).

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is the migration of tetrachloroethylene to ground-water drinking water supplies. There is substantial evidence that such migration has occurred in the past. Inhalation resulting from volatilization from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (45): Ingestion and inhalation cause nausea, vomiting, headache, dizziness, drowsiness and tremors. Skin contact with liquid causes irritation and blistering. Both liquid and vapor are irritating to the eyes.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 8850 (47); oral [mouse] 8100 (59); skin — no data. LC_{50} (ppm) inhalation [mouse] 5200·4 hr (25)
	Long-Term Effects: Liver and kidney toxicity
	Pregnancy/Neonate Data: Negative
	Mutation Data: Negative
	Carcinogenicity Classification: IARC - catetory 3; NTP - clear evidence. NOTE: IARC has not yet reviewed NTP data

HANDLING PRECAUTIONS (38,52)	Handle chemical only with adequate ventilation • Vapor concentrations of 100-500 ppm: any supplied-air respirator or self-contained breathing apparatus with full facepiece; gas mask with organic vapor canister; chemical cartridge respirator with full facepiece and organic vapor cartridge • Above 500 ppm: self-contained breathing apparatus with full facepiece operated in positive-pressure mode • Chemical goggles if there is probability of eye contact • Butyl, natural rubber, neoprene or PVC gloves/apron/boots to prevent repeated or prolonged skin contact with the liquid.

EMERGENCY FIRST AID TREATMENT (38,45,56, 578)	Ingestion: Induce vomiting if victim is conscious. Get medical attention • Inhalation: Move victim to fresh air. Give artificial respiration if necessary. Get medical attention • Skin: Remove contaminated clothing. Wash skin with soap and water. If irritation persists after washing, get medical attention • Eye: Flush with large amount of water for a minimum of 15 minutes. Get medical attention.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Tetrachloroethene Perchloroethylene Ethylene tetrachoride Carbon dichloride PCE Perc	127-18-4 NIOSH NO.: KX3850000	C_2Cl_4	6.78 mg/m³ ≅ 1 ppm 0.147 ppm ≅ 1 mg/m³
	STRUCTURE:	Cl–C=C–Cl | | Cl Cl	MOLECULAR WEIGHT: 165.85

REACTIVITY	Reactions of halogenated organic materials such as tetrachloroethylene with cyanides, mercaptans or other organic sulfides typically generate heat, while those with mineral acids, amines, azo compounds, hydrazines, caustics or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases and fires. Those with alkali or alkaline earth metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents, or strong reducing agents typically result in heat generation and explosions and/or fires (511).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless	(23)
	• Odor: ether-like	(23)
	• Odor Threshold: 50 ppm	(38)
	• Liquid Density (g/ml at 20°C): 1.625	(23)
	• Freezing/Melting Point (°C): -22.4	(23)
	• Boiling Point (°C): 121	(23)
	• Flash Point (°C): none	(23)
	• Flammable Limits in Air, % by Volume: nonflammable	( )
	• Autoignition Temperature (°C): nonflammable	( )
	• Vapor Pressure (mm Hg at 20°C): 14	(38)
	• Saturated Concentration in Air (mg/m³ at 20°C): 126,000	(67)
	• Solubility in Water (mg/L at 20°C): 150	(38)
	• Viscosity (cp at 20°C): 0.89 (estim)	(21)
	• Surface Tension (dyne/cm at 20°C): 31.3	(59)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 3.14	(29)
	• Soil Adsorption Coefficient, K_{oc}: 665	(652)
	• Henry's Law Constant (atm·m³/mol at 20°C): 0.0227	(74)
	• Bioconcentration Factor: 49 (bluegill), 66 (estim)	(170,659)

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Acetylene tetrachloride S-Tetrachloroethane Dichloro-2,2-dichloroethane Tetrachloroethane	79-34-5 NIOSH NO.: KI 8575000	$C_2H_2Cl_4$	6.86 mg/m³ ≅ 1 ppm 0.1458 ppm ≅ 1 mg/m³
	STRUCTURE:		MOLECULAR WEIGHT:
	Cl–CH–CH–Cl | | Cl Cl		167.86

REACTIVITY	Reactions of halogenated organic materials such as 1,1,2,2-tetrachloroethane with cyanides, mercaptans or other organic sulfides typically generate heat, while those with mineral acids, amines, azo compounds, hydrazines, caustics or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases and fires. Those with alkali or alkaline earth metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents, or strong reducing agents typically result in heat generation and explosions and/or fires (511,505). A laboratory procedure involving 2,4-dinitrophenyl disulfide and tetrachloroethane is also known to have resulted in an explosion (505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless	(23)
	• Odor: chloroform-like	(23)
	• Odor Threshold: 1.5 ppm	(384)
	• Liquid Density (g/ml at 20°C): 1.600	(14)
	• Freezing/Melting Point (°C): -42.5	(21)
	• Boiling Point (°C): 146.3	(21)
	• Flash Point (°C): nonflammable	(23)
	• Flammable Limits in Air, % by Volume: nonflammable	(60)
	• Autoignition Temperature (°C): nonflammable	(60)
	• Vapor Pressure (mm Hg at 20°C): 4.9	(21)
	• Saturated Concentration in Air (mg/m³ at 20°C): 45,000	(ADL estim)
	• Solubility in Water (mg/L at 20°C): 2900	(38)
	• Viscosity (cp at 20°C): 1.77	(21)
	• Surface Tension (dyne/cm at 20°C): 34.72	(21)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 2.39	(29)
	• Soil Adsorption Coefficient, K_{oc}: 220	(33)
	• Henry's Law Constant (atm·m³/mol at 25°C): 0.0005	(74)
	• Bioconcentration Factor: 8 (bluegills), 12 (estim)	(123,659)

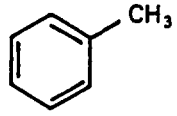
PERSISTENCE IN THE SOIL-WATER SYSTEM	1,1,2,2-Tetrachloroethane is expected to have limited mobility in surface soils with 1-2% organic carbon; mobility in deep soils is expected to be higher due to migration with the soil pore water. In the soil/ground-water system, 1,1,2,2-tetrachloroethane is expected to be persistent.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is the migration of 1,1,2,2-tetrachloroethane to ground-water drinking water supplies. Inhalation resulting from volatilization from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (54,38): Ingestion and inhalation cause irritation of nose and throat, fatigue, nausea, headache, tremors, loss of reflexes, insomnia and loss of appetite; liver dysfunction may occur with severe exposure. Prolonged skin contact with liquid may produce dermatitis due to its defatting action and may result in CNS effects. The liquid and vapor are irritating to the eyes, and may cause watering and burning.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 250 (25); skin [rabbits] 6400 (12); LCLo (ppm) inhalation [rat] 1000·4 hr (47)
	Long-Term Effects: Liver and kidney damage
	Pregnancy/Neonate Data: Positive teratogen
	Mutation Data: Conflicting evidence of mutagenicity
	Carcinogenicity Classification: IARC - category 3; NTP - none assigned

HANDLING PRECAUTIONS (38,52)	Handle chemical only with adequate ventilation • Vapor concentrations of 5-50 ppm: any supplied-air respirator, self-contained breathing apparatus or chemical cartridge respirator with an organic vapor cartridge • 50-150 ppm: self-contained breathing apparatus or supplied-air respirator with full facepiece; gas mask with organic vapor canister • Chemical goggles if there is probability of eye contact • Natural rubber, neoprene, nitrile, PVC, PE gloves/apron/boots should be worn if direct contact is unavoidable.

EMERGENCY FIRST AID TREATMENT (38,59)	Ingestion: Induce vomiting if victim is conscious; get medical attention immediately • Inhalation: Move victim to fresh air. Give artificial respiration if necessary. Keep victim warm. Get medical attention • Skin: Remove contaminated clothing. Wash skin with soap and water, two to three times. If irritation or pain persists after washing, get medical attention • Eye: Flush immediately with large amounts of water for at least 15 min; get medical attention.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Methyl benzene Toluol Phenyl methane Methyl benzol	108-88-3 NIOSH NO.: XS5250000	C_7H_8	3.77 mg/m³ ≅ 1 ppm 0.2652 ppm ≅ 1 mg/m³
	STRUCTURE: 		MOLECULAR WEIGHT: 92.14

REACTIVITY	Toluene may generate heat, react vigorously, and possibly ignite or explode in contact with oxidizing mineral acids or other strong oxidizing agents (507,38,511,505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless	(23)
	• Odor: benzene-like	(23)
	• Odor Threshold: 2.9 ppm	(384)
	• Liquid Density (g/ml at 20°C): 0.8669	(68)
	• Freezing/Melting Point (°C): -95	(68)
	• Boiling Point (°C): 110.6	(68)
	• Flash Point (°C): 4.4 (closed cup)	(23)
	• Flammable Limits in Air, % by Volume: 1.2-7.1	(51,38,506)
	• Autoignition Temperature (°C): 480-536	(510,506,504)
	• Vapor Pressure (mm Hg at 20°C): 22	(67)
	• Saturated Concentration in Air (mg/m³ at 20°C): 110,000	(67)
	• Solubility in Water (mg/L at 20°C): 515	(67)
	• Viscosity (cp at 20°C): 0.580	(ADL estim)
	• Surface Tension (dyne/cm at 20°C): 29	(59)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 2.73	(29)
	• Soil Adsorption Coefficient, K_{oc}: 259	(652)
	• Henry's Law Constant (atm·m³/mol at 25°C): 0.00661	(74)
	• Bioconcentration Factor: 27.1 (estim), 26 (estim)	(207,659)

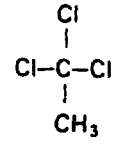
PERSISTENCE IN THE SOIL-WATER SYSTEM	Relatively mobile in soil-water systems, including transport of vapor through air-filled pores as well as transport in solution. Chemical is resistant to hydrolysis but will probably biodegrade easily if microbiological populations are sufficiently numerous and active. It may persist for months to years (or more) if biodegradation is not possible.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is the migration of toluene to ground-water drinking water supplies. Data from NPL sites indicate that migration of this compound has occurred in the past, although survey data do not show extensive contamination of drinking water. Inhalation resulting from volatilization from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (54): Acute exposure to toluene results in CNS depression. Symptoms include headache, dizziness, fatigue, muscular weakness, drowsiness and incoordination with staggering gait. The liquid splashed in the eyes may cause irritation and reversible corneal damage. Prolonged or repeated skin contact may cause drying and dermititis.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 5000 (47); skin [rabbit] 12,124 (47); LC_{50} (ppm) inhalation [mouse] (47) 5320·8 hr
	Long-Term Effects: No adverse effects based on limited data
	Pregnancy/Neonate Data: Conflicting teratogenic data
	Mutation Data: Conflicting data in toluene-exposed workers
	Carcinogenicity Classification: IARC - none assigned; NTP - none assigned (currently under evaluation)

HANDLING PRECAUTIONS (38)	Handle chemical only with adequate ventilation • Vapor concentrations of 200-500 ppm: any supplied-air respirator, self-contained breathing apparatus or chemical cartridge respirator with an organic vapor cartridge • 500-1000 ppm: chemical cartridge respirator with full facepiece and organic vapor canister • 1000-2000 ppm: any supplied-air respirator or self-contained breathing apparatus with full facepiece • Chemical goggles if there is probability of eye contact with the liquid • Impervious clothing to prevent prolonged or repeated skin contact.

EMERGENCY FIRST AID TREATMENT (54,38)	Ingestion: Do not induce vomiting. Seek medical attention • Inhalation: Move victim to fresh air; give artificial respiration if necessary. Get medical attention • Skin: Remove contaminated clothing. Wash skin with soap and water. If irritation persists after washing, get medical attention • Eye: Irrigate with large amounts of water; get medical attention.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Methyl chloroform alpha-Trichloroethane Chlorothene Trichloroethane	71-55-6 NIOSH NO.: KJ2975000	$C_2H_3Cl_3$	5.46 mg/m^3 ≅ 1 ppm 0.183 ppm ≅ 1 mg/m^3
	STRUCTURE:		MOLECULAR WEIGHT: 133.42

REACTIVITY	Reactions of halogenated organic materials such as 1,1,1-trichloroethane with cyanides, mercaptans or other organic sulfides typically generate heat, while those with mineral acids, amines, azo compounds, hydrazines, caustics or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases and fires. Those with alkali or alkaline earth metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents, or strong reducing agents typically result in heat generation and explosions and/or fires (511,505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless	(23)
	• Odor: ethereal	(21)
	• Odor Threshold: 120 ppm	(384)
	• Liquid Density (g/ml at 20°C): 1.325	(21)
	• Freezing/Melting Point (°C): -33	(21)
	• Boiling Point (°C): 74	(21)
	• Flash Point (°C): none	(23)
	• Flammable Limits in Air, % by Volume*: 7-16	(60,504,12)
	• Autoignition Temperature (°C)*: 500-537	(504,60)
	• Vapor Pressure (mm Hg at 20°C): 100	(38)
	• Saturated Concentration in Air (mg/m^3 at 20°C): 726,000	(67)
	• Solubility in Water (mg/L at 20°C): 950	(21)
	• Viscosity (cp at 20°C): 0.858	(21)
	• Surface Tension (dyne/cm at 20°C): 25.54	(21)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 2.49	(29)
	• Soil Adsorption Coefficient, K_{oc}: 152	(33)
	• Henry's Law Constant (atm·m^3/mol at 25°C): 0.0276	(74)
	• Bioconcentration Factor: 5.6 (bluegills), 15 (estim)	(123,659)

*A considerable amount of energy is required for ignition. The substance will not sustain combustion (12).

PERSISTENCE IN THE SOIL-WATER SYSTEM	1,1,1-Trichloroethane is expected to be fairly mobile in the soil/ground-water system, particularly in soils of low organic carbon where adsorption is low. Volatilization is an important removal process for near-surface 1,1,1-trichloroethane. Biodegradation in natural soils is not expected to be significant.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is the migration of 1,1,1-trichloroethane to ground-water drinking water supplies. This compound has been commonly detected in ground water at NPL sites as well as in drinking water surveys, illustrating the importance of this pathway. Inhalation from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (38,54): 1,1,1-Trichloroethane vapor is narcotic. Acute exposure leads to dizziness, drowsiness, lack of coordination, increased reaction time and irregular heart beat. Both liquid and vapor are irritating to the eyes. Skin contact may produce dermatitis.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 10,300 (47); skin -- no data; LCLo (ppm) inhalation [mouse] (59) 11,000·2 hr
	Long-Term Effects: Liver toxicity
	Pregnancy/Neonate Data: Negative
	Mutation Data: Conflicting data
	Carcinogenicity Classification: NTP - clear evidence; IARC - none assigned

HANDLING PRECAUTIONS (38,54)	Handle chemical only with adequate ventilation • Vapor concentrations of 350-500 ppm: any supplied-air respirator, self-contained breathing apparatus or chemical cartridge respirator with organic vapor cartridge • 500-1000 ppm: any supplied-air respirator or self-contained breathing apparatus with full facepiece • Chemical goggles if there is probability of eye contact with liquid • Impervious protective clothing and gloves (it attacks natural rubber) to prevent repeated or prolonged skin contact.

EMERGENCY FIRST AID TREATMENT (38,59)	Caution: Do not administer stimulants • Ingestion: Induce vomiting if victim is conscious. Get medical attention • Inhalation: Move victim to fresh air. Give artificial respiration if necessary. Get medical attention • Skin: Remove contaminated clothing. Wash skin with soap and water. If pain or irritation persists after washing, get medical attention • Eye: Irrigate with large amounts of water for at least 15 minutes; if pain or irritation persists after washing, get medical attention.

ENVIRONMENTAL AND OCCUPATIONAL STANDARDS AND CRITERIA

AIR EXPOSURE LIMITS:

Standards
- OSHA PEL (8-hr TWA): 350 ppm
- AFOSH PEL (8-hr TWA): 350 ppm; STEL (15-min): 450 ppm

Criteria
- NIOSH IDLH (30-min): 1000 ppm
- ACGIH TLV® (8-hr TWA): 350 ppm
- ACGIH STEL (15-min): 450 ppm

WATER EXPOSURE LIMITS:

Drinking Water Standards
None established

EPA Health Advisories
In the absence of formal drinking water standards, the EPA (383) has developed the following Health Advisories (formerly termed SNARLs) for noncarcinogenic risk for short and long-term exposure to 1,1,1-trichloroethane in drinking water:

- 1 day: none established
- 10 days: none established
- long-term: 1.07 mg/L

EPA Ambient Water Quality Criteria (355)
- Human Health
  - Based on ingestion of contaminated water and aquatic organisms, 18.4 mg/L.
  - Based on ingestion of contaminated aquatic organisms only, 1.03 g/L.
- Aquatic Life
  - Freshwater species
    acute toxicity: no criterion, but lowest effect level occurs at 18,000 µg/L trichloroethanes.

    chronic toxicity: no criterion established due to insufficient data.
  - Saltwater species
    acute toxicity: no criterion, but lowest effect level occurs at 31,200 µg/L trichloroethanes.

    chronic toxicity: no criterion established due to insufficient data.

REGULATORY STATUS (as of October 1, 1985)

Promulgated Regulations

- Federal Programs

Clean Water Act (CWA)

1,1,1-Trichloroethane is listed as a toxic pollutant (351). Water quality criteria have been set. No effluent limitations specific to this chemical have been set.

Safe Drinking Water Act (SDWA)

In states with an approved Underground Injection Control program, a permit is required for the injection of 1,1,1-trichloroethane-containing wastes designated as hazardous under RCRA (295).

Resource Conservation and Recovery Act (RCRA)

1,1,1-Trichloroethane is identified as a toxic hazardous waste (U226) and listed as a hazardous waste constituent (328,329). Non-specific sources of 1,1,1-trichloroethane-containing waste are solvent use (or recovery) activities and chlorinated aliphatic hydrocarbon production (325). Waste streams from the following industries contain 1,1,1-trichloroethane and are listed as specific sources of hazardous waste: organic chemicals (production of 1,2-dichloroethane, vinyl chloride and 1,1,1-trichloroethane) and inorganic chemicals (chlorine production) (326,327).

Toxic Substances Control Act (TSCA)

Manufacturers, processors or distributors of 1,1,1-trichloroethane must report production, usage and disposal information to EPA. They, as well as others who possess health and safety studies on 1,1,1-trichloroethane, must submit them to EPA (334,335).

Manufacturers and/or processors of 1,1,1-trichloroethane are required to sponsor tests for teratogenic effects. Testing protocols must be submitted to and approved by the EPA (340).

Comprehensive Environmental Response Compensation and Liability Act (CERCLA)

1,1,1-Trichloroethane is designated a hazardous substance under CERCLA. It has a reportable quantity (RQ) limit of 454 kg. Reportable quantities have also been issued for RCRA hazardous waste streams containing 1,1,1-trichloroethane but these depend upon the concentrations of the chemicals in the waste stream (556).

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)

1,1,1-Trichloroethane is exempt from a tolerance requirement when used as a solvent in pesticide formulations applied to growing crops or to raw agricultural commodities after harvest. It is also exempt when used as a solvent at a level no greater than 25% in pesticide formulation applied to animals (315) or when used in the post-harvest fumigation of citrus fruits (320).

This compound has also been reported in various surveys of drinking water, some of which were ground-water supplies as shown below:

Survey	No. Sampled	No. Positive	Range of Positives (µg/L)
State Data	3,333	715	Trace - 2,250
NOMS	113	19	0.2-1.3
NSP	142	32	Trace-21
CWSS	452	19	0.5-650
GWSS (random data)	466	27	0.2-18

The state data include only ground-water sources and were compiled from various state reports on local contamination problems. The state data are not considered to be statistically representative of national occurrence. The National Organics Monitoring Survey (NOMS) included data from both ground and surface water supplies, as did the National Screening Program (NSP) and the Community Water Supply Study (CWSS). The 1982 Groundwater Supply Survey (GWSS) is the most recent study (731). This survey sampled a total of almost 1000 drinking water systems using ground water; 466 selected at random, and about 500 selected by the state as potentially contaminated. The random results suggest that 1,1,1-trichloroethane is commonly found in drinking water, particularly in ground water as evidenced by the state reports of contamination problems. The USEPA (64) estimates that 0.3% of the nation's ground-water supplies are contaminated with 1,1,1-trichloroethane ($\geq$10 µg/L).

These survey data indicate that 1,1,1-trichloroethane is mobile in ground water and this mobility has resulted in exposure through drinking water. The subsequent contamination of surface waters may result in a number of exposure pathways:

- Surface waters may be used as drinking water supplies, resulting in direct ingestion exposure;
- Aquatic organisms residing in these waters may be consumed, also resulting in ingestion exposures through bioaccumulation;
- Recreational use of these waters may result in dermal exposures;
- Domestic animals may consume or be dermally exposed to contaminated ground or surface waters; the consumption of meats and poultry could then result in ingestion exposures.

In general, exposures associated with surface water contamination can be expected to be lower than exposure from drinking contaminated ground water for two reasons. First, the Henry's law constant for 1,1,1-trichloroethane suggests that it will volatilize upon reaching surface waters. Secondly, the bioconcentration factor for this compound is low, suggesting limited bioaccumulation in aquatic organisms or domestic animals.

10.2.4 Other Sources of Exposure

The data presented above from various drinking water surveys suggest that 1,1,1-trichloroethane is found in both ground water and surface waters used as drinking water supplies.

The volatility of this compound suggests that it may be found in air as well. Brodzinsky and Singh (84) compiled all available atmospheric monitoring data for a number of volatile organics. For 1,1,1-trichloroethane, they had data for 2673 locations. In rural and remote areas, the median concentration was 0.6 $\mu g/m^3$; in urban and suburban, the median concentration was 2.8 $\mu g/m^3$; and in source-dominated areas, the median concentration was 6.5 $\mu g/m^3$. These data show that persons even in rural and remote areas may be exposed to this compound through inhalation.

McConnell et al. (224) found levels of 1,1,1-trichloroethane in various foods in the United Kingdom at 1-10 µg/kg. These data suggest that people may be exposed to this compound in the diet.

10.3 HUMAN HEALTH CONSIDERATIONS

10.3.1 Animal Studies

10.3.1.1 Carcinogenicity

Three previous studies (660,661,622) have examined the carcinogenicity of 1,1,1-trichloroethane. Inadequate duration of study or excessive mortality render the data from these studies inadequate for the assessment of human cancer risk. The National Toxicology Program (393) conducted a re-test of 1,1,1-trichloroethane in 1979. The test chemical had a purity of 99.7% and contained 0.1% butylene oxide as a stabilizer. It was administered in corn oil by gavage to male and female F344/N rats at doses of 375 and 750 mg/kg. Male and female B6C3F1 mice received 1500 or 3000 mg/kg. The animals were dosed 5 times per week for 103 weeks. No treatment-related tumors were observed in male rats; the study was inadequate for evaluation of female rats because the high dose was toxic and there was a large number of

accidental deaths. In mice, the association between an increased incidence of hepatocellular carcinoma and exposure to 1,1,1-trichloroethane was considered equivocal in male mice; 1,1,1-trichloroethane was carcinogenic in female mice, causing an increased incidence of hepatocellular carcinoma.

10.3.1.2 Mutagenicity

The 1,1,1-isomer of trichloroethane was weakly mutagenic in Salmonella typhimurium strain TA 100 in an Ames test, with and without metabolic activation. This compound also induced a clear positive response in the BALB/c-3T3 cell transformation assay (708). It was negative, however, in a dominant lethal assay in mice given daily oral doses as high as 8500 mg/kg (12).

10.3.1.3 Teratogenicity, Embryotoxicity and Reproductive Effects

No fetal toxicity or teratogenicity was found when rats and mice were exposed to vapor concentrations of 875 ppm seven hours daily on days 6 through 15 of gestation (115).

No dose-dependent effects on fertility, gestation or viability were observed in male and female ICR mice that received 1,1,1-trichloroethane in drinking water at concentrations of 0, 0.58, 1.75 or 5.83 mg/mL/day for 25 weeks. These concentrations were designed to yield daily doses of 0, 100, 300 or 1000 mg/kg. Trichloroethane exposure also failed to produce significant dominant lethal mutations or teratogenic effects (386).

10.3.1.4 Other Toxicologic Effects

10.3.1.4.1 Short-term Toxicity

Results of animal experimentation show that 1,1,1-trichloroethane is relatively nontoxic upon short-term exposure (43). Adams et al. (127) exposed various species of animals 7 hours daily, 5 days per week for 1 to 3 months. At 10,000 ppm, rats showed irregular respiration and semiconsciousness after 3 hours. In those that succumbed, death appeared to be due to cardiac or respiratory failure. At 5000 ppm, there was a mild narcotic effect within 1 hour. The rats survived for 31 exposures at this level without apparent injury. Rabbits at this level showed slight growth retardation. At 3000 ppm, rabbits and monkeys showed no response over a 2 month period. Even continuous exposure for 14 weeks produced little injury to rats, mice, dogs and monkeys at 1000 ppm and essentially no effect at 250 ppm except minor, reversible cytoplasmic alterations in the livers of mice.

10.3.1.4.2 Chronic Toxicity

MacEwen and Vernot (395) reported no adverse effects in monkeys and dogs exposed to 250 or 1000 ppm continuously by inhalation for 90 or 100 days. Mice and rats exposed to the higher dosage level exhibited increased liver weights as well as cellular changes of the liver. No liver or kidney effects were observed in rats, rabbits, guinea pigs or monkeys exposed to 500 ppm 7 hours per day, 5 days a week for 130 exposures (396).

10.3.2 Human and Epidemiologic Studies

10.3.2.1 Short-term Toxicologic Effects

Depression of the central nervous system is the primary toxic effect in humans who have been subjected to short-term, high-level inhalation exposure to trichloroethane. Exposure to vapor concentrations in excess of 1000 ppm for 15 minutes or 2000 ppm for 5 minutes causes disequilibrium in adults (38). An investigation by Gamberale and Hultengren (129) indicated that inhalation of 350 ppm for 1 hour can impair manual dexterity. Acute, high-level inhalation can also adversely effect the cardiovascular system. Dornette and Jones (128), using concentrations of 10,000 to 26,000 ppm for surgical anesthesia, noted no respiratory depression or hepatotoxicity in their patients, but did observe a number of cardiovascular effects including hypotension, premature ventricular contractions and in one patient, cardiac arrest.

Numerous deaths have been attributed to deliberate or occupational inhalation exposure to trichloroethane. In the majority of human fatalities, death results from CNS depression, edema and pulmonary congestion. However, even in cases of acute, high-level inhalation exposures, 1,1,1-trichloroethane possesses a limited capacity to exert hepatic injury (43).

There is one account of accidental ingestion of 30 mL by a 47-year-old male. The initial symptoms were CNS depression and gastrointestinal upset. Clinical tests revealed only minimal evidence of hepatorenal injury. The patient recovered within 2 weeks (131).

NIOSH cites numerous instances of inhalation exposures to 1,1,1-trichloroethane. Several deaths have been reported; in most cases, the exposure levels have been estimated to be several thousand ppm. Based on 8-hour exposures, NIOSH has determined a minimal to no-response level of 250 to 350 ppm (394).

Trichloroethane is irritating to the skin. Various studies have shown the liquid to be absorbed through intact skin in moderate amounts. Vapors, however, are not absorbed by this route in toxicologically significant quantities (394).

Vapor concentrations of 500 to 1000 ppm cause minor, transient eye irritation in humans. The effect of splash contact is similar to that of chloroform. If the corneal epithelium is injured, it will regenerate within 3 days (19).

10.3.2.2 Chronic Toxicologic Effects

The most extensive study of industrially-exposed workers has been reported by Kramer and associates (130) who conducted an epidemiological study of 151 subjects and 151 matched controls with emphasis placed on cardiovascular and hepatic effects. Employees in the study population had solvent exposures ranging from several months up to 6 years. Vapor concentrations ranged from 1 to 250 ppm. Statistical analysis of the data did not reveal any clinically pertinent findings. In addition, Maroni et al. (398) reported no signs attributed to nervous system impairment in 22 factory workers exposed to vapor concentrations between 100 and 1000 ppm for up to 6 years.

10.3.3 Levels of Concern

The USEPA (388) has established a water quality criterion for 1,1,1-trichloroethane of 18.4 mg/L for the maximum protection of human health. The criterion is based on reduced survival noted in Osborne-Mendel rats administered 750 mg/kg of this compound by gavage, 5 days per week for 78 weeks (i.e., 536 mg/kg/day) (660). Assuming a 70-kg body weight and a safety factor of 1000, an acceptable daily intake (ADI) of 37.5 mg/day was calculated. It should be noted that this criterion was established prior to the NTP findings of an increased incidence of hepatocellular carcinoma in female B6C3F1 mice (393).

OSHA (298) currently permits and the ACGIH (3) recommends exposure to 350 ppm (1910 mg/m^3) averaged over an 8-hour work-shift. The ACGIH (3) also recommends a short-term exposure limit of 450 ppm for 15 minutes.

10.3.4 Hazard Assessment

Although inhalation exposure is most common, percutaneous absorption of both liquid and vapor 1,1,1-trichloroethane, as well as exposure via ingestion, have been demonstrated in humans. Accidental ingestion of 30 mL (~40g) of 1,1,1-trichloroethane by an human adult was survived (131). Oral LD_{50} values in experimental animals range

from 500 to 12,000 mg/kg (21). The primary effects of low level inhalation exposures to 1,1,1-trichloroethane (≤1000 ppm ≤1 hr) are psychophysiological, including dose-related impairment of perception and coordination. The effects of chronic low-level exposures are not known.

No reproductive abnormalities have been noted with 1,1,1-trichloroethane exposure in experimental animals. Mutagenic studies revealed negative results in a dominant-lethal assay conducted with mice given oral doses as high as 8500 mg/kg (12). Weak mutagenic activity was reported in one strain of Salmonella and a clear positive response in the BALB/c-3T3 cell transformation assay (708).

Mixed carcinogenic results were observed in the recent NTP study (393). The compound was judged to be an equivocal carcinogen in male mice but provided clear evidence of carcinogenicity (hepatocellular carcinoma) in female mice. No increased incidence of tumors was noted for rats; the compound may not have been adequately studied in female rats due to the high mortality in this group. IARC has not reviewed this chemical.

10.4 SAMPLING AND ANALYSIS CONSIDERATIONS

Determination of 1,1,1-trichloroethane concentrations in soil and water requires collection of a representative field sample and laboratory analysis. Due to the volatility of 1,1,1-trichloroethane, care is required to prevent losses during sample collection and storage. Soil and water samples should be collected in airtight containers with no headspace; analysis should be completed within 14 days of sampling. In addition to the targeted samples, quality control samples such as field blanks, duplicates, and spiked matrices may be specified in the recommended methods.

EPA-approved procedures for the analysis of 1,1,1-trichloroethane, one of the EPA priority pollutants, in aqueous samples include EPA Methods 601, 624, and 1624 (65). An inert gas is bubbled through the aqueous sample in a purging chamber at ambient temperature, transferring the 1,1,1-trichloroethane from the aqueous phase to the vapor phase and onto a sorbent trap. The trap is then heated and backflushed to desorb the 1,1,1-trichloroethane and transfer it onto a gas chromatographic (GC) column. The GC column is programmed to separate the volatile organics; 1,1,1-trichloroethane is then detected with a halide specific detector (Method 601) or a mass spectrometer (Methods 624 and 1624).

I. CHEMICAL IDENTITY

Common name: 1,1,2-Trichloroethane
Formula: $CHCl_2CH_2Cl$
Synonyms: Vinyl trichloride; beta-trichloroethane
CAS No.: 79-00-5
Carcinogen: NCI

II. REGULATORY INFORMATION

Hazardous substance: No
Hazardous waste: EPA
DOT Hazard Class: N/A

III. PHYSICAL CHARACTERISTICS

Boiling point: 113 C (236 F)
Specific gravity: 1.43
Vapor density: 4.55
Melting point: −37 C (−34 F)
Vapor pressure: 18.8 mm Hg
Solubility in water: 0.45
Evaporation rate: Data not available
Appearance and odor: Colorless liquid with a sweet odor, like chloroform

IV. PHYSICAL HAZARDS

Flash point: None in normal test method
Autoignition temperature: Data not available
Flammable limits in air (% by vol.): Lower: 6.0; Upper: 15.5
Extinguishants: Foam carbon dioxide, dry chemical

V. HEALTH HAZARDS

Can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. Effects of short-term overexposure: May cause irritation of the eyes and nose, drowsiness, incoordination, unconsciousness, and death. Effects of long-term overexposure: May cause liver or kidney damage.

VI. EMERGENCY FIRST AID

Eyes: Irrigate immediately
Skin: Wash with soap and water
Breathing: Move affected to fresh air at once. If necessary, perform artificial respiration and get medical attention immediately.
Swallowing: Give large quantities of water. Induce vomiting and get medical attention immediately.

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA TWA: 10 ppm (45 mg/m^3) with skin caution
ACGIH STEL: 20 ppm
IDLH: 500 ppm

VIII. PRECAUTIONS FOR USE AND SAFE HANDLING

Conditions contributing to instability: Heat
Incompatibilities: Contact with strong oxidizers, strong caustics, and chemically active metals such as aluminum and magnesium powders, sodium or postassium may cause fires and explosions.
Hazardous decomposition products: Toxic gases and vapors may be released in a fire involving 1, 1,2-trichloroethane.
Special precautions: Will attack some forms of plastics, rubber, and coatings.

IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

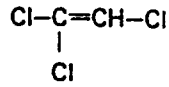
Protective equipment and clothing must be used. In the case of spills, ventilate area. Collect for reclamation or absorb in vermiculite, dry sand, or a similar material.

X. PROTECTIVE EQUIPMENT

Provide employees and require the use of impervious clothing, gloves, face shields (eight-inch minimum), splash-proof safety goggles, and other appropriate protectiveclothing necessary to prevent repeated or prolonged skin contact.

Respirators–

(Required above 10 ppm)
500 SAF;SCBAF
Escape: GMOV;SCBA

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Trichloroethene Ethylene trichloride Ethinyl trichloride Acetylene trichloride TCE Tri	79-01-6 NIOSH NO.: KX4550000	C_2HCl_3	5.38 mg/m³ ≅ 1 ppm 0.1858 ppm ≅ 1 mg/m³
	STRUCTURE:		MOLECULAR WEIGHT:
			131.39

REACTIVITY	Reactions of halogenated organic materials such as trichloroethylene with cyanides, mercaptans or other organic sulfides typically generate heat, while those with mineral acids, amines, azo compounds, hydrazines, caustics or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases and fires. Those with alkali or alkaline earth metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents, or strong reducing agents typically result in heat generation and explosions and/or fires (511,505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless (often dyed pale blue)	(23,59)
	• Odor: sweet, chloroform-like	(23)
	• Odor Threshold: 100 ppm	(12)
	• Liquid Density (g/ml at 20°C): 1.462	(48)
	• Freezing/Melting Point (°C): -84.4/-73	(48,23)
	• Boiling Point (°C): 87.2	(48)
	• Flash Point (°C): practically nonflammable	(12,23)
	• Flammable Limits in Air, % by Volume: 8.0-10.5	(60,507,504)
	• Autoignition Temperature (°C): 410-420	(60,506,504)
	• Vapor Pressure (mm Hg at 20°C): 58.7	(48)
	• Saturated Concentration in Air (mg/m³ at 20°C): 4.22×10^5	(ADL estim)
	• Solubility in Water (mg/L at 20°C): 1000	(10)
	• Viscosity (cp at 20°C): 0.570	(48)
	• Surface Tension (dyne/cm at 20°C): 29.3	(60)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 2.42	(29)
	• Soil Adsorption Coefficient, K_{oc}: 127	(652)
	• Henry's Law Constant (atm·m³/mol at 20°C): 0.00892	(74)
	• Bioconcentration Factor: 17 (bluegill sunfish), 39 (rainbow trout), 13 (estim)	(31,61,659)

PERSISTENCE IN THE SOIL-WATER SYSTEM	Trichloroethylene is relatively mobile in the soil/ground-water system, particularly in soils with low organic content. Volatilization may be significant for trichloroethylene near the surface or in the soil-air phase. Transformation processes such as hydrolysis and biodegradation are not expected to be important in natural soils.

PATHWAYS OF EXPOSURE	The primary pathway of concern from a soil-water system is the migration of trichloroethylene to ground-water drinking water supplies. Drinking water surveys suggest that such migration has been common in the past. Inhalation resulting from volatilization from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (54): Acute exposure to trichloroethylene depresses the central nervous system causing such symptoms as headache, dizziness, vertigo, tremors, irregular heartbeat, fatigue, nausea, vomiting, blurred vision and intoxication similar to that of ethanol. The vapors may cause irritation of the eyes, nose and throat. The liquid may cause burning irritation and damage to the eye. Repeated or prolonged skin contact with the liquid may cause dermatitis.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 4920 (59); skin — no data; LCLo (ppm) inhalation [rat] (59) 8000·4 hr
	Long-Term Effects: Liver and kidney injury
	Pregnancy/Neonate Data: Negative
	Mutation Data: Conflicting
	Carcinogenicity Classification: IARC - category 3; NTP - clear evidence

HANDLING PRECAUTIONS (709)	Handle chemical only with adequate ventilation • Vapor concentrations of 100-1000 ppm: chemical cartridge respirator with organic vapor cartridge or type C demand-type supplied-air respirator with half-mask facepiece • Chemical goggles if there is probability of eye contact with liquid • Impervious protective clothing to prevent contact with liquid.

EMERGENCY FIRST AID TREATMENT (54,59)	Caution: Do not administer stimulants • Ingestion: Get medical attention; give large quantities of salt water and induce vomiting if victim is conscious • Inhalation: Move victim to fresh air at once; give artificial respiration if needed • Skin: Remove any contaminated clothing; wash skin with soap and water. If pain of irritation persists after washing, get medical attention • Eye: Irrigate copiously for at least 15 minutes. If pain of irritation persists after washing, get medical attention.

CHEMICAL NAME
VINYL CHLORIDE

FORMULA
C2H3CL

SYNONYMS
CHLOROETHYLENE
CHLOROETHENE
MONOCHLOROETHYLENE
VC
VCM
VINYL CHLORIDE MONOMER
UN 1086
ETHYLENE, CHLORO-
CHLORETHENE
CHLORETHYLENE
ETHYLENE MONOCHLORIDE
MONOCHLOROETHENE
TROVIDUR
VINYL C MONOMER
ETHENE, CHLORO-
OHS24940

PERMISSIBLE EXPOSURE LIMIT
1 PPM OSHA TWA - 5 PPM OSHA 15 MINUTE CEILING
NIOSH RECOMMENDED EXPOSURE - LOWEST DETECTABLE LIMIT
5 PPM ACGIH TWA
CANCER SUSPECT AGENT (OSHA 29CFR1910.1017)
HUMAN CARCINOGEN (ACGIH, IARC, NTP)
ANIMAL CARCINOGEN (IARC)
TERATOGENIC DATA (RTEC)
MUTAGENIC DATA (RTEC)
AQUATIC TOXICITY RATING 0 (TLM96 >1000 PPM)
TLM96 - BLUEGILL 1220 PPM, LARGEMOUTH BASS 1060 PPM
CERCLA HAZARD RATINGS - TOXICITY 2 - IGNITABILITY 3 - REACTIVITY 1 - PERSISTENCE 1

TOXICOLOGY: VINYL CHLORIDE IS A HUMAN CARCINOGEN. IT IS CARCINOGENIC TO THE LIVER, BRAIN, LUNG, BLOOD, AND LYMPHATIC SYSTEM. SYSTEMIC EFFECTS INCLUDE LIVER AND KIDNEY DAMAGE AND CENTRAL NERVOUS SYSTEM DISORDERS.
VINYL CHLORIDE ALSO CAUSES RAYNAUD'S PHENOMENON AND ACROOSTEOLYSIS.
CONCENTRATIONS ABOVE 1000 PPM CAUSES DROWSINESS, BLURRED VISION, STAGGERING, AND TINGLING AND NUMBNESS IN THE FEET AND HANDS.
LIQUID CONTACT CAN CAUSE FROSTBITE AND SEVERE SKIN IRRITATION AND BURNS. FUMES FROM THE HEATED POLYMER MAY CAUSE PULMONARY SENSITIZATION.
ORL-RAT LD50:500 MG/KG
IHL-GPG LCLO: 20 PPM/30 MIN
ORL-RAT LD50:500 MG/KG

IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONCENTRATION
NONE SPECIFIED

PHYSICAL DESCRIPTION
COLORLESS GAS; EASILY LIQUIFIED;
ETHEREAL ODOR.

CHEMICAL AND PHYSICAL PROPERTIES
MOLECULAR WEIGHT: 62.5
BOILING POINT AT 1 ATM, F: 8 F
SOLUBILITY IN WATER, G/100 G WATER AT 20C: NEGLIGIBLE
FLASH POINT, CLOSED CUP, F (OR OPEN CUP IF 0C): -108 F
VAPOR PRESSURE @ 20 C, MMHG: 3.31 ATM @ 21.1 C
MELTING POINT, F: -245 F
UPPER EXPLOSIVE LIMIT IN AIR, % BY VOLUME: 33%
LOWER EXPLOSIVE LIMIT IN AIR, % BY VOLUME: 3.6%
AUTOIGNITION TEMPERATURE: 882 F
SPECIFIC GRAVITY: 0.9100
VAPOR DENSITY (AIR=1): 2.24

INCOMPATIBILITIES
STRONG OXIDIZERS
STRONG BASES
ALUMINUM POWDER
COPPER
COPPER ALLOYS
PEROXIDES

PERSONAL PROTECTIVE EQUIPMENT
29CFR1910.1017 VINYL CHLORIDE
(H) HAZARDOUS OPERATION (1) EMPLOYEES ENGAGED IN HAZARDOUS OPERATIONS, INDLUDING ENTRY OF VESSELS TO CLEAN POLYVINYL CHLORIDE RESIDUE FROM VESSEL WALLS, SHALL BE PROVIDED AND REQUIRED TO WEAR AND USE;
(II) PROTECTIVE GARMENTS TO PREVENT SKIN CONTACT WITH LIQUID VINYL CHLORIDE OR POLYVINYL CHLORIDE RESIDUE FROM VESSEL WALLS. THE PROTECTIVE GARMENTS SHALL BE SELECTED FOR THE OPERATION AND ITS POSSIBLE EXPOSURE CONDITIONS.
(2) PROTECTIVE GARMENTS SHALL BE PROVIDED CLEAN AND DRY FOR EACH USE.

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ACGIH "GUIDELINES FOR THE SELECTION OF CHEMICAL PROTECTIVE CLOTHING" INDICATES THE FOLLOWING PROTECTIVE RATINGS FOR MATERIALS COMMONLY USED FOR PROTECTIVE CLOTHING. THESE RATINGS ARE BASED PRIMARILY ON QUANTITATIVE TEST RESULTS AND QUALITATIVE RESISTANCE INFORMATION. (THE RECOMMENDATIONS APPLY TO THE PURE SUBSTANCE ONLY; BREAKTHROUGH-TIME MAY VARY FOR MIXTURES.)
VINYL CHLORIDE:
EXCELLENT/GOOD:
NONE INDICATED

GOOD/FAIR:
NITRILE RUBBER
CHLORINATED POLYETHYLENE
VITON

FAIR/GOOD:
BUTYL RUBBER
POLYVINYL CHLORIDE

GOGGLES
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE SPLASH-PROOF GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THERE IS ANY POSSIBILITY OF THIS LIQUID CONTACTING THE EYES.

WASHING CHEMICALS FROM THE SKIN
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE IMMEDIATELY WASH OR SHOWER TO REMOVE ANY CONTAMINANT FROM THE SKIN.

ROUTINE CHANGING OF WORK CLOTHING
NOT REQUIRED

CLOTHING REMOVAL FOLLOWING ACCIDENTAL CONTAMINATION
EMPLOYERS SHALL ENSURE THAT NON-IMPERVIOUS CLOTHING WHICH BECOMES CONTAMINATED WITH THIS SUBSTANCE BE REMOVED IMMEDIATELY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

SPECIFIC EMERGENCY PROVISIONS
WHERE THERE IS ANY POSSIBILITY OF EXPOSURE OF AN EMPLOYEE'S BODY TO THIS SUBSTANCE, EMPLOYERS SHALL PROVIDE FACILITIES FOR QUICK DRENCHING OF THE BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

WHERE THERE IS ANY POSSIBILITY THAT AN EMPLOYEE'S EYES MAY BE EXPOSED TO THIS SUBSTANCE, EMPLOYERS SHALL PROVIDE AN EYE-WASH FOUNTAIN WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED)

10 PPM
- TYPE 'C' SUPPLIED-AIR RESPIRATOR
- SUPPLIED-AIR RESPIRATOR
  WITH HALF-MASK
  OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- AUXILIARY SELF-CONTAINED BREATHING APPARATUS
- CHEMICAL CARTRIDGE RESPIRATOR
  WITH AN ORGANIC VAPOR CANISTER
  PROVIDING PROTECTION AGAINST SPECIFIC COMPOUND OF CONCERN

25 PPM
- POWERED AIR-PURIFYING RESPIRATOR
  WITH A FULL FACE-PIECE, HELMENT, OR HOOD
  PROVIDING PROTECTION AGAINST SPECIFIC COMPOUND OF CONCERN
- GAS MASK
  (CHIN-STYLE OR FRONT- OR BACK-MOUNTED CANISTER)
  PROVIDING PROTECTION AGAINST SPECIFIC COMPOUND OF CONCERN

100 PPM
- TYPE 'C' SUPPLIED-AIR RESPIRATOR
- SUPPLIED-AIR RESPIRATOR
  WITH A FULL FACE-PIECE
  OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- AUXILIARY SELF-CONTAINED BREATHING APPARATUS
- SELF-CONTAINED BREATHING APPARATUS
  WITH A FULL FACE-PIECE
  OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- TYPE 'C' SUPPLIED-AIR RESPIRATOR
- SUPPLIED-AIR RESPIRATOR
  WITH A FULL FACE-PIECE
  OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

1000 PPM
- TYPE 'C' SUPPLIED-AIR RESPIRATOR
- SUPPLIED-AIR RESPIRATOR
  WITH A FULL FACE-PIECE
- AUXILIARY SELF-CONTAINED BREATHING APPARATUS
- TYPE 'C' SUPPLIED-AIR RESPIRATOR
- SUPPLIED-AIR RESPIRATOR
  WITH A FULL FACE-PIECE, HELMENT, OR HOOD
  OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- TYPE 'C' SUPPLIED-AIR RESPIRATOR
- SUPPLIED-AIR RESPIRATOR
  WITH HALF-MASK
  OPERATED IN PRESSURE-DEMAND, POSITIVE-PRESSURE, OR CONTINUOUS-FLOW MODE

3600 PPM
- TYPE 'C' SUPPLIED-AIR RESPIRATOR
- SUPPLIED-AIR RESPIRATOR
  WITH A FULL FACE-PIECE
- AUXILIARY SELF-CONTAINED BREATHING APPARATUS
- TYPE 'C' SUPPLIED-AIR RESPIRATOR
- SUPPLIED-AIR RESPIRATOR
  WITH HALF-MASK
- AUXILIARY SELF-CONTAINED BREATHING APPARATUS

ESCAPE
- SELF-CONTAINED BREATHING APPARATUS
  WITH A FULL FACE-PIECE
  OPERATED IN PRESSURE-DEMAND, POSITIVE-PRESSURE, OR CONTINUOUS-FLOW MODE

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS
  WITH A FULL FACE-PIECE
  OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

ROUTE OF ENTRY INTO BODY
INHALATION
SKIN ABSORPTION
INGESTION
SKIN OR EYE CONTACT

SYMPTOMS
STRABISMUS
BRAIN CANCER
FROSTBITE
LIGHTHEADEDNESS
NAUSEA
RAYNAUD'S DISEASE
DERMATITIS
KIDNEY DAMAGE
HEPATIC ANGIOSARCOMA
REPRODUCTIVE EFFECTS

CENTRAL NERVOUS SYSTEM DEPRESSION
CONJUNCTIVITIS
ANEMIA
NARCOSIS
PARESTHESIA
WEAKNESS
ABDOMINAL PAIN
DROWSINESS
ANOREXIA
WEIGHT LOSS
GASTROINTESTINAL HEMORRHAGE
SWEATING
SENSITIZATION DERMATITIS
LIVER DAMAGE
LUNG CANCER
ACROOSTEOLYSIS
THROMBOCYTOPENIA
HEMATOPOIETIC CANCER
LYMPHATIC CANCER
EYE IRRITATION
CARDIAC DAMAGE
HEADACHE
DIZZINESS
HYPERCALCEMIA
HEPATOMEGALY

FIRST AID PROCEDURES FOLLOWING EXPOSURE

IF THIS CHEMICAL GETS INTO THE EYES, IMMEDIATELY WASH THE EYES WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING THE LOWER AND UPPER LIDS. GET MEDICAL ATTENTION IMMEDIATELY. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS CHEMICAL.

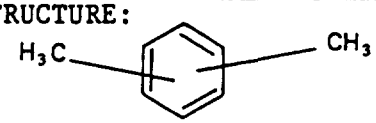
IF THIS CHEMICAL GETS ON THE SKIN, IMMEDIATELY WASH CONTAMINATED SKIN WITH SOAP OR MILD DETERGENT & WATER. IF THIS CHEMICAL SOAKS CLOTHING, IMMEDIATELY REMOVE CLOTHING & WASH SKIN WITH SOAP OR MILD DETERGENT & WATER. GET MEDICAL ATTENTION PROMPTLY.

IF A PERSON BREATHES IN LARGE AMOUNTS OF THIS CHEMICAL, 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.

IF THIS HALOGENATED HYDROCARBON HAS BEEN SWALLOWED, REMOVE BY GASTRIC LAVAGE OR EMESIS. MAINTAIN BLOOD PRESSURE BY ADMINISTERING 5% GLUCOSE INTRAVENOUSLY.
DO NOT GIVE STIMULANTS. GET FURTHER MEDICAL TREATMENT IMMEDIATELY.
(DREISBACH - HANDBOOK OF POISONING, 11TH ED.)

ORGANS
CENTRAL NERVOUS SYSTEM
KIDNEYS
LIVER
SPLEEN
CARDIOVASCULAR SYSTEM

STATUS OF REGULATORY ENFORCEMENT
OSHA STANDARD 29CFR1910.1200 HAZARD COMMUNICATION

COMMON SYNONYMS: Dimethylbenzene, Xylol	STRUCTURE: 	AIR W/V CONVERSION FACTORS at 25°C (12): 4.34 mg/m³ ≅ 1 ppm; 0.2304 ppm ≅ 1 mg/m³

ISOMER	CAS REG. NO.:	NIOSH NO.:
mixed	1330-20-7	ZE2100000
		ZE2190000
m	108-38-3	ZE2275000
o	95-47-6	ZE2450000
p	106-42-3	ZE2625000

FORMULA: C_8H_{10}

MOLECULAR WEIGHT: 106.17

REACTIVITY	Xylenes may generate heat, react vigorously, and possibly ignite or explode in contact with oxidizing mineral acids or other strong oxidizing agents (512,507,38,511).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): liquid	(23)
	• Color: colorless	(23)
	• Odor: aromatic	(2)
	• Odor Threshold: 1.1 ppm	(384)
	• Liquid Density (g/ml at 25°C): 0.8802(o-); 0.8642(m-); 0.8610(p-)	(21)
	• Freezing/Melting Point (°C): -25.2(o-); -47.9(m-); +13.3(p-)	(21)
	• Boiling Point (°C): 144.4(o-); 139.1(m-); 138.7(p-)	(21)
	• Flash Point (°C): 31(o-); 29(m-); 27(p-)	(21)
	• Flammable Limits in Air, % by Volume: 1.0-7.0(o-,m-,p-)	(504,12)
	• Autoignition Temperature (°C): 464(o-); 528-530(m-); 529(p-)	(51,506, 60,513)
	• Vapor Pressure (mm Hg at 20°C): 7(o-); 9(m-); 9(p-)	(38)
	• Saturated Concentration in Air (mg/m³ at 20°C): 40,750(o-); 52,400(m-,p-)	(ADL estim)
	• Solubility in Water (mg/L at 20°C): 0.3(o-,m-,p-)	(38)
	• Viscosity (cp at 20°C): 0.802(o-); 0.0608(m-); 0.635(p-)	(48)
	• Surface Tension (dyne/cm at 20°C): 32.5(o-); 31.2(m-); 28.3(p-)	(21)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 3.12(o-); 3.20(m-); 3.15(p-); 3.16(avg)	(29)
	• Soil Adsorption Coefficient, K_{oc}: 691	(652)
	• Henry's Law Constant (atm·m³/mol at 25°C): 4.94×10^{-3}(o-); 6.91×10^{-3}(m-); 7.01×10^{-3}(p-)	(74)
	• Bioconcentration Factor: 70 (avg estim)	(659)

NOTE: Throughout this chapter, the term xylene refers to the mixed isomers unless otherwise specified. Where appropriate, the isomers are identified by the prefixes o-(ortho), m-(meta) or p-(para).

PERSISTENCE IN THE SOIL-WATER SYSTEM	Relatively mobile in soil-water systems, especially in aqueous phase. Volatilization through air-filled pores is also possible. Chemical is resistant to hydrolysis but is probably biodegradable. Should assume chemical could persist for months to years (or longer).

PATHWAYS OF EXPOSURE	The primary pathway of concern from soil-water systems is the migration of xylene to ground-water drinking water supplies. Data from NPL sites indicate that migration of this compound has occurred in the past. Inhalation resulting from volatilization from surface soils may also be important.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (54): Acute exposure to high concentrations of xylene vapors in air may cause CNS depression with symptoms including dizziness, drowsiness, nausea, vomiting, abdominal pain, loss of appetite, pulmonary edema, and unconsciousness, as well as reversible effects on the liver and kidneys. Liquid xylene and high vapor concentrations are irritating to the eyes and the vapor may cause transient, reversible damage to the cornea. Aspiration of liquid into the lungs may cause chemical pneumonitis, pulmonary edema and hemorrhage.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 4300 (47); skin -- no data; LC_{50} (ppm) inhalation [rat] 5000·4 hr (47)
	Long-Term Effects: Possible damage to liver and kidneys, but such effects have not been demonstrated with certainty
	Pregnancy/Neonate Data: Negative in rats; cleft palates in mice but only at near lethal levels
	Mutation Data: Negative
	Carcinogenicity: No data

HANDLING PRECAUTIONS (38,52)	Handle xylene only with adequate ventilation • Vapor concentrations of 100-1000 ppm: chemical cartridge respirator with full facepiece and organic vapor cartridge • 1000-5000 ppm: any supplied-air respirator or self-contained breathing apparatus with full facepiece or gas mask with organic vapor canister • Chemical goggles if there is probability of eye contact • Natural rubber, neoprene, PVA, PVC, gloves/apron/boots and protective clothing to prevent prolonged or repeated skin contact with liquid.

EMERGENCY FIRST AID TREATMENT (38,54)	Ingestion: Do not induce vomiting. Get medical attention immediately • Inhalation: Move victim to fresh air. Give artificial respiration if necessary. Keep victim warm and at rest. Seek medical attention • Skin: Remove contaminated clothing. Wash skin with soap and water. If irritation persists, get medical attention • Eye: Irrigate with large amounts of water. Get medical attention.

ENVIRONMENTAL AND OCCUPATIONAL STANDARDS AND CRITERIA

AIR EXPOSURE LIMITS:

Standards

- OSHA PEL (8-hr TWA): 100 ppm
- AFOSH PEL (8-hr TWA): 100 ppm; STEL (15-min): 150 ppm

Criteria

- NIOSH IDLH (30-min): 10,000 ppm
- ACGIH TLV® (8-hr TWA): 100 ppm
- ACGIH STEL (15-min): 150 ppm

WATER EXPOSURE LIMITS:

Drinking Water Standards

None established

EPA Health Advisories

In the absence of formal drinking water standards, the EPA (383) has developed the following Health Advisories (formerly termed SNARLs) for noncarcinogenic risk for short and long-term exposure to xylene in drinking water:

- 1 day: 12 mg/L
- 10 days: 1.4 mg/L
- long-term: 0.62 mg/L

EPA Ambient Water Quality Criteria (355)

- Human Health
  No criterion established; xylene is not a priority pollutant.

- Aquatic Life
  No criterion established; xylene is not a priority pollutant.

Xylene is found in drinking water obtained from ground water. There is a lack of data on the occurrence of xylenes in finished surface water supplies. Discharge of effluents contaminated with xylenes near water intakes in surface water could potentially result in ingestion exposures from drinking water. The use of this compound as a solvent in a variety of consumer products suggest that direct dermal and inhalation exposures may occur during consumer use.

21.3 HUMAN HEALTH CONSIDERATIONS

21.3.1 Animal Studies

21.3.1.1 Carcinogenicity

Xylene (commercial mixture), administered to rats and mice by gavage, has been tested for carcinogenicity by NTP (594); the histopathological results are not yet available. Dosage levels administered were 250 and 500 mg/kg for rats, 500 and 100 mg/kg for mice.

21.3.1.2 Mutagenicity

Xylenes have been tested for mutagenicity in both bacterial and mammalian systems and have shown fairly conclusive evidence for the absence of mutagenic activity. Xylene failed to induce sister chromatid exchange in cultured human lymphocytes (798) and produced no evidence of bone marrow chromosome damage in rats exposed to technical-grade xylene by inhalation at 300 ppm, 6 hours per day, 5 days per week for up to 18 weeks (799). The ortho-, meta- and para-isomers of xylene gave negative results in the Salmonella microsome assay (795). Technical-grade xylene was also inactive in DNA repair assays with E. coli and B. subtilis (796,797). Technical-grade xylene (which contains 18.3% v/v ethyl benzene) did induce a low frequency of recessive lethals in Drosophila; the orth- and meta-isomers of xylene alone, as well as ethyl benzene alone, were negative in this assay (799).

21.3.1.3 Teratogenicity, Embryotoxicity and Reproductive Effects

A study assessing the teratogenicity of the xylene isomers was conducted by Ungvary et al. (212). Rats were exposed by inhalation to 35, 350 or 700 ppm of ortho-, meta-, or para-xylene continuously on days 7 through 14 of gestation. The incidence of visceral, skeletal and external abnormalities was not affected by any of the isomers leading the authors to conclude that xylene was not a teratogen. Decreased fetal development was observed at the highest exposure level for all 3 isomers. This was attributed to the decrease in maternal food intake at that level. Additional groups of rats were exposed to

the same vapor concentrations but only to o-xylene for 2 hours on the 18th day of gestation. The o-xylene was found to cross the placenta and was present in the fetal blood and amniotic fluid.

In a study conducted with CD-1 mice, a commercial mixture of xylene was administered by gavage (in 3 divided doses daily) at dosages of 0, 520, 1030, 2060, 2580, 3100 or 4130 mg/kg/day on days 6-15 of gestation. The commercial mixture, administered in cottonseed oil, consisted of 9.1% o-, 60.2% m-, 13-6% p-xylene and 17% ethyl benzene. No effects were observed in either the dams or fetuses exposed to a level of 1030 mg/kg/day or less. At exposures of 2060 mg/kg/day and higher, doses approaching lethal levels in the dams, fetal weight was significantly decreased and the average percentage of malformed fetuses was increased; cleft palate was the major malformation noted (794).

21.3.1.4 Other Toxicologic Effects

Early animal experiments indicated xylene induced changes in the blood and bone marrow. These older findings have little significance, and have not been reported here, because the xylene used at that time was contaminated with benzene and other hydrocarbons. Recent studies strongly support the conclusion that uncontaminated xylene does not have myelotoxic effects (599).

21.3.1.4.1 Short-term Toxicity

Acute exposure to xylene primarily affects the central nervous system. No signs of CNS impairment were observed in rats and mice after a 4-hour exposure to vapor concentrations ranging from 510 to 800 ppm. Animals exposed to 1350 ppm for 2 hours exhibited poor coordination which disappeared shortly after exposure ceased. Higher concentrations of xylene (7000 ppm), cause initial symptoms of excitement which are followed by depression and death due to respiratory paralysis (70). An LC_{50} value of 500 ppm·4 hr and an oral LD_{50} value of 4300 mg/kg have been reported for rats (47).

Acute liver injury was found in guinea pigs who were administered 1 to 2 g xylene/kg body weight intraperitoneally while rats exposed to vapor concentrations ranging from 1000 to 2000 ppm for 4 hours exhibited hepatotoxic effects which were inferred from increased serum enzyme activities (70).

Corneal vacuoles were observed in cats exposed for several hours to xylene vapor concentrations that were just sublethal. The vacuoles disappeared when xylene exposure was discontinued (599, 19). Two drops of xylene instilled into rabbits' eyes produced slight conjunctival irritation with very slight but transient, corneal injury (19,599).

Repeated application of undiluted xylene to rabbit skin produced moderate irritation and necrosis (12).

21.3.1.4.2 Chronic Toxicity

Studies in animals indicate that xylene has a relatively low toxicity over the long-term. No changes were found in rats, guinea pigs, dogs and monkeys continuously exposed to 80 ppm for 127 days, nor in rats exposed to 700 ppm for 130 days (70). Another investigator reported behavioral changes in rats exposed by inhalation to 300 ppm, 6 hours a day for 5 to 18 weeks (70). Slight inflammation, congestion and necrosis of the kidney tubules were found in rabbits exposed by inhalation to 700 ppm, 8 hours daily, 6 days per week for 130 days (70). Repeated exposure of rabbits to 1150 ppm for 40 to 55 days caused a reversible decrease in red and white blood cell count and an increase in platelets (70).

21.3.2 Human and Epidemiologic Studies

21.3.2.1 Short-term Toxicologic Effects

Xylene has narcotic effects on the central nervous system, variable effects on the liver and kidneys and irritant effects on the gastrointestinal tract (599).

NIOSH reports one incident of an accidental ingestion of a "small amount" of paint thinner composed of xylene (90%) and toluene. Several acetate impurities were also present. There was serological evidence of toxic hepatitis but the victim recovered within 20 days (599).

One fatality has been attributed to the inhalation of xylene vapors. Morley et al. (617) described an incident in which 3 painters were overcome by xylene vapors; the concentration was estimated to be 10,000 ppm. It is not known how long it took the men to lose consciousness because they were not found until 18.5 hours later. An autopsy conducted on one worker who was found dead revealed pulmonary edema, liver congestion and brain hemorrhages. The two surviving workers suffered from amnesia and hepatic impairment; one had evidence of temporary renal impairment. Both recovered within 2 days.

Exposure of human subjects to 90 ppm of m-xylene produced impairment of reaction time, manual coordination and body balance. Although tolerance to these effects developed over one work-week, it was largely lost over a weekend (17).

Brief exposure to 200 ppm causes irritation of the eyes, nose and throat (38). Workers exposed to concentrations above 200 ppm complained of nausea, vomiting, abdominal pain and loss of appetite (9). A recent report noted that artists as well as others who employ felt-tip-marker pens for extended periods of time in enclosed rooms may develop symptoms of nausea, dizziness and headache which can be attributed to xylene exposure; xylene is used as an ink solvent in these products (618).

Xylenes have been reported to cross the human placenta (43). Incomplete brain development has been reported in children whose mothers had been exposed to xylene, toluene and white spirit (59).

Xylene is a skin irritant and causes redness, dryness and defatting. Prolonged skin contact may cause the formation of vesicles (46). Absorption of liquid xylene through intact skin occurs readily and has been estimated to occur at a rate of 4.5-9.6 $mg/cm^2/hr$ (599).

An accidental splash of xylene into the eye causes only transient superficial damage with rapid recovery (19). Corneal vacuoles were reported in workers exposed to "practically pure" xylene vapors (concentration unspecified) for 2-3 days. Recovery occurred 8 to 11 days after exposure ceased. Is not known whether this effect is totally reversible on intermittent exposure or whether it may lead to permanent damage (19,599).

21.3.2.2 Chronic Toxicologic Effects

The effects of long-term xylene exposure resemble those from acute exposure, but more severe. Headache, irritability, fatigue, digestive disorders and sleep disorders have been reported (70). Inhalation of high concentrations of xylene vapors may produce CNS excitation, followed by depression and characterized by paresthesia, tremors, apprehension, impaired memory, weakness, vertigo, headache and anorexia (12). No bone marrow aplasia, but hyperplasia, moderate liver enlargement necrosis and nephrosis may occur (12).

21.3.3 Levels of Concern

In the absence of formal drinking water standards, the USEPA (383) developed Health Advisories for xylene levels in drinking water. They are: 1 day - 12 mg/L; 10 days - 1.4 mg/L; and long-term - 0.62 mg/L.

Both OSHA (298) and the ACGIH (3) have set an occupational exposure limit of 100 ppm (435 mg/m^3) for xylene.

21.3.4 Hazard Assessment

Data on the effects of long-term human exposure to xylene are primarily high-level occupational inhalation exposures which have resulted in CNS effects, incoordination, nausea, vomiting and abdominal pain. Short-term inhalation exposures are associated with narcotic effects on the central nervous sytem. Ingestion data are almost completely lacking.

Studies in laboratory animals suggest xylene has a relatively low chronic toxicity. Some data suggest possible kidney and liver impairment with high level (>1000 ppm) inhalation exposures. No data are currently available regarding the carcinogenic activity of xylene. Available evidence indicates an absence of mutagenic activity for xylene. One study in rats indicated xylene was not a teratogen in that species, while another study in mice indicated an increased incidence of cleft palates but only at doses which approached lethal levels for the dams; ingestion of up to 1030 mg/kg/day produced no adverse effects.

A definitive assessment of the human health hazards associated with long-term, low-level ingestion of xylene cannot be made in the absence of data on carcinogenic potential. However, human experience with xylene in the industrial sector provides no indications of major health concerns associated with xylene exposure.

21.4 SAMPLING AND ANALYSIS CONSIDERATIONS

Determination of the concentrations of xylenes in soil and water requires collection of a representative field sample and laboratory analysis. Due to the volatility xylenes, care is required to prevent losses during sample collection and storage. Soil and water samples should be collected in airtight containers with no headspace; analysis should be completed within 14 days of sampling. In addition to the targeted samples, quality assurance samples such as field blanks, duplicates, and spiked matrices should be included in the analytical program.

Xylenes are not included among the EPA-designated priority pollutants. However, EPA Methods 602, 624, and 1624 (65) would be appropriate methods of choice for the analysis of xylenes in aqueous samples. An inert gas is bubbled through the aqueous sample in a purging chamber at ambient temperature, transferring the xylenes from the aqueous phase to the vapor phase and onto a sorbent trap. The trap is then heated and backflushed to desorb the xylenes and transfer them onto a gas chromatographic (GC) column. The GC column is programmed to separate

I. CHEMICAL IDENTITY

Common name: Coal tar pitch volatiles include coal tar, creosote and coal tar pitch.
Synonyms: 5-Methyl-o-Anisidine; NCI-CO2982; 4-Methyl-2-Aminoanisole
CAS No.: Coal tar—8007-45-2; Coal tar pitch—None; Coal tar distillate—None
Carcinogen: OSHA; ACGIH human

II. REGULATORY INFORMATION

Coal tar pitch volatiles are one of a group of carcinogens or suspected carcinogens strictly controlled under federal regulations (29 CFR 1910.1002). Exposure must be controlled through engineering (design of work buildings and equipment), work practice, and personal protective controls. A restricted work area, respiratory protection, training, emergency plans, medical surveillance, monitoring and measuring, specific reporting and recordkeeping, and warning labels and placards are required. The OSHA standard is published in BNA's **Occupational Safety & Health Reporter** service.
Hazardous substance: N/A
Hazardous waste: N/A
DOT Hazard Class: Coal tar distillate: Combustible liquid

III. PHYSICAL CHARACTERISTICS

Boiling point: Anthracene: 340 C (644F); Phenanthrene: 340 C (644 F); Pyrene: Greater than 360 C (greater than 680 F); Carbazole: 355 C (671 F); Benzo(a)pyrene: Greater than 360 C (greater than 680 F);
Specific gravity: Anthracene:1.24; Phenanthrene: 1.18; Pyrene: 1.28; Carbazole: Greater than 1; Benzo(a)pyrene: Greater than 1;
Vapor density: Anthracene: 6.15; Phenanthrene: 1.18; Pyrene;6.9; Carbazole: 5.8; Benzo(a)pyrene: 8.7
Melting point: Anthracene: 217 C (423 F); Phenanthrene: 100.5 C ((213 F); Pyrene: 150.4 C (303 F); Carbazole: 246 C (475 F); Benzo(a)pyrene: 179 C (354 F)
Vapor pressure: Anthracene: Less than 1 mm Hg; Phenanthrene: Less than 1 mm Hg; Pyrene: Less than 1 mm Hg; Carbazole: Less than 1 mm Hg; Benzo(a)pyrene: Less than 1 mm Hg
Solubility in water: Anthracene: Insoluble; Phenanthrene: Insoluble; Pyrene: Insoluble; Carbazole: Insoluble; Benzo(a)pyrene: Insoluble
Evaporat[illegible] rate: Anthracene: N/A; Phenanthrene: N/A; Pyrene:N[illegible], Carbazole: N/A; Benzo(a)pyrene: N/A

Appearance and odor: Anthracene: Pale green solid with faint aromatic odor; Phenanthrene: Colorless solid with a faint aromatic odor; Pyrene: Bright yellow solid; Carbazole: Colorless solid with faint aromatic odor; Benzo(a)pyrene: Colorless solid with a faint aromatic odor.

IV. PHYSICAL HAZARDS

Flash point: Anthracene: 121 C (250 F); Others: Data not available
Autoignition temperature: Anthracene: 540 C (1004 F); Others: Data not available
Flammable limits in air (% by vol.): Anthracene: Lower: 0.6; Others: Data not available
Extinguishants: Foam, dry chemical, and carbon dioxide

V. HEALTH HAZARDS

Affects the respiratory system, lungs, bladder, kidneys, and skin.

VI. EMERGENCY FIRST AID

Eyes: Wash with large amounts of water, lifting the lids occasionally.
Skin: Wash with water and soap.
Breathing: Move patient to fresh air. Perform artificial respiration if needed. Keep patient warm and at rest. Get medical attention as soon as possible.

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA TWA: 0.1 mg/m^3 of the cyclohexane-extractable fraction of a sample determined as a time weighted average concentration for up to a 10-hour workshift in a 40-hour workweek.
ACGIH TLV: 0.2 mg/m^3 of the benzene-soluble fraction

VIII. PRECAUTIONS FOR USE AND SAFE HANDLING

Conditions contributing to instability: None hazardous
Incompatibilities: Strong oxidizers
Special precautions: None

IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

Incineration

X. PROTECTIVE EQUIPMENT

Impervious clothing, gloves, face shields (eight-inch minimum) to prevent prolonged or repeated skin contact. Contaminated clothing should be placed in closed containers pending disposal or cleaning. Splash-proof safety goggles where there is danger of eye contact.

Respirators–

2 mg/m^3: CCROVFuHiE;SA;SCBA
10 mg/m^3: CCROVFFuHiE;GMOVFFuHiE;SAF;SCBAF
200 mg/m^3: SA:PD, PP, CF;PAPCCROVHiEP
400 mg/m^3: SAF:PD,PP,CF
Escape: GMOVPest;SCBA

I. CHEMICAL IDENTITY

Common name: Cresol (all isomers)
Formula: $CH_3C_6H_4OH$
Synonyms: Cresylic acid; hydroxytoluene
CAS No.: o= 95-48-7; m= 108-39-4; p= 106-44-5
Carcinogen: N/A

II. REGULATORY INFORMATION

Hazardous substance: EPA
Hazardous waste: EPA
DOT Hazard Class: Corrosive material

III. PHYSICAL CHARACTERISTICS

Boiling point: o= 191 C (376 F); m= 202 C (396 F) (ignites); p= 202 C (396 F)
Specific gravity: o=1.05; m=p= 1.04
Vapor density: o= 3.72; m= 3.72; p= 3.72
Melting point: o= 30 C (86 F); m= 11 C (52 F); p= 35.5 C (95.9 F)
Vapor pressure (mm Hg): At 25 C, o= 5; m=p= 5
Solubility in water: At 25 C, o= 31 ppm; m= 235 ppm; p= 24 ppm
Evaporation rate: Data not available
Appearance and odor: Sweet, tarry odor; colorless

IV. PHYSICAL HAZARDS

Flash point: o= 81 C (178 F); m= 86 C (187 F); p= 86 C (187 F)
Autoignition temperature: o= m= p= 559 C (1038 F)
Flammable limits in air (% by vol.): o= Lower: 1.35; m= Lower: 1.06; Upper: 1.35; p= Lower: 1.06; Upper: 1.4
Extinguishants: Carbon dioxide, dry chemical, foam, water spray

V. HEALTH HAZARDS

Toxic by inhalation, skin absorption, ingestion. May cause skin irritation or be extremely corrosive to body tissue (including eyes); causes severely destructive burns if not removed promptly and completely. Burns may go unnoticed for a time. May lead to liver and kidney damage.

VI. EMERGENCY FIRST AID

Eyes: Wash with large amounts of water, lifting the lids occasionally. Get medical attention as soon as possible.
Skin: Wash very thoroughly with soap or mild detergent. Remove contaminated clothing. Get medical attention immediately.

Breathing: Move patient to fresh air. Perform artificial respiration if needed. Keep patient warm and at rest. Get medical attention as soon as possible.
Swallowing: Get medical attention immediately. Give large quantities of water, and then induce vomiting (mechanically with finger).

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA TWA: 5 ppm with ACGIH skin caution

VIII. SPILL, LEAK, AND DISPOSAL PROCEDURES

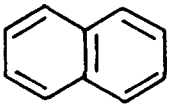
Persons not wearing protective equipment and clothing should stay out of spill area. May be atomized in a suitable combustion chamber.

IX. PROTECTIVE EQUIPMENT

Impervious clothing, gloves, face shields (eight-inch minimum) to prevent any possibility of skin contact. Remove contaminated clothing immediately. Contaminated clothing should be placed in closed containers pending disposal or cleaning. Clothing should be changed daily if there is a possibility of contamination. Splash-proof safety goggles required where there is danger of eye contact. Emergency showers and eye-wash fountains should be provided in the immediate workplace.

Respirators–

<50 ppm: CCROVFDM; SA; SCBA
<250 ppm: CCROVFDM; GMOVDM; SAF; SCBAF
Escape: GMOVP; escape SCBA.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
Naphthene White tar Tar camphor Mothballs	91-20-3 NIOSH NO.: QJ0525000	$C_{10}H_8$	5.24 mg/m³ ≅ 1 ppm 0.191 ppm ≅ 1 mg/m³
	STRUCTURE: 		MOLECULAR WEIGHT: 128.16

REACTIVITY	Naphthalene may generate heat, react vigorously, and possibly ignite or explode in contact with oxidizing mineral acids or other strong oxidizing agents (511,505).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): volatile crystalline flakes	(23)
	• Color: white	(23)
	• Odor: "moth balls" or coal tar	(54,59)
	• Odor Threshold: 0.084 ppm	(384)
	• Liquid Density (g/ml at 20°C): 1.145	(14)
	• Freezing/Melting Point (°C): 80.2	(23)
	• Boiling Point (°C): 218	(23)
	• Flash Point (°C): 79 (closed cup)	(21)
	• Flammable Limits in Air, % by Volume: 0.9-5.9	(51,38,506)
	• Autoignition Temperature (°C): 526-567	(51,38,506)
	• Vapor Pressure (mm Hg at 20°C): 0.053	(30)
	• Saturated Concentration in Air (mg/m³ at 20°C): 375	(ADL estim)
	• Solubility in Water (mg/L at 20°C): 31.7	(440)
	• Viscosity (cp): 0.754 at 100°C	(21)
	• Surface Tension (dyne/cm): 31.8 at 100°C	(59)
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 3.30	(29)
	• Soil Adsorption Coefficient, K_{oc}: 962	(652)
	• Henry's Law Constant (atm·m³/mol at 25°C): 4.82×10^{-4}	(74)
	• Bioconcentration Factor: 44 (blue mussel), 77 (sand dab); 95 (estim)	(439,659)

PERSISTENCE IN THE SOIL-WATER SYSTEM	Naphthalene is expected to be fairly mobile in the soil/ground-water system. Transport with infiltrating water is expected to be important, particularly in sandy soils and soils of low organic content. Volatilization may be important at the surface. Biodegradation has been shown to occur with acclimated microbial populations and under aerobic conditions; biodegradation in natural soils and ground water is not expected to be significant.

PATHWAYS OF EXPOSURE	The primary pathway of concern from the soil-water system is the migration of naphthalene to ground-water drinking water supplies. There is some evidence that migration from disposal sites to ground water and surface water has occurred in the past. Inhalation exposures resulting from volatilization from surface soils may also occur.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (54): Ingestion or inhalation of naphthalene causes eye irritation, headache, nausea, vomiting, sweating and abdominal pain. Skin contact may cause redness and dermatitis. Both the vapor and the solid are irritating to the eye.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral [rat] 1780 (59) skin -- no data; LCLo (mg/m^3) inhalation -- no data
	Long-Term Effects: No significant changes
	Pregnancy/Neonate Data: Negative
	Mutation Data: Negative
	Carcinogenicity Classification: NTP - none assigned; IARC - none assigned

HANDLING PRECAUTIONS (38)	Handle chemical only with adequate ventilation • Vapor concentrations of 10-500 ppm: any supplied-air respirator or self-contained breathing apparatus with full facepiece; chemical cartridge respirator with full facepiece, organic vapor cartridge and dust filter • Above 500 ppm: self-contained breathing apparatus with full facepiece operated in positive-pressure mode o Chemical goggles if there is probability of eye contact • Protective clothing to prevent prolonged or repeated skin contact.

EMERGENCY FIRST AID TREATMENT (54)	Ingestion: Induce vomiting if victim is conscious • Inhalation: Move victim to fresh air. Give artificial respiration if necessary • Skin: Remove contaminated clothing. Wash skin with soap and water • Eye: Irrigate with large amounts of water.

Personal Protective Methods: Wear appropriate clothing to prevent any reasonable probability of skin contact. Wear eye protection to prevent any possibility of eye contact. Employees should wash immediately when skin is wet or contaminated. Work clothing should be changed daily if it is possible that clothing is contaminated. Remove nonimpervious clothing immediately if wet or contaminated. Provide emergency eyewash.

Respirator Selection:

15 mg/m^3: DMSXPest
30 mg/m^3: DMXSQPest/FuHiEP/SA/SCBA
150 mg/m^3: HiEPF/SAF/SCBAF
1,800 mg/m^3: PAPHiE/SA:PD,PP
Escape: DMXS/SCBA

Disposal Method Suggested: This pesticide is more stable to hydrolysis than dichlorvos (50% hydrolysis at pH 9 at 37.5°C in 301 minutes). It is unstable in alkaline conditions, in presence of iron, and is degraded by sunlight. About 10% hydrolysis per day is obtained in ambient water (A-32).

References

(1) U.S. Environmental Protection Agency, *Investigation of Selected Potential Environmental Contaminants: Haloalkyl Phosphates*, Report EPA 560/2-76-007, Wash., DC (Aug. 1976).
(2) United Nations Environment Programme, *IRPTC Legal File 1983*, Vol. II, pp VII/549-50, Geneva, Switzerland, International Register of Potentially Toxic Chemicals (1984).

NAPHTHALENE

- Hazardous substance (EPA)
- Hazardous waste (EPA)
- Priority toxic pollutant (EPA)

Description: $C_{10}H_8$, naphthalene, is a white crystalline solid with a characteristic "moth ball" odor. It melts at 74° to 80°C and boils at 218°C.

Code Numbers: CAS 91-20-3 RTECS QJ0525000 UN 1334 and 2304 (molten)

DOT Designation: ORM-A.

Synonyms: Naphthalin, moth flake, tar camphor, white tar, moth balls.

Potential Exposures: Naphthalene is used as a chemical intermediate or feedstock for synthesis of phthalic, anthranilic, hydroxyl (naphthols), amino (naphthylamines), and sulfonic compounds which are used in the manufacture of various dyes. Naphthalene is also used in the manufacture of hydronaphthalenes, synthetic resins, lampblack, smokeless powder, and celluloid. Naphthalene has been used as a moth repellent.

Approximately 100 million people worldwide have G6PD deficiency which would make them more susceptible to hemolytic anemia on exposure to naphthalene. At present, more than 80 variants of this enzyme deficiency have been identified. The incidence of this deficiency is 0.1% in American and European Caucasians, but can range as high as 20% in American blacks and greater than 50% in certain Jewish groups.

Newborn infants have a similar sensitivity to the hemolytic effects of naphthalene, even without G6PD deficiency.

Incompatibilities: Strong oxidizers.

Permissible Exposure Limits in Air: The Federal standard and the ACGIH (1983/84) TWA value is 10 ppm (50 mg/m^3). The STEL value is 15 ppm (75 mg/m^3). The IDLH level is 500 ppm.

Determination in Air: Adsorption on charcoal, workup with CS_2, analysis by gas chromatography. See NIOSH Methods, Set T. See also reference (A-10).

Permissible Concentration in Water: To protect freshwater aquatic life–2,300 µg/ℓ on an acute toxicity basis and 620 µg/ℓ on a chronic basis. To protect saltwater aquatic life–2,350 µg/ℓ on an acute toxicity basis. For the protection of human health from the toxic properties of naphthalene ingested through water and through contaminated aquatic organisms, no ambient water criterion has been set due to insufficient data.

Determination in Water: Methylene chloride extraction followed by high pressure liquid chromatography with fluorescence or UV detection; or gas chromatography (EPA Method 610) or gas chromatography plus mass spectrometry (EPA Method 625).

Routes of Entry: Inhalation of vapor or dust, skin absorption, ingestion, skin and eye contact.

Harmful Effects and Symptoms: *Local* – Naphthalene is a primary irritant and causes erythema and dermatitis upon repeated contact. It is also an allergen and may produce dermatitis in hypersensitive individuals. Direct eye contact with the dust has produced irritation and cataracts.

Systemic – Inhaling high concentrations of naphthalene vapor or ingesting may cause intravascular hemolysis and its consequences. Initial symptoms include eye irritation, headache, confusion, excitement, malaise, profuse sweating, nausea, vomiting, abdominal pain, and irritation of the bladder.

There may be progressive jaundice, hematuria, hemoglobinuria, renal tubular blockage, and acute renal shutdown. Hematologic features include red cell fragmentation, icterus, severe anemia with nucleated red cells, leukocytosis, and dramatic decreases in hemoglobin, hematocrit, and red cell count. Individuals with a deficiency of glucose-6-phosphate dehydrogenase in erythrocytes are more susceptible to hemolysis by naphthalene.

Points of Attack: Eyes, blood, liver, kidneys, skin, red blood cells, central nervous system.

Medical Surveillance: Consider eyes, skin, blood, liver, and renal function in placement and follow-up examinations. Low erythrocyte glucose-6-phosphate dehydrogenase increases risk.

First Aid: If this chemical gets into the eyes, irrigate immediately. If molten naphthalene contacts the skin, flush with water immediately. Wash promptly after solution contact. If a person breathes in large amounts of this chemical move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of water and induce vomiting. Do not make an unconscious person vomit.

Personal Protective Methods: Wear appropriate clothing to prevent repeated or prolonged skin contact. Wear eye protection to prevent any reasonable probability of eye contact. Employees should wash promptly when skin is wet or contaminated. Work clothing should be changed daily if it is possible that clothing is contaminated. Remove nonimpervious clothing promptly if wet or contaminated.

Respirator Selection:

500 ppm: CCROVD/GMOVD/SAF/SCBAF
Escape: GMOVP/SCBA

Disposal Method Suggested: Incineration.

References

(1) U.S. Environmental Protection Agency, *Naphthalene: Ambient Water Quality Criteria*, Wash., DC (1980).
(2) Nat. Inst. for Occup. Safety and Health, *Profiles on Occupational Hazards for Criteria Document Priorities: Naphthalene*, pp 269-273, Report PB-274,073, Cincinnati, Ohio (1977).
(3) U.S. Environmental Protection Agency, *Naphthalene*, Health and Environmental Effects Profile No. 131, Wash., DC, Office of Solid Waste (April 30, 1980).
(4) See Reference (A-61).
(5) See Reference (A-60).
(6) Parmeggiani, L., Ed., *Encyclopedia of Occupational Health & Safety*, Third Edition, Vol. 2, pp 1425-26, Geneva, International Labour Office (1983).

NAPHTHAS

Description: Naphthas derived from both petroleum and coal tar are included in this group.

Petroleum naphthas are composed principally of aliphatic hydrocarbons and are termed "close-cut" fractions. "Medium-range" and "wide-range" fractions are made up of 40 to 80% aliphatic hydrocarbons, 25 to 50% naphthenic hydrocarbons, 0 to 10% benzene, and 0 to 20% other aromatic hydrocarbons.

Coal tar naphtha is a mixture of aromatic hydrocarbons, principally toluene, xylene, and cumene. Benzene, however, is present in appreciable amounts in those coal tar naphthas with low boiling points. Rubber solvent naphtha boils at 75° to 110°C, and coal tar naphtha at 160° to 220°C.

Code Numbers: CAS 8030-30-6 RTECS DE3030000 UN 1255 (petroleum) UN 2553 (coal tar) UN 1256 (solvent)

DOT Designation: Combustible liquid.

Synonyms: Coal tar naphtha–naphtha, 49° Bé-coal tar type; crude solvent coal tar naphtha; high solvent naphtha. Petroleum naphtha–aliphatic petroleum naphtha; petroleum ether (95° to 115°C); naphtha, petroleum, ligroin, benzine.

Potential Exposures: Naphthas are used as organic solvents for dissolving or softening rubber, oils, greases, bituminous paints, varnishes, and plastics. The less flammable fractions are used in dry cleaning, the heavy naphthas serving as bases for insecticides.

Incompatibilities: Strong oxidizers.

Permissible Exposure Limits in Air: The Federal standard for petroleum naphtha is 500 ppm (2,000 mg/m^3); for coal tar naphtha it is 100 ppm (400 mg/m^3). NIOSH (1980) has recommended a TWA for petroleum naphtha of 350 mg/m^3 and for rubber solvent naphtha 400 ppm (1,600 mg/m^3); ACGIH (1983/84) gives these same values for rubber solvent naphtha. ACGIH gives a TWA of 300 ppm (1,350 mg/m^3) and an STEL of 400 ppm (1,800 mg/m^3) for VM & P (varnish makers' and painters' naphtha). The IDLH levels for both types of naphtha is 10,000 ppm.

Determination in Air: Charcoal adsorption, workup with CS_2, analysis by gas chromatography. See NIOSH Methods, Set G. See also reference (A-10).

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation of vapor, ingestion, skin and eye contact. Percutaneous absorption of liquid is probably not important in development of systemic effects unless benzene is present.

Harmful Effects and Symptoms: *Local* – The naphthas are irritating to the skin, conjunctiva, and the mucous membranes of the upper respiratory tract. Skin "chapping" and photosensitivity may develop after repeated contact with the liquid. If confined against skin by clothing, the naphthas may cause skin burn.

Systemic – Petroleum naphtha has a lower order of toxicity than that derived from coal tar, where the major hazard is brought about by the aromatic hydrocarbon content. Sufficient quantities of both naphthas cause central nervous system depression. Symptoms include inebriation, followed by headache and nausea. In severe cases, dizziness, convulsions, and unconsciousness occasionally result. Symptoms of anorexia and nervousness have been reported to persist for several months following an acute overexposure, but this appears to be rare. One fraction, hexane, has been reported to have been associated with peripheral neuropathy. (See Hexane.) If benzene is present, coal tar naphthas may produce blood changes such as leukopenia, aplastic anemia, or leukemia. The kidneys and spleen have also been affected in animal experiments. (See Benzene.)

Points of Attack: Respiratory system, eyes and skin (and central nervous system in the case of petroleum naphthas).

Medical Surveillance: Preplacement and periodic medical examination should include the central nervous system. If benzene exposure is present, workers should have a periodic complete blood count (CBC) including hematocrit, hemoglobin, white blood cell count and differential count, mean corpuscular volume and platelet count, reticulocyte count, serum bilirubin determination and urinary phenol in the preplacement examination and at 3-month intervals. There are no specific diagnostic tests for naphtha exposure but urinary phenols may indicate exposure to aromatic hydrocarbons. It should be noted that benzene content of vapor may be higher than predicted by content in the liquid.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, wash with soap promptly. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Do not induce vomiting.

Personal Protective Methods: Wear appropriate clothing to prevent repeated or prolonged skin contact. Wear eye protection to prevent any reasonable probability of eye contact. Employees should wash promptly when skin is wet or contaminated. Remove clothing immediately if wet or contaminated to avoid flammability hazard.

Respirator Selection:

Coal tar naphtha:
1,000 ppm: CCROVF
5,000 ppm: GMOV/SAF/SCBAF
10,000 ppm: SAF:PD,PP,CF
Escape: GMOV/SCBA

CHEMICAL NAME
PHENOL

FORMULA
C6H6O

SYNONYMS
CARBOLIC ACID
MONOHYDROXYBENZENE
NCI-C50124
PHENYLHYDROXIDE
UN 1671
BAKER'S P AND S LIQUID AND OINTMENT
HYDROXYBENZENE
OXYBENZENE
PHENIC ACID
PHENYL HYDRATE
PHENYL HYDROXIDE
PHENYLIC ACID
PHENYLIC ALCOHOL
IZAL
PHENYL ALCOHOL
OHS18380

PERMISSIBLE EXPOSURE LIMIT
5 PPM OSHA TWA (SKIN NOTATION); 5 PPM ACGIH TWA (SKIN NOTATION)
20 MG/M3 NIOSH RECOMMENDED TWA;60 MG/M3 NIOSH RECOMMENDED 15 MIN CEILING
NEGATIVE CARCINOGEN IN RATS/MICE (NCI, TR 203)
TERATOGENIC DATA (RTEC); MUTAGENIC DATA (RTEC)
AQUATIC TOXICITY RATING 2/T (TLM96 10 - 100 PPM)
TLM96 - FINGERLING CHANNEL CATFISH 16.7 PPM, BLUEGILL 23.88 PPM, FATHEAD 32 PPM, GUPPY 39.19 PPM, GAMBUSIA AFFINIS 56 PPM
TLM48 - SALMO GAIRDNERII 9.3 PPM, PINK SHRIMP 17.5 PPM, BROWN SHRIMP 23.5 PPM, COCKLE 500 PPM, FLOUNDER 33-100 PPM, SHORE CRAB 56 PPM, RASBORA HETEROMORPHA 6.8 PPM, DAPHNIA MAGNA 16 PPM
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 2 - REACTIVITY 0 - PERSISTENCE 1

TOXICOLOGY: PHENOL IS AN EYE AND MUCOUS MEMBRANE IRRITANT, PRIMARY SKIN IRRITANT, AND CONVULSANT.

ACUTE POISONING CAUSES EYE IRRITATION, DIZZINESS, HEADACHE, DELIRIUM, SWEATING, AND BREATHING DIFFICULTY. OTHER SIGNS ARE THIRST, NAUSEA AND VOMITING, DIARRHEA, CYANOSIS AND EXCITEMENT. SEVERE POISONING PRODUCES MUSCULAR WEAKNESS, STUPOR, HYPOTENSION, HEMOLYSIS, CONVULSIONS, COMA, AND PULMONARY EDEMA. DEATH MAY OCCUR IMMEDIATELY FROM RESPIRATORY FAILURE, OR LATER FROM LIVER DAMAGE OR ANURIA. INHALATION IS UNLIKELY DUE TO THE LOW VAPOR PRESSURE OF PHENOL.

CHRONIC EXPOSURE CREATES SYMPTOMS SIMILAR TO THAT OF ACUTE POISONING.

SKIN CONTACT DESTROYS THE BLOOD SUPPLY, CAUSING TINGLING AND LOSS OF FEELING. SKIN SENSITIVITY REACTIONS HAVE OCCASIONALLY OCCURRED. EYE CONTACT CAUSES SEVERE CORNEAL INJURY.

THE THRESHOLD LIMIT VALUE WAS SET TO PREVENT SYSTEMIC POISONING IF SKIN ABSORPTION IS AVOIDED.

ORL-HMN LDLO:140 MG/KG
ORL-RAT LD50:414 MG/KG
ORL-MUS LD50:300 MG/KG
IHL-RAT LC50:316 MG/M3
IHL-MUS LC50:177 MG/M3

IHL-MAM LC50: 74 MG/M3
SKN-RAT LD50:669 MG/KG
SKN-RBT LD50:850 MG/KG

IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONCENTRATION
100 PPM
OSHA/NIOSH

PHYSICAL DESCRIPTION
WHITE, CRYSTALLINE MASS WHICH TURNS PINK OR RED IF NOT PERFECTLY PURE OR IF UNDER THE INFLUENCE OF LIGHT; DISTINCTIVE ODOR, SHARP BURNING TASTE. WHEN IN VERY WEAK SOLUTION IT HAS A SWEETISH TASTE.

CHEMICAL AND PHYSICAL PROPERTIES
MOLECULAR WEIGHT: 94
BOILING POINT AT 1 ATM, F: 359 F
SOLUBILITY IN WATER, G/100 G WATER AT 20C: 8.4%
FLASH POINT, CLOSED CUP, F (OR OPEN CUP IF 0C): 175F
VAPOR PRESSURE @ 20 C, MMHG: 0.36 MM
MELTING POINT, F: 109 F
UPPER EXPLOSIVE LIMIT IN AIR, % BY VOLUME: 8.6%
LOWER EXPLOSIVE LIMIT IN AIR, % BY VOLUME: 1.8%
AUTOIGNITION TEMPERATURE: 1319 F
SPECIFIC GRAVITY: 1.0576
VAPOR DENSITY (AIR=1): 3.2
ODOR THRESHOLD: 0.05 PPM
OCTANOL/WATER PARTITION COEFFICIENT: 1.46

INCOMPATIBILITIES
STRONG OXIDIZERS
CALCIUM HYPOCHLORITE

PERSONAL PROTECTIVE EQUIPMENT
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":

EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT ANY POSSIBLITY OF SKIN CONTACT WITH THIS SUBSTANCE. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).

EMPLOYERS SHALL ENSURE THAT CLOTHING WHICH HAS HAD ANY POSSIBILITY OF BEING CONTAMINATED WITH THIS SUBSTANCE IS PLACED IN CLOSED CONTAINERS FOR STORAGE UNTIL IT CAN BE DISCARDED OR UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF THE CONTAMINANT FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE CONTAMINANT, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE OPERATION OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.

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ACGIH "GUIDELINES FOR THE SELECTION OF CHEMICAL PROTECTIVE CLOTHING" INDICATES THE FOLLOWING PROTECTIVE RATINGS FOR MATERIALS COMMONLY USED FOR PROTECTIVE CLOTHING. THESE RATINGS ARE BASED PRIMARILY ON QUANTITATIVE TEST RESULTS AND QUALITATIVE RESISTANCE INFORMATION. (THE RECOMMENDATIONS APPLY TO THE PURE SUBSTANCE ONLY; BREAKTHROUGH-TIME MAY VARY FOR MIXTURES.)

PHENOL:
EXCELLENT/GOOD:
BUTYL RUBBER
NEOPRENE

GOOD/FAIR:
NATURAL RUBBER
NEOPRENE/NATURAL RUBBER
POLYETHYLENE
CHLORINATED POLYETHYLENE

FAIR/GOOD:
NITRILE/POLYVINYL CHLORIDE
POLYURETHANE
STYRENE-BUTADIENE RUBBER
VITON

FAIR/POOR:
NITRILE
POLYVINYL ALCOHOL
POLYVINYL CHLORIDE

PHENOL, <30%
EXCELLENT/GOOD:
NONE INDICATED

GOOD/FAIR:
POLYETHYLENE
CHLORINATED POLYETHYLENE
POLYVINYL CHLORIDE

GOGGLES
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":

EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE DUST-RESISTANT SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THERE IS ANY POSSIBILTY OF THIS SOLID CONTACTING THE EYES.

WASHING CHEMICALS FROM THE SKIN
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":

EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE IMMEDIATELY WASH OR SHOWER WITH SOAP OR MILD DETERGENT AND WATER TO REMOVE ANY CONTAMINANT FROM THE SKIN.

EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHO HANDLE THIS SUBSTANCE WASH THEIR HANDS THOROUGHLY WITH SOAP OR MILD DETERGENT AND WATER BEFORE EATING, SMOKING, OR USING TOILET FACILITIES.

ROUTINE CHANGING OF WORK CLOTHING
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":

EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE CLOTHING HAS HAD ANY POSSIBILITY OF BEING CONTAMINATED WITH THIS SUBSTANCE CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

CLOTHING REMOVAL FOLLOWING ACCIDENTAL CONTAMINATION
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":

EMPLOYERS SHALL ENSURE THAT NON-IMPERVIOUS CLOTHING WHICH BECOMES CONTAMINATED WITH THIS SUBSTANCE BE REMOVED IMMEDIATELY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.
EMPLOYERS SHALL ENSURE THAT ANY CLOTHING WHICH BECOMES WET WITH THIS FLAMMABLE LIQUID BE REMOVED IMMEDIATELY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

SPECIFIC EMERGENCY PROVISIONS
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":

WHERE THERE IS ANY POSSIBILITY OF EXPOSURE OF AN EMPLOYEE'S BODY TO THIS SUBSTANCE, EMPLOYERS SHALL PROVIDE FACILITIES FOR QUICK DRENCHING OF THE BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

WHERE THERE IS ANY POSSIBILITY THAT AN EMPLOYEE'S EYES MAY BE EXPOSED TO THIS SUBSTANCE, EMPLOYERS SHALL PROVIDE AN EYE-WASH FOUNTAIN WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

EMPLOYERS SHALL ENSURE THAT EMPLOYEES DO NOT EAT OR SMOKE IN AREAS WHERE THIS SUBSTANCE IS HANDLED, PROCESSED OR STORED.

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED)

50 PPM
- CHEMICAL CARTRIDGE RESPIRATOR
  WITH AN ORGANIC VAPOR CARTRIDGE
  WITH A DUST AND MIST FILTER
- SUPPLIED-AIR RESPIRATOR
- SELF-CONTAINED BREATHING APPARATUS

100 PPM
- CHEMICAL CARTRIDGE RESPIRATOR
  WITH AN ORGANIC VAPOR CARTRIDGE
  WITH A FULL FACE-PIECE
  WITH A DUST AND MIST FILTER
- GAS MASK
  WITH AN ORGANIC VAPOR CANISTER
  WITH A DUST AND MIST FILTER
- SUPPLIED-AIR RESPIRATOR
  WITH A FULL FACE-PIECE, HELMENT, OR HOOD
- SELF-CONTAINED BREATHING APPARATUS
  WITH A FULL FACE-PIECE

ESCAPE
- GAS MASK
  WITH AN ORGANIC VAPOR CANISTER
  WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- SELF-CONTAINED BREATHING APPARATUS

FIREIFGHTING
- SELF-CONTAINED BREATHING APPARATUS
  WITH A FULL FACE-PIECE
  OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

ROUTE OF ENTRY INTO BODY
SKIN ABSORPTION
INGESTION
SKIN OR EYE CONTACT
INHALATION

SYMPTOMS
EYE IRRITATION
NASAL IRRITATION
PHARYNGITIS
THIRST
SWEATING
DIARRHEA
WEAKNESS
METHEMOGLOBINEMIA
CYANOSIS
EXCITATION
SKIN BURNS
STUPOR
NAUSEA
VOMITING
HYPOTENSION
CENTRAL NERVOUS SYSTEM DEPRESSION
PANCREATITIS
SPLEEN DAMAGE
KIDNEY DAMAGE
LIVER DAMAGE
RESPIRATORY FAILURE
SHOCK
COLLAPSE
COMATOSE
CONVULSIONS
ABDOMINAL PAIN
CONJUNCTIVITIS
HEMOLYSIS
RESPIRATORY EDEMA
PNEUMONIA
JAUNDICE
OLIGURIA
ANURIA
HEMATURIA
PROTEINURIA
ACIDOSIS
ALKALOSIS
GANGRENE
ANOREXIA
WEIGHT LOSS
OCHRONOSIS
CACHEXIA
CORNEAL DAMAGE
TREMORS
HEADACHE

EUPHORIA
TINNITUS
VERTIGO
TACHYCARDIA
REPRODUCTIVE EFFECTS IN EXPERIMENTAL ANIMALS

FIRST AID PROCEDURES FOLLOWING EXPOSURE

IF THIS CHEMICAL GETS INTO THE EYES, IMMEDIATELY WASH THE EYES WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING THE LOWER AND UPPER LIDS. GET MEDICAL ATTENTION IMMEDIATELY. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS CHEMICAL.

IF THIS CHEMICAL GETS ON THE SKIN, IMMEDIATELY WASH CONTAMINATED SKIN WITH SOAP OR MILD DETERGENT & WATER. IF THIS CHEMICAL SOAKS CLOTHING, IMMEDIATELY REMOVE CLOTHING & WASH SKIN WITH SOAP OR MILD DETERGENT & WATER. GET MEDICAL ATTENTION PROMPTLY.

IF THIS CHEMICAL GETS ON SKIN, IMMEDIATELY FLUSH CONTAMINATED SKIN WITH WATER. IF THIS CHEMICAL PENETRATES CLOTHING, IMMEDIATELY REMOVE THE CLOTHING AND FLUSH THE SKIN WITH WATER. GET MEDICAL ATTENTION PROMPTLY.

WHEN THIS CHEMICAL HAS BEEN SWALLOWED, IMMEDIATELY GET MEDICAL ATTENTION. IF MEDICAL ATTENTION IS NOT IMMEDIATELY AVAILABLE, GET THE AFFECTED PERSON TO VOMIT BY HAVING HIM TOUCH THE BACK OF HIS THROAT WITH HIS FINGER OR BY GIVING HIM SYRUP OF IPECAC AS DIRECTED ON PACKAGE. THIS NON-PRESCRIPTION DRUG SHOULD BE KEPT WITH EMERGENCY MEDICAL SUPPLIES IN THE WORKPLACE AND IS AVAILABLE AT MOST DRUG COUNTERS. DO NOT MAKE AN UNCONSCIOUS PERSON VOMIT.

IF THIS PHENOLIC COMPOUND IS SWALLOWED, IMMEDIATELY ADMINISTER ACTIVATED CHARCOAL AT A DOSAGE 5 TO 10 TIMES THE ESTIMATED WEIGHT OF THE SUBSTANCE INGESTED OR AT LEAST 30 GRAMS OF ACTIVATED CHARCOAL DISSOLVED IN WATER. DILUTE STOMACH CONTENTS WITH WATER OR MILK. CASTOR OIL (30 TO 60 ML) MAY BE ADMINISTERED TO REDUCE ABSORPTION OF CHEMICAL.

SYRUP OF IPECAC - GIVE 15 ML (ONE TABLESPOON) OF SYRUP OF IPECAC FOLLOWED BY ONE-HALF GLASS OF WATER. IF EMESIS DOES NOT OCCUR IN THIRTY MINUTES, REPEAT WITH SAME DOSE. IF PATIENT MUST BE MOVED, KEEP IN HEAD-DOWN POSITION TO FACILITATE EMESIS AND PREVENT ASPIRATION OF VOMITUS. IF EMESIS DOES NOT OCCUR AFTER SYRUP OF IPECAC IS GIVEN, PERFORM GASTRIC LAVAGE TO PREVENT EMETINE POISONING. SAVE SPECIMENS OF EMESIS FOR ANALYSIS.
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

METHEMOGLOBINEMIA - GIVE 100% OXYGEN BY MASK IF PATIENT SHOWS SIGNS OF DYSPNEA OR AIR HUNGER. REMOVE POISON BY GASTRIC LAVAGE OR EMESIS FOLLOWED BY CATHR0IS. WASH SKIN THOROUGHLY WITH SOAP AND WATER. GIVE METHYLENE BLUE, 1% SOLUTION, 0.1 ML/KG INTRAVENOUSLY OVER A 10 MINUTE PERIOD. ADMINISTRATION OF METHYLENE BLUE MAY CAUSE HYPERTENSION, NAUSEA, AND DIZZINESS. LARGER DOSES (>500 MG) WILL CAUSE VOMITING, DIARRHEA, CHEST PAIN, MENTAL CONFUSION, CYANOSIS, AND SWEATING. HEMOLYTIC ANEMIA HAS OCCURED SEVERAL DAYS AFTER ADMINISTRATION. IF METHYLENE BLUE IS NOT AVAILABLE, GIVE ASCORBIC ACID, 1 G SLOWLY INTRAVENOUSLY.
(ANTIDOTE MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL)
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

LIVER DAMAGE - REMOVE FROM EXPOSURE TO ALL CHEMICALS AND DRUGS. MAINTAIN COMPLETE BED REST. AVOID ANESTHESIA OR SURGICAL PROCEDURES. AVOID DEHYDRATION OR OVERHYVrCTION. IF VOMITING SEVERE AND ORAL FLUIDS NOT

RETAINED, REPLACE VOMITUS WITH AN EQUAL QUANTITY OF 100% DEXTROSE IN NORMAL SALINE. IN RENAL FUNCTION ADEQUATE, GIVE 1 LITER OF 5% DEXTROSE OR INVERT SUGAR IN NORMAL SALINE PLUS 1-3 LITERS OF 10% DEXTROSE OR INVERT SUGAR IN DISTILLED WATER INTRAVENOUSLY EVERY TWENTY-FOUR HOURS.
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

ACUTE RENAL FAILURE - TREAT SHOCK. FOR HEMOLYTIC REACTIONS, GIVE SODIUM BICARONATE, 5 G EVERY 1-2 HOURS AS NECESSARY TO MAINTAIN AN ALKALINE URINE.
(MEDICATION MUST BE GIVEN BE QUALIFIED MEDICAL PERSONNEL)
(DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

ORGANS
EYES
SKIN
RESPIRATORY SYSTEM
BLOOD
CENTRAL NERVOUS SYSTEM
CARDIOVASCULAR SYSTEM
GASTROINTESTINAL
KIDNEYS
LIVER

I. CHEMICAL IDENTITY

Common name: Aldrin
Formula: $C_{12}H_8Cl_6$
Synonyms: HHDN, octalene
CAS No.: 309-00-2
Carcinogen: EPA

II. REGULATORY INFORMATION

Hazardous substance: EPA
Hazardous waste: EPA
DOT Hazard Class: Poison B

III. PHYSICAL CHARACTERISTICS

Boiling point:
Specific gravity: Data not available
Vapor density: Data not available
Melting point: 49 F (60 C)
Vapor pressure: Data not available
Evaporation rate: Data not available
Appearance and odor: Aldrin is a colorless, crystalline solid; technical grade aldrin is a tan to dark brown solid.

IV. PHYSICAL HAZARDS

Flash point: N/A
Autoignition temperature: N/A
Flammable limits in air (% by vol.): N/A
Extinguishers: N/A

V. HEALTH HAZARDS

Can affect the body if it is inhaled, swallowed, or comes in contact with the eyes or skin (it possibly can be absorbed through the skin).
Effects of short-term overexposure: May cause headaches, dizziness, nausea, vomiting, malaise, jerking limbs, convulsions, and coma, among other conditions.
Effects of long-term overexposure: May cause cancer.

VI. EMERGENCY FIRST AID

Eyes: Irrigate immediately.
Skin: Wash with soap immediately.
Breathing: Move affected person to fresh air at once and perform artificial respiration, if necessary.

Swallowing: Get medical attention immediately; give large quantities of water and induce vomiting in conscious person.

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA TWA: 0.25 mg/m³ with skin caution
ACGIH STEL: 0.75 mg/m³
IDLH: 100 mg/m³

VIII. PRECAUTIONS FOR USE AND SAFE HANDLING

Conditions contributing to instability: None
Incompatibilities: None
Hazardous decomposition products: None
Special precautions: None

IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

Protective equipment and clothing must be provided. Incinerate at 1500 F for 0.5 second minimum for primary combustion and at 3200 F for 1.0 second for secondary combustion, with adequate scrubbing and ash disposal facilities. Materials contaminated with aldrin should be buried 8 to 12 feet underground in an isolated area away from water supplies, with a layer of clay, a layer of lye, and a second layer of clay beneath the wastes.
Provide emmployees with and require the use of impervious clothing, gloves, face shields, and eye goggles to prevent any possibility of skin contact. Provide emergency showers.

Respirators–

2.5 mg/m³: CCROVDPest;SA;SCBA
12.5 mg/m³: CCROVFDMPest;GMOVFDMPest;SAF;SCBAF
100 mg/m³: SA:PD,PP,CF;CCROVHiEPest
Escape: GMOVPest;SCBA

COMMON SYNONYMS:	FORMULA OF MAJOR COMPONENTS:	
Aroclor® 1016 Chlorodiphenyl (41% Cl) PCB	$C_{12}H_8Cl_2$ (20%) $C_{12}H_7Cl_3$ (57%) $C_{12}H_6Cl_4$ (21%)	CAS REG. NO.: 12674-11-2 NIOSH NO.: TQ1351000 MOLECULAR WEIGHT: 258 (average)
Aroclor® 1242 Chlorodiphenyl (42% Cl) PCB	$C_{12}H_8Cl_2$ (16%) $C_{12}H_7Cl_3$ (49%) $C_{12}H_6Cl_4$ (25%) $C_{12}H_5Cl_5$ (8%)	CAS REG. NO.: 53469-21-9 NIOSH NO.: TQ1356000 MOLECULAR WEIGHT: 266 (average)
Aroclor® 1254 Chlorodiphenyl (54% Cl) PCB	$C_{12}H_6Cl_4$ (21%) $C_{12}H_5Cl_5$ (48%) $C_{12}H_4Cl_6$ (23%) $C_{12}H_3Cl_7$ (6%)	CAS REG. NO.: 11097-69-1 NIOSH NO.: TQ1360000 MOLECULAR WEIGHT: 328 (average)
Aroclor® 1260 Chlorodiphenyl (60% Cl) Clophen A60 Phenoclor DP6 PCB	$C_{12}H_5Cl_5$ (12%) $C_{12}H_4Cl_6$ (38%) $C_{12}H_3Cl_7$ (41%) $C_{12}H_2Cl_8$ (8%)	CAS REG. NO.: 11096-82-5 NIOSH NO.: TQ1362000 MOLECULAR WEIGHT: 376 (average)

REACTIVITY	Aroclor® compounds are generally considered halogenated organic compounds for compatibility classification purposes. Reactions of such materials with cyanides, mercaptans or other organic sulfides typically generate heat, while those with non-oxidizing mineral acids, amines, azo compounds, hydrazines, caustics or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases and fires. Reactions with alkali or alkaline earth metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents or strong reducing agents typically result in heat generation and explosions and/or fires. PCBs are specifically known to react exothermally with liquid chlorine. Photolysis in sunlight causes various degradative reactions (12,505,511).

PHYSICOCHEMICAL DATA

	Aroclor® 1016	Aroclor® 1242	Aroclor® 1254	Aroclor® 1260
• Physical State (at 20°C):	oily liquid (1457)	liquid (46)	viscous liquid (38)	liquid (23)
• Color:	clear (1457)	straw-dark brown (46)	pale yellow	colorless (23)
• Odor:	mild hydro-carbon (1457)	mild hydro-carbon (2)	mild hydro-carbon (38)	no data
• Odor Threshold:	<——— no data ———>			
• Liquid Density (g/ml at 20°C):		1.38-1.39 (12)		
(g/ml at 30°C):	1.44 (54)			1.44 (54)
(g/ml at 90°C):			1.47-1.49 (12)	
• Freezing/Melting Point (°C):	-18.89 (2)	-19 (38)	10 (pour point) (38)	no data
• Boiling Point (°C):	340-375 (54)	325-366 (38)	365-390 (38)	340-375 (54)
• Flash Point (°C):	<——— relatively non-flammable (67,508) ———>			
• Flammable Limits in Air, % by Volume:	<——— no data ———>			
• Autoignition Temperature (°C):	<— can be incinerated at high temperatures —> (12,54)			
• Vapor Pressure (mmHg at 20°C):			$6x10^{-5}$ (38)	
(mmHg at 25°C):	$4x10^{-4}$ (10)	$4x10^{-4}$ (10)		$4x10^{-5}$ (10)

PHYSICOCHEMICAL DATA - Continued

	Aroclor® 1016	Aroclor® 1242	Aroclor® 1254	Aroclor® 1260
• Saturated Concentration in Air (mg/m^3 at 20°C) (ADL estim)	5.6	5.8	1.1	0.8
• Solubility in Water (mg/L at 20°):			0.012-0.07 (10,1583)	0.0027 (10)
(mg/L at 25°):	0.22-0.91 (1586,1589,1583)	0.2-0.7		
• Log (Octanol-Water Partition Coefficient), log K_{ow}:	5.3-5.6 (29)	5.3-6.1 (29)	5.6-8 (29)	6.1-9.3 (29)
• Soil Adsorption Coefficient, K_{ow}:	~10^5 (611)	~10^5 (611)	10^5-10^7 (611)	10^5-10^9 (611)
• Henry's Law Constant ($atm \cdot m^3/mol$ at 20°):	3.2×10^{-4} (31)	3.4×10^{-4} (1571)	2.8×10^{-4} (1571)	3.4×10^{-4} (1571)
• Bioconcentration Factor:	<——— 10^4-10^6 (10) ———>			

PERSISTENCE IN THE SOIL-WATER SYSTEM	Aroclor® 1016, 1242, 1254 and 1260 are expected to be highly immobile in the soil/ground-water system due to rapid and strong sorption. In the absence of organic solvents, leaching is minimal; the presence of organic solvents (e.g., chlorobenzenes) may significantly increase mobility. Volatilization is expected to be slow, but may be a significant long-term transport process. Photolytic and biological degradation of PCBs may occur in the soil/ground-water environment but are not expected to be rapid. In general, the higher chlorinated biphenyls are less mobile and more persistent than the lower chlorinated species.

PATHWAYS OF EXPOSURE	Although they are generally strongly sorbed, the primary pathway of concern from a soil/ground-water system is the migration of PCBs to ground-water drinking water supplies. Inhalation may be an important exposure pathway in some cases. Fish contamination and consumption may occur upon release to surface waters.

HEALTH HAZARD DATA

Signs and Symptoms of Short-term Human Exposure (46):
Systemic effects include anorexia, nausea, edema of the face and hands, and abdominal pain. A burning sensation to the skin and eyes as well as eye discharge are also common.

Toxicity Based on Animal Studies:

	Aroclor® 1016	Aroclor® 1242	Aroclor® 1254	Aroclor® 1260
LD_{50} (mg/kg) oral	no data	4250 [rat] (51)	1295 [rat] (51)	4000-10,000 [rat] (59)
skin	no data	no data	no data	1300-2000 [rabbit] (59)
LC_{50} (mg/m^3) inhalation	<——— no data ———>			

Long-Term Effects (PCBs): Chloracne, liver injury

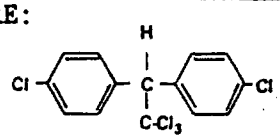
Pregnancy/Neonate Data (PCBs): Reduced reproductive capacity

Mutation Data (PCBs): Inadequate

Carcinogenicity Classification (PCBs): IARC - 2B

HANDLING PRECAUTIONS (38)	Aroclor® 1016 and 1242 Vapor concentrations of 1-10 mg/m^3: any supplied-air respirator with a full facepiece, helmet or hood or any self-contained breathing apparatus with full facepiece • > 10 mg/m^3: self-contained breathing apparatus with a full facepiece operated in the pressure-demand or other positive pressure mode or a combination respirator which includes a Type C supplied-air respirator with 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 • Impervious clothing, gloves, face shields (8-inch minimum) and other appropriate protective clothing to prevent possible skin contact • Splash-proof safety goggles if eye contact is possible. Aroclor® 1254 and 1260 Vapor concentrations of 0.5-5 mg/m^3: any supplied-air respirator with a full facepiece, helmet or hood or any self-contained breathing apparatus with full facepeice • > 5 mg/m^3: self-contained breathing apparatus with a full face-piece operated in the pressure-demand or other positive pressure mode or a combination respirator which includes a Type C supplied-air respirator with 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 • Impervious clothing, gloves, face shields (8-inch minimum) and other appropriate protective clothing to prevent possible skin contact • Splash-proof safety goggles if eye contact is possible.

EMERGENCY FIRST AID TREATMENT (54)	Ingestion: Induce vomiting if victim is conscious. Get medical attention • Inhalation: Move victim to fresh air immediately. Perform artificial respiration if necessary. Get medical attention • Skin: Remove contaminated clothing. Wash skin with soap and water immediately. Get medical attention • Eye: Irrigate immediately with large amounts of water. Get medical attention.

COMMON SYNONYMS:	CAS REG. NO.:	FORMULA:	AIR W/V CONVERSION FACTORS at 25°C (12)
1,1'-(2,2,2-Trichloroethylidene)bis(4-chlorobenzene) 1,1,1-Trichloro-2,2-bis(p-chlorophenyl)ethane	50-29-3 NIOSH NO.: KJ3325000	$C_{14}H_9Cl_5$	14.5 mg/m³ ≈ 1 ppm 0.0689 ppm ≈ 1 mg/m³
	STRUCTURE: 		MOLECULAR WEIGHT: 354.5

REACTIVITY	DDT is considered incompatible with strong oxidizers by one source and incompatible with alkaline materials by another. For general compatibility classification purposes, the compound is considered to be a halogenated organic. Reactions of halogenated organic materials with cyanides, mercaptans or other organic sulfides typically generate heat, while those with mineral acids, amines, azo compounds, hydrazines, caustics, or nitrides commonly evolve heat and toxic or flammable gases. Reactions with oxidizing mineral acids may generate heat, toxic gases, and fires. Those with alkali or alkaline earth elemental metals, certain other chemically active elemental metals like aluminum, zinc or magnesium, organic peroxides or hydroperoxides, strong oxidizing agents, or strong reducing agents typically result in heat generation and explosions and/or fires (23,54,511).

PHYSICO-CHEMICAL DATA	• Physical State (at 20°C): crystals or powder	(12)
	• Color: colorless to slight off-white	(12)
	• Odor: odorless or slightly aromatic	(12)
	• Odor Threshold: no data	( )
	• Density (g/ml at 20°C): 0.98-0.99	(12)
	• Freezing/Melting Point (°C): 108.5	(59)
	• Boiling Point (°C): 260	(59)
	• Flash Point (°C): combustible solid	(60)
	• Flammable Limits in Air, % by Volume: no data	( )
	• Autoignition Temperature (°C): no data	( )
	• Vapor Pressure (mm Hg at 20°C): 1.5×10^{-7}	(12)
	• Saturated Concentration in Air (mg/m³ at 20°C): 2.90×10^{-3}	(ADL estim)
	• Solubility in Water (mg/L at 25°C): 0.0031 - 0.0034	(67)
	• Viscosity (cp at 20°C): no data	( )
	• Surface Tension (dyne/cm at 20°C): no data	( )
	• Log (Octanol-Water Partition Coefficient), log K_{ow}: 6.36	(2162)
	• Soil Adsorption Coefficient, K_{oc}: 302,000	(2147)
	• Henry's Law Constant (atm•m³/mol at 25°C): 2.8×10^{-5}	(2146)
	• Bioconcentration Factor: 38,642 (rainbow trout); 1.1×10^5 (estim)	(2001, 659)

PERSISTENCE IN THE SOIL-WATER SYSTEM	DDT is expected to be relatively immobile in the soil/ground-water system due to its strong sorption properties. Volatilization may be an important loss pathway from aquatic systems but is much slower in soils. Translocation of sorbed DDT with soil particles may be important. Biodegradation is expected to be the predominant fate process in soils, but occurs slowly under aerobic conditions. Photolysis can also contribute to DDT degradation in soils exposed to sunlight.

PATHWAYS OF EXPOSURE	The primary pathway of concern from the soil/ground-water system is the migration of DDT to ground water drinking water supplies, although this is not likely to occur in most situations. Uptake by crops from soil or bioaccumulation by aquatic organisms or domestic animals may be important exposure pathways in some instances.

HEALTH HAZARD DATA	Signs and Symptoms of Short-term Human Exposure (54): DDT is of moderate acute toxicity to man. Symptoms of exposure include paresthesia of the tongue, lips and face; tremors, apprehension, dizziness, confusion, malaise, headaches, convulsions, paresis of the hands, vomiting, irritation of the eyes and skin.
	Toxicity Based on Animal Studies: LD_{50} (mg/kg) oral 87 [rat] (47); skin 1931 [rat] (47); LC_{50} (mg/m^3) inhalation -- no data
	Long-Term Effects: Liver and kidney damage
	Pregnancy/Neonate Data: Fetotoxic; not teratogenic
	Mutation Data: Conflicting data
	Carcinogenicity Classification: IARC-2B; NTP-none assigned

HANDLING PRECAUTIONS (54)	Handle chemical only with adequate ventilation • Vapor concentrations of 10 mg/m^3: chemical cartridge respirator with organic vapor cartridge with dust or mist filter, including pesticide respirators meeting these requirements or supplied-air respirator or self-contained breathing apparatus • 10-100 mg/m^3: supplied-air respirator with full facepiece or self-contained breathing apparatus with full facepiece • 100-500 mg/m^3: Type C supplied-air respirator operated in pressure demand, continuous flow mode or other positive pressure mode • Chemical goggles if there is probability of eye contact o Appropriate clothing and gloves to prevent repeated or prolonged skin contact.

EMERGENCY FIRST AID TREATMENT (54)	Ingestion: Because many pesticide formulations are combined with other pesticides, fungicides or insecticides and are frequently dissolved in petroleum distillates, vomiting involves a serious risk that solvent will be aspirated, leading to chemical pneumonitis. For these reasons, if the ingested DDT is dissolved in a petroleum-based carrier or a mixed formulation, do not induce vomiting. Contact physician or emergency medical facility immediately. If the ingested DDT is in an aqueous carrier, induce vomiting. Get medical attention immediately • Inhalation: Move victim to fresh air. Give artificial respiration if necessary. Get medical attention • Skin: Remove contaminated clothing. Wash skin with soap and water. If irritation persists after washing, get medical attention • Eye: Flush with large amounts of water. If irritation persists after washing, get medical attention.

I. CHEMICAL IDENTITY

Common name: Dieldrin
Formula: $C_{12}H_8Cl_6O$
Synonyms: 2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-; aldrin epoxide
CAS No.: 60-57-1
Carcinogen: IARC, animal positive

II. REGULATORY INFORMATION

Hazardous substance: EPA
Hazardous waste: EPA
DOT Hazard Class: ORM-A

III. PHYSICAL CHARACTERISTICS

Boiling point: At 1 atm., decomposes
Specific gravity: 1.75
Melting point: 176 C (349 F)
Vapor pressure: Essentially zero
Solubility in water: At 20 C, 110 ppb
Appearance and odor: Odorless, light-tan, flaked solid

IV. PHYSICAL HAZARDS

Flash point: N/A
Extinguishants: Use a suitable agent to surround the fire. Material itself does not burn readily.

V. HEALTH HAZARDS

Early symptoms include headache, nausea, vomiting, general malaise, dizziness, hyperexcitability, and hyperirritability. More severe symptoms are convulsions and coma.

VI. EMERGENCY FIRST AID

Eyes: Wash with large amounts of water, lifting the lids occasionally. Get medical attention as soon as possible.
Skin: Wash with soap or mild detergent. Remove contaminated clothing. If there is skin irritation, get medical attention.
Breathing: Move patient to fresh air. Perform artificial respiration if needed. Keep patient warm and at rest. Get medical attention as soon as possible.
Swallowing: Get medical attention immediately. Give large quantities of water, and then induce vomiting (mechanically with finger).

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA TWA: 0.25 mg/m^3
ACGIH STEL: 0.75 mg/m^3
IDLH: 450 mgm^3

VIII. PRECAUTIONS FOR USE AND SAFE HANDLING

Conditions contributing to instability: Heat.
Incompatibilities: Contact with nitrates, strong oxidizers, strong alkalies, and strong acids may cause fires and explosions.
Hazardous decomposition products: Toxic gases (such as carbon monoxide) may be released in a fire.
Special precautions: Will attack some forms of plastics, rubber, and coatings.

IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

Persons not wearing protective equipment and clothing should stay out of spill area. Remove all ignition sources. Ventilate area. Small quantities may be absorbed on paper towels and evaporated in a hood. Do not allow to enter confined space, such as a sewer. Larger quantities may be absorbed on vermiculite, dry sand, or earth and disposed of in secured sanitary landfill; or atomized in a suitable combustion chamber.

X. PROTECTIVE EQUIPMENT

Impervious clothing, gloves, face shields (eight-inch minimum) to prevent prolonged or repeated skin contact. Remove contaminated clothing immediately. Contaminated clothing should be placed in closed containers pending disposal or cleaning. Splash-proof safety goggles required where there is danger of eye contact. Emergency showers and eye-wash fountains should be provided in the immediate workplace.

Respirators–

(Required above 0.25 mg/m^3)
$<$2.5 mg/m^3: CCROVFDMPest; SA; SCBA
$<$12.5 mg/m^3: CCROVFDMPest; GMOVDMPest; SAF; SCBAF
$<$250 mg/m^3: PAPOVHiEPPest; SA:PD,PP,CF
$<$450 mg/m^3: SAF:PD,PP,CF
Escape: GMOVPPest; escape SCBA.

I. CHEMICAL IDENTITY

Common name: Endrin
Formula: $C_{12}H_8Cl_6O$
Synonyms: 1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-endo-5,8-dimethanonaphthalene
CAS No.: 72-20-8
Carcinogen: N/A

II. REGULATORY INFORMATION

Hazardous substance: EPA
Hazardous waste: EPA
DOT Hazard Class: Poison B

III. PHYSICAL CHARACTERISTICS

Boiling point: Decomposes
Specific gravity: 1.7
Vapor density: N/A
Melting point: 200 C (392 F) decomposes
Vapor pressure: At 20 C, 0.0000002 mm Hg
Solubility in water: At 20 C, 160 ppb
Appearance and odor: Colorless to tan solid with a mild chemical odor

IV. PHYSICAL HAZARDS

Flash point: Not combustible

V. HEALTH HAZARDS

May cause sudden convulsions occurring 30 minutes to 10 hours after exposure. Headache, dizziness, sleepiness, weakness, and loss of appetite may be present for two to four weeks following exposure. Swallowing has proved fatal. Less severe cases have shown headache, dizziness, abdominal discomfort, nausea, vomiting, insomnia, agitation, and mental confusion. Animal tests have shown abnormalities in offspring.

VI. EMERGENCY FIRST AID

Eyes: Wash with large amounts of water, lifting the lids occasionally. Get medical attention as soon as possible. Do not wear contacts when working with the substance.
Skin: Wash using soap or a mild detergent. Remove contaminated clothing. If there is skin irritation, get medical attention.
Breathing: Move patient to fresh air. Perform artificial respiration if needed. Keep patient warm and at rest. Get medical attention as soon as possible.

Swallowing: Get medical attention immediately. Give large quantities of water, and then induce vomiting mechanically with finger.

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA TWA: 0.1 mg/m³ with skin caution
ACGIH STEL: 0.3 mg/m³
IDLH: 200 mg/m³

VIII. PRECAUTIONS FOR USE AND SAFE HANDLING

Conditions contributing to instability: Temperatures above 200 C (392 F) result in decomposition with possible rupture of container.
Incompatibilities: Contact with strong oxidizers may cause fires and explosions. Contact with strong acids may cause evolution of heat and formation of explosive solvent vapors.
Hazardous decomposition products: Toxic gases (such as hydrogen chloride and carbon monoxide) may be released on decomposition.

IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

Persons not wearing protective equipment and clothing should stay out of spill area. Ventilate area. Collect spilled material and deposit is sealed containers for reclamation or for disposal in a secured sanitary landfill. Liquid containing endrin should be absorbed on vermiculite, dry sand, or earth.

X. PROTECTIVE EQUIPMENT

Impervious clothing, gloves, face shields (eight-inch minimum) to prevent prolonged or repeated skin contact. Contaminated clothing should be placed in closed containers pending disposal or cleaning. Splash-proof safety goggles where there is danger of eye contact. Emergency showers and eye-wash fountains should be provided in the workplace.

Respirators–

< 1 mg/m³: CCROVDMPest; SA; SCBA
< 5 mg/m³: CCROVDMPest; GMOVDMPest; SAF; SCBAF
< 100 mg/m³: PAPCCROVHiEPPest; SAF:PD,PP,CF
< 200 mg/m³: SAF:PD,PP,CF
> 200 mg/m³: SCBAF:PD, PP; comb SAF:PD, PP,CF w/ SCBA:PD, PP
Fire fighting: SCBAF:PD, PP
Escape: Any gas mask providing protection against organic vapors and particulates; escape SCBA.

I. CHEMICAL IDENTITY

Common name: Hydrogen sulfide
Formula: H_2S
Synonyms: Sulfuretted hydrogen; hydrosulfuric acid; hepatic gas
CAS No.: 7783-06-4
Carcinogen: N/A

II. REGULATORY INFORMATION

Hazardous substance: EPA
Hazardous waste: EPA
DOT Hazard Class: Flammable gas

III. PHYSICAL CHARACTERISTICS

Boiling point: −60 C (−76 F)
Specific gravity: Liquid, 1.54
Vapor density: At 15 C, 1.189
Melting point: −82.4 C (−116 F)
Vapor pressure: At 25 C, 20 atmospheres
Solubility in water: At 20 C, 2.9 g/100g water
Evaporation rate: N/A
Appearance and odor: Colorless gas with a strong odor of rotten eggs. The odor is an unreliable warning, since it may deaden the sense of smell.

IV. PHYSICAL HAZARDS

Flash point: Flammable gas
Autoignition temperature: 260 C (500 F)
Flammable limits in air (% by vol.): Lower: 4.3; Upper: 46
Extinguishants: Alcohol foam, carbon dioxide

V. HEALTH HAZARDS

Inhalation of high concentrations may cause loss of consciousness and death. Lower concentrations may cause headache, dizziness, and upset stomach. Exposure can cause temporary loss of the sense of smell, irritation of the eyes, nose, and throat.

VI. EMERGENCY FIRST AID

Eyes: If liquid gets in eyes, wash with large amounts of water, lifting the lids occasionally. Get medical attention as soon as possible. Do not wear contacts when working with the substance.
Skin: If liquid gets on skin, flush with water. Remove contaminated clothing. If there is skin irritation, get medical attention.

Breathing: Move patient to fresh air. Perform artificial respiration if needed. Keep patient warm and at rest. Get medical attention as soon as possible.

VII. PERMISSIBLE EXPOSURE LIMIT

OSHA ceiling: 20 ppm or a maximum allowable of 50 ppm (once, if no other exposure occurs)

VIII. PRECAUTIONS FOR USE AND SAFE HANDLING

Conditions contributing to instability: Heat may cause containers to burst.
Incompatibilities: Contact strong oxidizers and oxidizing materials may cause fires and explosions. Attacks many metals, forming sulfides.
Hazardous decomposition products: Toxic gases (such as sulfur oxides) may be released in a fire.
Special precautions: Liquid will attack some forms of plastics, rubber, and coatings.

IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

Persons not wearing protective equipment and clothing should stay out of spill area. Remove all ignition sources. Ventilate area. Stop flow of gas, or, if this is impossible, vent in open air.

X. PROTECTIVE EQUIPMENT

Impervious clothing, gloves, face shields (eight-inch minimum) to prevent the skin from being frozen from contact with liquid hydrogen sulfide. Remove contaminated clothing. Splash-proof safety goggles where there is danger of eye contact.

Respirators–

< 300 ppm: SAF; SCBAF
> 300 ppm: SCBAF:PD, PP; comb SAF:PD, PP,CF w/ SCBA:PD, PP
Fire fighting: SCBAF:PD, PP
Escape: Any gas mask providing protection against acid gases or hydrogen sulfide; escape SCBA.

IV

APPENDIX IV

RESPIRATOR PROGRAM FOR SKINNER LANDFILL

The following respirator program is in accordance with OSHA 29 CRF 1910.134 Respirator Protection Program requirements. This program governs the selection and use of respirators on-site.

Respirators for the field contractors sampling team will be provided by the employer. The respirator protection program will be administered by, and is the responsibility of, the SSO for the site. Subcontractors (i.e., drillers) will furnish their own respirators and medical surveillance for their employees. The respirators and levels are:

Level	Respirator
B	Positive Pressure-Pressure Demand SCBA or Supplied Air Respirator with 5-minute escape bottle. Level B is 5 to 250 ppm above background in (BZ).
C	Full-face air purifying respirator with combination dust (HEPA) and organic vapor/acid gas cartridge. Level C is 1 ppm to 5 ppm above background in BZ based on identification of contaminant present. The full facepiece respirator with combination dust and organic vapor/acid gas cartridge will be appropriate for the dust conditions and organics that may be encountered.
D	No respirator required. Continuous reading of background (0.2 ppm) to 1 ppm in the worker's BZ.

The respirator users will be fit tested with the size, style, and make of the respirator they will be using on-site. The fit test will be recorded and these Fit Test Records will be maintained in the site field trailer.

Employee respirator training is provided on an annual basis and at site-specific training sessions. This training includes:

- A discussion of the nature of the respiratory hazards and the dangers if the respirator is not used properly.
- The reasons that respirators are required for protection, along with any engineering controls that may be used.
- Instruction in the selection, use, sanitary care, maintenance, proper storage, and limitation of the full facepiece respirator with combination cartridge, and the SCBA.
- Practice in proper fitting, wearing, adjusting, and checking face seal of the respirator.
- An opportunity to handle the respirator.

- Instruction on how to recognize and cope with emergency situations requiring respiratory protection.

- Explanation of the requirements for a self-contained breathing device for work in unknown concentrations and Immediately Dangerous to Life or Health (IDLH) atmosphere and for fire fighting.

- Explanation of the medical surveillance program and how it relates to respirator use.

- Explanation of the requirements for maintaining a tight seal, why beard and facial hair is prohibited, and why use of contact lenses while wearing respirators is prohibited.

Respirators will be assigned to individual workers. Each individual will be responsible for cleaning and maintaining their assigned respirator and documenting this using the Respirator Service Log presented in Appendix II. They will be cleaned and disinfected before being reassigned. Respirators will be cleaned after each day of work according to manufacturer's instructions. The cleaning will be done at the Command Post. Used cartridges will be disposed of and replaced with new ones.

After cleaning, the respirators will be inspected and checked for defects such as excessive dirt, cracks or other distortions, scratches, incorrectly mounted lens, broken or worn cartridge holders on the facepiece, breaks, loss of elasticity, broken buckles, and excessively worn serrations on head harness that may cause slippage on the headstraps or head harness.

Further checks include:

- A check of the tightness of the connections.

- A check of the facepiece, valves, connecting tube, and canisters.

- A check of the regulator and warning devices on SCBA for proper functioning.

- For air purifying:

  - Check the exhalation valve after removing its cover for:

    - Foreign material, such as detergent residue, dust particles, or human hair under the valve seat.

    - Cracks, tears, or distortion in the valve material.

    - Improper insertion of the valve body in the facepiece.

    - Cracks, breaks, or chips in the valve body, particularly in the sealing surface.

    - Missing or defective valve cover.

- -- Improper installation of the valve in the valve body.

- -- Check the air purifying elements for:

  - -- Incorrect cartridges, canister, or filter for the hazard.

  - -- Incorrect installation, loose connections, missing or worn gaskets, or cross threading in holder.

  - -- Expired shelf life of cartridge or canister.

  - -- Cracks, dents, or breaks in the cartridge or canisters case.

  - -- Evidence of prior use of cartridge or canister, such as broken seal tape foil or other sealing material.

- For air supplied respirators, check the air supply system for:

  - -- Integrity and condition of air supply lines and hoses, including attachments and end fitting.

  - -- Correct operation and condition of all regulators, valves, or other air-flow regulators.

  - -- If SCBA, that the cylinder is sufficiently charged for the intended use, preferably fully charged (mandatory on an emergency device). The emergency SCBA will have a tag for logging in the monthly inspections.

Monitoring of the work area will be performed and the results will be used to select the appropriate level of protection. Refer to air monitoring section of the HASP (Section 9.0).

This Respirator Program will be re-evaluated and revisions and updates added regularly.

Persons will not be assigned to tasks requiring the use of respirators unless it has been determined that they are physically able to perform the work and use the equipment. The employer-contracted physicians will determine what health and physical conditions are pertinent.

Only those respirators jointly approved by NIOSH/MSHA will be used. All component parts (i.e., canister, replacement straps, etc.) will be of the same make.

Employees will document their respirator use time on the Record of Respiratory Wear Log presented in Appendix II. This record will be submitted to the primary SSO on a weekly basis.

DRILLING HEALTH AND SAFETY

Personnel involved in the operation of drilling rigs have the potential to be exposed to health and safety hazards associated with drilling activities. Presented below is a description of health and safety procedures that must be followed when working around a drilling rig. Drilling is typically conducted for either geotechnical projects for identifying subsurface lithology or for environmental projects for identifying subsurface contamination. A site specific health and safety plan must be developed for all environmental drilling jobs and drillers should read and sign these plans.

Personal Protective Equipment

The following is a minimum list of personal protective equipment that must be worn by drillers and drillers helpers during the operation of a drilling rig:

- Class B Hard Hat
- Impact resistant safety goggles or glasses
- Steel-toe work boots
- Long-sleeve shirt and pants or coveralls
- Hearing protection during operation of hammer or rotary unit
- Work gloves

This list of equipment applies to drilling activities for geotechnical borings, or activities conducted in Level D PPE for environmental borings. If rotary drilling is conducted, disposable coveralls should also be worn as there is a high potential for splash. Additional PPE may be required for sites suspected of chemical contamination. PPE for these sites will be stipulated in a site-specific health and safety plan.

It is important that no loose clothing be worn at any time in the vicinity of a drilling rig. If disposable coveralls are worn, these should always be taped at the wrists, waist and ankles. Boot laces should be tucked into boots or taped. Jewelry, including watches, chains, ties or lanyards and rings, should not be worn during the operation of a drilling rig.

Electrical Hazards

Both underground and overhead power lines present a potential electrical hazard for drilling crews. Prior to the initiation of drilling, the project manager should check with local utilities and the property owners for the presence of underground utilities. If these checks have not been conducted, drilling should not be initiated until they are.

Overhead power lines (including elevated pipe sections) are a hazard if the mast or other portions of the drilling rig, come in contact with energized conductors. Prior to drilling, insure that there is adequate clearance between the mast and the power lines. Allow for additional vertical clearance above the top of the rig, and the highest pipe section. Avoid drilling near trees or posts in contact with wires that could touch the drilling rig to complete a ground circuit.

Drilling should not occur during a thunderstorm or electrical storm. If threatening weather approaches during drilling, the mast should be lowered and drilling activities ceased until the storm passes.

Impact and Pinch Hazards

During the operation of a drilling rig there is a potential for workers to be impacted by, caught between, or caught on moving equipment. As the augers turn there is a potential to be pinched or pulled if body parts become entangled with the rotary drill parts. There is also the potential for impacts and pinches when the hammer falls to drive the auger or split-spoon. During drilling, operators should avoid contact with moving equipment parts

whenever possible. If repairs or alterations need to be made to the drilling equipment, the drilling rig should be turned off prior to initiating repairs.

If a drilling rig is to be left unattended, special precautions should be taken to lock the rig and disengage any movable or dangerous parts that could cause injury. Where possible lower the mast section, discharge hydraulic lines and be sure the rig tires are chocked in place. Caution flagging should be placed around the work area to prevent unauthorized entry.

Fire Hazards

There is a potential for fires during the operation of drilling rigs from overheating equipment or fuel spillage. Each drilling rig should be equipped with an ABC-class fire extinguisher and drillers should be trained in their use. On-site personnel should not attempt to fight any fires other than small fires that can be extinguished with one fire extinguisher volume. The fire extinguishers shall be inspected and/or replaced periodically.

Fire/Exhaust Hazards

Fumes and exhaust are generated during drilling rig operations. Whenever possible, the drilling area should be well ventilated. The drilling rig should undergo periodic muffler system inspections and routine equipment maintenance to keep exhaust fumes to a minimum.

Dust Hazards

Dust is often generated during drilling operation, especially when rock coring or air rotary drilling occurs. If possible, when it will not interfere with drilling activities, dust suppression methods, such as a fine water spray, should be employed. Dust may also be generated when poring silica sand around the annulus of wells. If dust suppression cannot be used or is

inadequate, drillers should use NIOSH-approved dust masks to reduce inhalation exposures to dust. ONLY THOSE EMPLOYEES INVOLVED IN THE RESPIRATOR PROGRAM SHOULD WEAR DUST MASKS OR OTHER TYPES OF RESPIRATORS.

Chemical Hazards

For all environmental drilling jobs a site-specific health and safety plan detailing the potential chemical hazards should be prepared. PPE and exposure effects will be addressed in these plans. In the event that potential chemical contamination is encountered when it is not expected and there is no health and safety plan addressing this hazard, the drillers should contact the project manager, and halt work until the hazard can be assessed.

Training

All drillers and drillers helpers are required to complete the OSHA 1910.120 40-hour health and safety course, 3-days supervised field training, and annual 8-hour refreshers. Respirator training and fit-testing will be included in this training. Some drillers may also be required to take the field supervisor's health and safety course. At least one member of each drilling crew, and preferably all members, should have current certification in first-aid and CPR. Drillers may not engage in confined space entry unless they have been trained and all other protocols involving confined space entry have been followed.

Indoor Drilling

For some drilling jobs it becomes necessary to conduct drilling within the interior of a building. As with exterior drilling, overhead and buried utility lines should be identified prior to drilling. In addition, the structural integrity of the building should be assessed prior to drilling to insure that drilling operations will not cause instability and that workers will be safe during drilling operations. Ceiling height should be assessed to assure adequate

space for the mast. Where there is a potential for buildup of fumes from the drilling rig or other equipment, artificial ventilation such as fans should be set up.

Maintenance

The drilling rig, augers, and other associated drilling equipment should be serviced and inspected on a regular basis. Parts showing signs of wear should be replaced. Stressed equipment parts have the potential for breakage during drilling and injury could occur.

Noise Hazards

A drill rig under normal circumstances is a source of a variety of noise hazards. The operation of the split-spoon and hammer results in periodic percussion noise pulses. The normal drilling operation can result in high ambient background noise levels due to the operation or the engine and various rotary parts. Adequate noise protection in the form of ear plugs or ear muff protectors should be worn while high operational noise levels are encountered. Care must be taken when selecting hearing protection to avoid complete sound isolation for the individual which could result in hazard conditions from reduced hearing conditions.

Pressurized Line Hazards

Pressurized line hazards are an additional potential hazard source. Pressurized lines associated with pressure washer decontamination equipment are a source of liquid pressure from 1,200 - 2,000 PSI which is adequate to cause severe penetration or tissue damage of unprotected skin. In addition, use of compressed air tools and equipment or drilling rigs can be an additional pressurized line hazard. Adequate maintenance of pressurized equipment should include visual inspection of hoses, fittings and flexible couplings prior to use. In addition, adequate personal protection including safety goggles (splash shield), gloves, coveralls and steel toed work shoes should be worn when operating pressurized

equipment. Personnel should remain outside and behind the pressurized line hazard work area when equipment is in use.

Slip, Trip, Fall Hazards

Slips, trips and falls are potential hazards in wet or slippery areas. If overboots are worn, these boots should have soles that provide traction in these conditions. Drillers should also be observant of holes or ditches, precariously positioned objects, sharp objects on the ground, steep grades, and unstable surfaces. A visual inspection should be conducted prior to setting up the drilling rig.

Health and Safety Equipment

In addition to personal protective equipment required for the project and a fire extinguisher, each drilling rig should be equipped with a first-aid kit, an emergency eye-wash, a location map showing the nearest hospital, and a list of local emergency telephone numbers.

SUPPORT PLAN D

SKINNER LANDFILL SUPERFUND SITE
SPILL PREVENTION CONTROL AND
COUNTERMEASURE PLAN (SPCC)
WEST CHESTER, BUTLER COUNTY, OHIO

Rust Environment & Infrastructure of Ohio Inc.
PROJECT NO. 72680

May 20, 1996

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1.0 INTRODUCTION

This Spill Prevention Control and Countermeasure Plan (SPCC) has been developed for the purpose of providing guidelines in the event of a spill during construction and other remedial activities. This plan will be implemented, if a spill of oil or hazardous material occurs that will impact the soil or surface water. During site activities, the project manager will appoint a SPCC coordinator who will report any activity involving this plan to the Site Safety Officer (SSO) and contractor safety representative(s). The Project Manager may choose to appoint the SSO as SPCC Coordinator.

2.0 SITE LOCATION AND DESCRIPTION

The Skinner Landfill is located approximately 15 miles north of Cincinnati, Ohio near West Chester, Butler County, Ohio in Township 3, Section 22, Range 2. The site is located along Cincinnati-Dayton Road. The site is bordered on the south by the East Fork of Mill Creek, on the north by wooded land, on the east by a Consolidated Railroad Corporation (Conrail) railroad right-of-way, and on the west by the Skinner Creek.

The site is located in a highly dissected area that slopes from a till-mantled bedrock upland to a broad, flat-bottomed valley that is occupied by the main branch of Mill Creek. Elevations on the site range from a high of nearly 800 feet above mean sea level (MSL) in the northeast, to a low of 645 feet MSL near the confluence of the Skinner Creek and the East Fork of Mill Creek. Both Skinner Creek and the East Fork of Mill Creek are small, shallow streams. Both of these streams flow to the southwest from the site toward the main branch of Mill Creek. A third on-site stream, Dump Creek, borders the landfill on the east. Dump Creek is intermittent and flows south into the East Fork of Mill Creek. Three shallow ponds are also located on the site.

In general, the site is underlain by relatively thin glacial drift over interbedded shales and limestones of Ordovician age. The composition of the glacial drift ranges from intermixed silt, sand and gravel, to silty, sandy clays; and its thickness ranges from zero to over 40 ft on the site. The sand and gravel deposits comprise the hills and ridges and are encountered near the surface of the central portion of the site. The silts and clays usually occur as lenses in the sands and gravel or directly overlie bedrock.

2.1 Site History and Background

The property was originally developed as a sand and gravel mining operation, and was subsequently used as a landfill from 1934 to 1990. According to U.S. EPA studies, materials deposited at the site include demolition debris, household refuse and a wide variety of chemical wastes. The waste disposal areas include a now-buried waste lagoon near the center of the site and a landfill. According to U.S. EPA studies, the buried waste lagoon was used for the disposal of paint wastes, ink wastes, creosote, pesticides, and other chemical wastes. The landfill area, located north and northeast of the buried lagoon, received predominantly demolition and landscaping debris.

In 1976, the Ohio EPA (OEPA) initiated an investigation of the site in response to reports of a black oily liquid that was observed during a fire call to the site. Before the OEPA could complete the investigation, the landfill owners, the Skinners, covered the lagoon with a layer of demolition debris. Mr. Skinner further dissuaded the OEPA from accessing the site by claiming that nerve gas, mustard gas, and explosives were buried in the landfill. The OEPA requested the assistance of the U.S. Army after obtaining this information. Mr. Skinner later retracted his statements concerning buried ordnance, and an U.S. Army records review performed in 1992 did not reveal any evidence of munitions disposal at the site.

In 1982, the site was placed on the National Priority List by the U.S. EPA based on information obtained during a limited investigation of the site. The investigation indicated groundwater contamination had occurred as a result of the buried wastes. In 1986, a Phase I Remedial Investigation was conducted that included sampling of groundwater, surface water and soil, as well as a biological survey of the East Fork of Mill Creek and Skinner Creek. A Phase II Remedial Investigation was conducted from 1989 to 1991 and involved further investigation of groundwater, surface water, soils and sediments. A Baseline Risk Assessment and Feasibility Study (FS) were completed in 1992.

The Phase II Remedial Investigation revealed that the most contaminated media at the site is the soil from the buried waste lagoon. Lower levels of contamination were also found in soils on other portions of the site and in the groundwater, and very low levels were found in the sediments of the Mill Creek, the Skinner Creek, the Duck Pond, and the Diving Pond. Migration of the landfill constituents has been limited, and the Phase II Remedial Investigation concluded that there had been no off-site migration of landfill constituents via groundwater flow.

3.0 SPILL PROCEDURES

If a spill occurs that will impact the soil or surface water, the following procedures will be followed:

- The SPCC Coordinator will be contacted to coordinate the spill response procedures;
- The SPCC Coordinator will survey the scene of the spill to determine if personnel present can be involved further in the response. This may involve monitoring with the Photoionization Detector (PID), Flame Ionization Detector (FID) or Combustible Gas Indicator (CGI);
- If it is determined that site personnel are in immediate danger and no further action should be attempted, the SPCC Coordinator will contact the local fire department, the Butler County Emergency Management Agency and the Project Manager who will in turn determine if a response team must be contacted;
- If the SPCC Coordinator determines that site personnel can conduct the spill response, site personnel will don PPE, as required;

- Site personnel will take the following steps:

  - Initiate measures to prevent further spillage (disconnect hose, turn container upright, etc.);
  - Remove ignition sources from the area;
  - Restrict access to the spill area;
  - Establish containment with sorbent materials to prevent spread of spill;
  - Use additional sorbent materials to collect remainder of spilled material;
  - Shovel visibly impacted media and sorbent material into drum; and
  - Seal and label drums. Mark area of spill if further evaluation is required;

The SPCC Coordinator will document the procedures followed during a spill response in the field log.

4.0 NOTIFICATION

Based on the typical quantities of chemicals and fuels introduced during field operations, such as sample preservatives, decontamination solutions, and vehicle fluids and fuels it is not anticipated that reportable quantity hazardous material spills will occur at the site. However, upon occurrence of a spill on the site, the SPCC Coordinator will contact the Project Manager who will make the determination of a reportable quantity spill. Oil or petroleum product spills are considered reportable if they create a visible sheen on surface water.

In the event of a reportable quantity spill, the Project Manager will notify the designated implementor's representative who will either authorize the Project Manager to proceed with the notification or begin the notification procedure themselves. The following agencies must be notified upon discovery of the spill:

- The Ohio Environmental Protection Agency
  Department of Emergency and Remedial Response
  (800) 282-9378

- The National Response Center (for reportable quantity spill or immediate threat to health or the environment)
  (800) 424-8802

- The United States Environmental Protection Agency
  Remedial Project Manager - Jamey Bell
  (312) 886-6436

- Butler County
  Emergency Management Agency
  (513) 887-3472

Information to be given during this notification will include the amount, type and location of material spilled, time of occurrence, countermeasures taken, and type of soil and water involved.

Specifically, each of the following items must be addressed:

1. Location and source of release.

2. The times at which the discharge occurred and was discovered and duration of release.

3. The approximate amount, identity and the characteristics of the discharge.

4. The stream(s) or other environmental media affected by the discharge.

5. The circumstances that created the discharge.

6. The names and telephone numbers of the persons who have knowledge of these circumstances.

7. What remedial steps are being taken.

8. Names and telephone numbers of those responsible for remedial activities.

9. Known acute or chronic health effects.

During the telephone conversation, the notifying party should ask for the incident number to be used on associated correspondence. All telephone calls regarding the spill should be carefully logged. The notification call should be made within thirty minutes after discovery of the release.

A written notification should be made as soon as possible but no later than 30 days following the release. The written notification will include those items listed in OAC 3750-25-25(A)(2).

5.0 PREVENTION PROGRAM

Contractor personnel, subcontractors and site visitors will take steps to avoid releases of hazardous materials on the site. The hazardous materials that may be introduced to the site during field activities include decontamination fluids/solvents, laboratory preservative chemicals, and vehicle fuels and oils.

Decontamination of equipment and personnel will occur only at established temporary or the fixed decontamination area. Decontamination fluids will be managed as described in the Health and Safety Plan and in the Field Sampling Plan. Use of solvents and decontamination detergents will not occur directly over exposed soil or surface water.

Laboratory preservatives will be used only as described in the Field Sampling Plan and laboratory protocols. Personnel will carefully pack and visually inspect preservative containers for leaks.

To avoid spills of vehicle fluids or oils at the site, a temporary containment area will be established during fueling or servicing of vehicles on-site. The containment area will consist of bermed plastic sheeting that could contain drips or overfills. Any fuels or vehicle fluids that are stored on-site will also be stored in a temporary containment area.

In the event containers of hazardous materials are encountered on-site during the field work, field personnel will note and report the locations of these materials and field work will be conducted to avoid these materials. Field personnel should not attempt to investigate or move unknown materials discovered during the site activities.

The SPCC Coordinator (and SSO if they are not the same person) will visually inspect the decontamination and fueling areas to assure that procedures are being followed to avoid releases. On-site contractors will review their work areas to assure that potentially hazardous materials and fuels are properly stored. The SPCC Coordinator will also review material storage and housekeeping. Only authorized contractor personnel and approved visitors will be permitted within the fenced area during remedial activities to avoid unauthorized use or release of materials.

Site vehicles will be equipped with mobile telephones. The SPCC Coordinator can contact the Project Manager (if not on-site), the client representatives, and local emergency assistance via the mobile telephones. A list of emergency contacts can be found in Section 3.2 of the Contingency Plan. This contact list should be maintained in each site vehicle. Should the SPCC Coordinator determine that evacuation is required, a single long horn blast will be utilized to signal workers to move to the site exit gate.

Emergency Spill Control equipment will be maintained on-site. This equipment may include: PPE such as tyveks, gloves, boots, and respiratory protection, as required, shovels, sorbant materials, drums and labels.

SUPPORT PLAN E

SKINNER LANDFILL SUPERFUND SITE
AIR MONITORING PROGRAM (AMP)
WEST CHESTER, BUTLER COUNTY, OHIO

Rust Environment & Infrastructure of Ohio Inc.
PROJECT NO. 72680

May 20, 1996

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1.0 INTRODUCTION

This Air Monitoring Plan (AMP) has been developed for field activities to be conducted during remedial activities at the Skinner Landfill site. This plan includes methods for airborne contaminant migration control as well as methods and procedures for perimeter, personnel, and real-time air monitoring during site activities.

2.0 SITE LOCATION AND DESCRIPTION

The Skinner Landfill is located approximately 15 miles north of Cincinnati, Ohio near West Chester, Butler County, Ohio in Township 3, Section 22, Range 2. The site is located along Cincinnati-Dayton Road. The site is bordered on the south by the East Fork of Mill Creek, on the north by wooded land, on the east by a Consolidated Railroad Corporation (Conrail) railroad right-of-way, and on the west by the Skinner Creek.

Though the Skinner property is comprised of approximately 78-acres of hilly terrain, only a portion of the site is subject to remedial action. As per the Statement of Work, the remedial action area is generally limited to a fenced area established under the December 9, 1992 Unilateral Administrative Order (UAO) relating to the first operable unit for the site. Throughout this report the remedial action work will refer to this fenced portion of the site.

The site is located in a highly dissected area that slopes from a till-mantled bedrock upland to a broad, flat-bottomed valley that is occupied by the main branch of Mill Creek. Elevations on the site range from a high of nearly 800 feet above mean sea level (MSL) in the northeast, to a low of 645 feet MSL near the confluence of the Skinner Creek and the East Fork of Mill Creek. Both Skinner Creek and the East Fork of Mill Creek are small, shallow streams. Both of these streams flow to the southwest from the site toward the main branch of Mill Creek. A third on-site stream, Dump Creek, borders the landfill on the east. Dump Creek is intermittent and flows south into the East Fork of Mill Creek. Three shallow ponds are also located on the site.

In general, the site is underlain by relatively thin glacial drift over interbedded shales and limestones of Ordovician age. The composition of the glacial drift ranges from intermixed silt, sand and gravel, to silty, sandy clays; and its thickness ranges from zero to over 40 ft on the site. The sand and gravel deposits comprise the hills and ridges and are encountered near the surface of the central portion of the site. The silts and clays usually occur as lenses in the sands and gravel or directly overlie bedrock.

2.1 Site History and Background

The property was originally developed as a sand and gravel mining operation, and was subsequently used as a landfill from 1934 to 1990. According to U.S. EPA studies, materials deposited at the site include demolition debris, household refuse and a wide variety of chemical wastes. The waste disposal areas include a now-buried waste lagoon near the center of the site and a landfill.

According to U.S. EPA studies, the buried waste lagoon was used for the disposal of paint wastes, ink wastes, creosote, pesticides, and other chemical wastes. The landfill area, located north and northeast of the buried lagoon, received predominantly demolition and landscaping debris.

In 1976, the Ohio EPA (OEPA) initiated an investigation of the site in response to reports of a black oily liquid that was observed during a fire call to the site. Before the OEPA could complete the investigation, the landfill owners, the Skinners, covered the lagoon with a layer of demolition debris. Mr. Skinner further dissuaded the OEPA from accessing the site by claiming that nerve gas, mustard gas, and explosives were buried in the landfill. The OEPA requested the assistance of the U.S. Army after obtaining this information. Mr. Skinner later retracted his statements concerning buried ordnance, and an U.S. Army records review performed in 1992 did not reveal any evidence of munitions disposal at the site.

In 1982, the site was placed on the National Priority List by the U.S. EPA based on information obtained during a limited investigation of the site. The investigation indicated groundwater contamination had occurred as a result of the buried wastes. In 1986, a Phase I Remedial Investigation was conducted that included sampling of groundwater, surface water and soil, as well as a biological survey of the East Fork of Mill Creek and Skinner Creek. A Phase II Remedial Investigation was conducted from 1989 to 1991 and involved further investigation of groundwater, surface water, soils and sediments. A Baseline Risk Assessment and Feasibility Study (FS) were completed in 1992.

The Phase II Remedial Investigation revealed that the most contaminated media at the site is the soil from the buried waste lagoon. Lower levels of contamination were also found in soils on other portions of the site and in the groundwater, and very low levels were found in the sediments of the Mill Creek, the Skinner Creek, the Duck Pond, and the Diving Pond. Migration of the landfill constituents has been limited, and the Phase II Remedial Investigation concluded that there had been no off-site migration of landfill constituents via groundwater flow.

3.0 AIRBORNE CONTAMINANT MIGRATION CONTROL

When possible, OSHA requires that engineering controls be implemented to limit worker exposure to potential contaminants. Use of engineering controls is the preferred method of limiting worker exposure. Use of administrative controls and personal protective equipment are methods used to limit exposures when engineering controls are not adequate or are not feasible. This section of the AMP describes the methods to be employed to limit airborne contaminant migration that could impact human health and the environment.

3.1 Dust Control

Dust generation could occur as the result of material excavation, movement of soil and landfill debris, vehicle movement, etc.

Some soil excavated at the site may be moist, depending on site conditions. Dust generation is anticipated to be minimal under these conditions. If dry soil is encountered and wind and/or excavation activities facilitate dust generation, then dust suppression methods will be employed. The following methods may be employed to reduce dust generation and may be selected by the construction manager and utilized based on the site conditions:

- Expose only the minimum area required for immediate excavation of material. Maintain the existing vegetation or soil covering, where present, over the area not under excavation.
- Maintain truck speeds at 15 mph or less.
- Cover the excavation face with tarp, plastic, cover soil or other means at the end of each day.
- Use a fine water mist or biodegradable suppressant foam to suppress dust. If water is utilized, it should be clean and only used in a quantity and location that the water will not produce run-off or impact nearby surface water. Foam suppressants may be applied to the working face, and staging areas, as required.

Nuisance dust may be generated as the result of vehicles passing over site roads. Clean water will be applied to dusty areas, as required; however, the amount of water used should not be in quantities that would create significant surface runoff or impact the landfill itself. Access roads will be maintained in a non-contaminated state by careful control of construction equipment. A wheel wash will be established as part of the decontamination area for vehicles leaving the exclusion zone portion of the site.

3.2 Vapor and Odor Control

Real-time area monitoring will occur during site activities for the purpose of identifying the presence of vapors in the work area. Odors and/or vapors may be released from landfill material. Action levels and methods are described below for the perimeter, personal, and area monitoring programs and in the site Health and Safety Plan (HASP). In the event that monitoring indicates the need for vapor or odor control, the applicable methods, such as minimization of exposed soil, described in Section 3.1 of the AMP for dust suppression will be utilized. If the vapors/odors cannot be controlled using the techniques outlined in Section 3.1 then the SSO will assess the need for limiting or halting site work.

4.0 PERIMETER MONITORING

Perimeter monitoring will be conducted during excavation activities and earth moving at the site. Provided below is a description of the locations, methods, and action levels associated with the perimeter monitoring.

4.1 Methods and Instrumentation

Perimeter monitoring will be conducted using high volume air samplers and media appropriate for the contaminants of concern. Constituents for which perimeter monitoring will be conducted may include volatile organic compounds, semi-volatile organic compounds, methane, particulates, and metals. Provided in Table 1 is a list of potential site contaminants based on previous sampling of site media. Monitoring will be conducted in accordance with applicable, standardized, and defined test methods such as those by NIOSH, U.S. EPA and OSHA. During actual sampling, periodic checks will be performed to assure the proper operation of the sampling equipment. These checks will be conducted frequently at the beginning of field activities to ensure proper function. Once proper pump operation is established, less frequent checks may be implemented with the approval of the Site Safety Officer (SSO). When the sampling media must be handled during installation or replacement, personnel will wear latex or other surgical-type gloves. In the event of inclement weather that could compromise sample integrity, the entire sample holder assembly can be removed and taken to a sheltered area for media removal or replacement.

The high volume samplers will be calibrated before and after each sampling period. Dedicated calibration media will be used for calibration only and will not be used later for sample collection or as a sample blank. Calibration is conducted based on ambient pressure, temperature, and instrument-specific calibration curves. All calibration results will be recorded on calibration logs and maintained for this project. Calibration protocols will follow recommended manufacturers' procedures described in the user's manual.

4.2 Location and Sampling Schedule

Samples will be collected at (1) a downwind location at the perimeter of the work area exclusion zone, (2) a background or upwind location, and (3) at one location off-site near Union Elementary School. The placement of the perimeter monitor will be determined by site activities and wind direction. The stations will be established in unobstructed areas, at least two meters from any obstacle to air flow. A meteorological station will also be set up at the site trailer to collect wind speed and direction information. Meteorological data will be collected daily during the time that remedial activities are occurring.

Perimeter monitoring initially will be conducted on a daily basis. After the initial period of perimeter monitoring, the sampling data will be reviewed to determine the frequency of additional monitoring. If perimeter sampling data indicates near or below background concentrations, less frequent perimeter monitoring will be performed. If perimeter sampling data indicates exposures above background or as other site conditions warrant, the frequency of perimeter monitoring may be increased.

4.3 Action Levels

Detectable airborne concentrations of contaminants will be reviewed by the air monitoring contractor under the direction of the SSO. Perimeter samples will be analyzed and results obtained within seven working days following the completion of sample collection. Concentrations above established action levels will be brought to the attention of the Project Manager. Action levels for individual contaminants at the site perimeter will be 25% of the established OSHA permissible exposure limit. The action level for particulates will be 150 mg/m^3 for a 24-hour period. OSHA permissible exposure limits are presented on Table 1. Additional dust suppression methods will be considered. Prior to the initiation of field activities, and during field activities when perimeter monitoring is being conducted, pumps will be operated and samples collected to establish background conditions. Action levels for real-time monitoring and monitoring methods requiring laboratory analysis for key potential contaminants are presented on Table 2. Data collected from perimeter monitoring requiring laboratory analysis will be compared with real-time monitoring data to help identify individual contaminants of concern, when applicable.

5.0 PERSONNEL MONITORING

Personnel monitoring will be conducted periodically during excavation and earth moving activities at the site. Provided below is a description of the locations, methods, and action levels associated with the personnel monitoring. The procedures provided below serve as a basis for personnel monitoring; however, it is the responsibility of the site contractor(s) and subcontractor(s) to determine the extent of their personnel monitoring. The SSO can assist the contractor safety personnel with implementation of the personnel monitoring.

5.1 Instruments and Methods

Personnel monitoring will be conducted in accordance with applicable standardized test methods such as those defined by NIOSH, U.S. EPA and OSHA. Samples will be collected using a precalibrated High/Low-Volume personal sampling pump as appropriate. The sampling media will be attached to the collar of the worker in the breathing zone. During actual sampling, periodic checks will be performed to assure the proper operation of the sampling equipment. The pumps will be checked frequently to ensure they are operating, the sampler is assembled properly, and that the hose has not become pinched or detached from the pump or sampling media. Personnel monitoring will be conducted for volatile organic compounds, semi-volatile organic compounds, metals, and particulates as deemed necessary by the SSO and the individual contractors.

The personal samplers will be calibrated before and after each sampling period. Dedicated calibration media will be used for calibration only and will not be used later for sample collection or as a blank. Calibration can be conducted using manufacturer calibration kits or a soap bubble burette system. All calibration results will be recorded on calibration logs and maintained for this project. Calibration protocols will follow recommended manufacturers procedures described in the user's manual.

5.2 Location and Sampling Schedule

Personnel sampling will be initiated at the start of the work shift and be completed at the end of the work shift. One to two workers, representative of each work area or team, will be monitored periodically. At the initiation of sampling activities an air monitoring log will be completed that includes such information as personnel sampled, sampling times and flow rates, sampling pump number designation, protective equipment, work area, and other pertinent information. Standardized air monitoring and calibration logs will be used to record the data.

After the initial period of personnel monitoring, data will be reviewed to determine the frequency of additional monitoring. If exposures near or below background levels are experienced, less frequent personnel monitoring will be performed. If personnel sampling data indicates exposures above background, real-time monitoring indicates the possibility of worker exposure, or as other site conditions warrant, the frequency of personnel monitoring may be increased and, as appropriate, other protective measures employed such as the use of additional PPE.

5.3 Action Levels

Personnel samples will be analyzed and results obtained within seven working days following the completion of sample collection. The time-weighted average (TWA) will be calculated based on the sampling results and the known exposure times. These TWAs will be compared to Threshold Limit Values (TLVs) and permissible exposure limits for the contaminants of concern. The site Health and Safety Officer will review the results to determine if changes in personal protective equipment is required. TLVs and PELs for contaminants of concern are presented in the HASP.

6.0 REAL-TIME AREA MONITORING

Real-time monitoring will be conducted for the duration of excavation and earth moving activities at the site. Provided below is a description of the locations, methods, and action levels associated with the personnel and perimeter real-time monitoring. Real-time monitoring will be conducted for elevated dust levels, volatile organic compounds, and potentially explosive gases. Inorganic compounds such as metals cannot be measured directly with real-time instruments. Because dust particles are the primary vehicle of airborne inorganic compounds, real-time monitoring of dust levels will be performed. Real-time monitoring will be the responsibility of the site contractor(s) and subcontractor(s) for their own personnel; however the primary SSO will also conduct real-time monitoring during site activities. Contractors will communicate exceedances of action levels to the primary SSO.

6.1 Instruments and Methods

A photoionization detector (PID) or a flame ionization detector (FID) will be used for the monitoring of volatile organic compounds during project activities. A real-time dust sampler, such as a Miniram Aerosol Monitor, will be used to monitor for airborne particulates. A combustible gas indicator

(CGI) with oxygen alarm and hydrogen sulfide detector may be used to monitor for explosive gases including methane. Procedures for use and calibration of these instruments in the field are described in the HASP.

6.2 Location and Sampling Schedule

Real-time monitoring will be conducted in the areas where personnel are performing work for site activities. The HASP includes the schedule and frequency of real-time monitoring based on site activities and conditions. Where possible, this monitoring will occur in the breathing zone of the workers. Background readings will be taken prior to the start of activities each day and during daily monitoring, upwind and near the site, but outside the Work Zone.

Volatile organics and dust levels will be measured at least daily on the eastern and western fence boundary and at any other time monitoring indicates increased levels in the work zone. The eastern fence boundary is assumed to be the general downwind direction and the western fence boundary is the closest fence location to Union Elementary School. If there is visible evidence of dust generation, additional real-time monitoring will be conducted downwind at the site perimeter. A CGI with the alarm set will be used to measure explosive gases near the eastern and western site boundaries with the reading checked at least daily. If radiation monitoring conducted during field activities indicates elevated radiation levels, radiation monitoring will also be conducted at the eastern and western perimeter of the site or other appropriate downwind locations.

6.3 Action Levels

Action levels for site workers are described in detail in the HASP. If VOCs exceed 1 ppm above background, LEL readings exceed 10%, particulates exceed 150 ug/m^3, field activities will be halted until these emissions can be controlled. If VOCs exceed 1 ppm above background, benzene and vinyl chloride detector tubes will be used to determine if either of these substances are present. If these substances are not detected, the action level will be raised to 5 ppm. The action levels are presented on Table 2.

If it is determined that the source of these emissions cannot be controlled or if action levels are greatly exceeded, community notification procedures will be initiated as described in the HASP and contingency plan.

The remedial activities planned at the site include a program to manage landfill gas including the installation of perimeter gas probes. Gas monitoring protocols and response actions is associated with these probes are described in Section 4.4.5 of the Remedial Design Report. Action levels described in this AMP are for ambient perimeter conditions. The response actions associated with the landfill Gas Management program are for conditions within the gas probes.

7.0 LABORATORY ANALYSIS AND PROTOCOLS

Air samples collected as part of the perimeter air monitoring and personnel sampling programs will be obtained and analyzed in accordance with appropriate standardized procedures such as these defined by U.S. EPA, NIOSH and OSHA. Perimeter and personnel samples will be submitted to an off-site laboratory under chain-of-custody using established handling and shipping protocols. Blank samples will be submitted with perimeter and personnel samples. Further discussion of laboratory procedures and chemical data quality management is discussed in the QAPP. If sampling results indicate the need for chemical-specific sampling and analysis, these procedures will be added as an addendum to the QAPjP and this AMP.

8.0 DATA REPORTING

Detectable airborne concentrations of contaminants obtained from perimeter monitoring will be reviewed by the SSO. The SSO will report concentrations above established background or action levels from real-time monitoring to the Project Manager.

If personal samples with concentrations greater than 25 percent of the established TLV or PEL are obtained, the SSO and Project Manager will be notified. A weekly summary of personnel monitoring results will be submitted to the SSO after results are received. OSHA record keeping requirements will be followed for personal sample results.

Field monitoring logs and calibration logs will be maintained on-site for real-time and perimeter monitoring activities. Weekly summaries of real-time and perimeter sampling results will be submitted and/or maintained by the SSO. Exceedance of action levels requiring a stoppage of work will be immediately reported to the SSO and Project Manager.

Tables

TABLE 1
EXPOSURE LIMITS
SKINNER LANDFILL

Compound	PEL	TLV	STEL	IDLH	Carcinogen	IP(eV)	LEL/UEL (%)
Arsenic	0.005 mg/m³	0.01 mg/m³	NE	100 mg/m³	Y	NA	NA
Barium	0.5 mg/m³	0.5 mg/m³	NE	1100 mg/m³	N	NA	NA
Cadmium	0.2 mg/m³	0.01 mg/m³	NE	50 mg/m³	Y	NA	NA
Chromium	1 mg/m³	0.5 mg/m³	NE	NE	N	NA	NA
Cobalt	0.1 mg/m³	0.05 mg/m³	NE	20 mg/m³	N	NA	NA
Copper	1 mg/m³	1 mg/m³	NE	NE	N	NA	NA
Lead	0.05 mg/m³	0.15 mg/	NE	700 mg/m³	N	NA	NA
Manganese	5 mg/m³**	5 mg/m³	NE	NE	N	NA	NA
Nickel	1 mg/m³	1 mg/m³	NE	NE	Y	NA	NA
Vanadium	0.5 mg/m³**	0.05 mg/m³	NE	70 mg/m³	N	NA	NA
Zinc	15 mg/m³	10 mg/m³	NE	NE	N	NA	NA
Cyanide	5 mg/m³	5 mg/m³*	NE	50 mg/m³	N	NA	NA
Acetone	100 ppm	750 ppm	1000 ppm	20,000 ppm	N	9.69	2.5/13
Benzene	10 ppm	10 ppm	NE	3,000 ppm	Y	9.24	1.3/7.9
2-Butanone	200 ppm	200 ppm	300 ppm	3,000 ppm	N	9.54	1.4/11.4
Carbon Tetrachloride	10 ppm	5 ppm*	10 ppm	300 ppm	Y	11.47	NA
Chlorobenzene	75 ppm	10 ppm	NE	2,400 ppm	N	9.07	1.3/9.6
Chloroethane	1000 ppm	1000 ppm	NE	20,000 ppm	N	10.97	3.8/15.4
Chloroform	50 ppm**	10 ppm	NE	1,000 ppm	Y	11.42	NA
1,1 - dichloroethane	100 ppm	100 ppm	NE	4,000 ppm	N	11.06	5.6/?
1,2 - dichloroethane	50 ppm	10 ppm	NE	1,000 ppm	Y	11.05	6.2/16
1,1 - dichloroethene	NE	5 ppm	20 ppm	NE	N	9.6	5.6/12.8
1,2 - dichloropropane	75 ppm	75 ppm	110 ppm	2,000 ppm	Y	10.87	3.4/14.5
Ethyl benzene	100 ppm	100 ppm	125 ppm	2,000 ppm	N	8.76	6.8/8.0
Methylene chloride	500 ppm	50 ppm	NE	5,000 ppm	Y	11.32	14/22
Styrene	100 ppm	50 ppm*	100 ppm	5,000 ppm	N	8.40	1.1/7.0
Tetrachloroethene	100 ppm	25 ppm	100 ppm	500 ppm	Y	9.32	NA

TABLE 1
EXPOSURE LIMITS
SKINNER LANDFILL - CONTINUED

Compound	PEL	TLV	STEL	IDLH	Carcinogen	IP(eV)	LEL/UEL (%)
1,1,2,2 - tetrachloroethane	5 ppm*	1 ppm*	NE	150 ppm	Y	11.10	NA
Toluene	200 ppm	50 ppm*	NE	2,000 ppm	N	8.82	1.2/7.1
1,1,1 - trichloroethane	350 ppm*	350 ppm	450 ppm	1,000 ppm	N	11.00	7.5/12.5
1,1,2 - trichloroethane	10 ppm*	10 ppm *	NE	500 ppm	N	11.00	NA
Trichloroethene	100 ppm	50 ppm	100 ppm	1,000 ppm	N	9.45	8/10.5
Vinyl Chloride	1 ppm	5 ppm	NE	NE	Y	9.99	3.6/33
Xylene	100 ppm	100 ppm	150 ppm	1,000 ppm	N	8.56	1.0/7.0
bis (2-chloroethyl) ether	15 ppm	5 ppm	10 ppm	250 ppm	Y	NA	NA
bis (2-ethyl hexyl) phthalate	5 mg/m^3	5 mg/m^3	10 mg/m^3	NE	Y	NA	0.3/?
Butyl benzyl phthalate	NE	NE	NE	NE	NE	NA	NA
Coal Tar Pitch Volatiles***	0.2 mg/m^3	0.2 mg/m^3	NE	700 mg/m^3	Y	NA	NA
Di-n-butyl phthalate	5 mg/m^3	5 mg/m^3	NE	9300 mg/m^3	N	NA	0/5/?
Diethyl phthalate	NE	5 mg/m^3	NE	NE	N	NA	NA
4-methyl phenol (cresol)	5 mg/m^3*	5 mg/m^3	NE	250 ppm	N	8.93	1.1/?
2-methyl naphthalene	NE	NE	NE	NE	NE	NA	NA
Napthalene	10 ppm	10 ppm	15 ppm	500 ppm	N	8.12	0.9/5.9
Phenol*	5 ppm*	5 ppm*	NE	250 ppm	N	8.5	1.8/?
Aldrin	0.25 mg/m^3	0.25 mg/m^3*	NE	100 mg/m^3	Y	NA	NA
Arochlor 1254 (PCB)	0.5 mg/m^3*	0.5 mg/m^3*	NE	10 mg/m^3	Y	NA	NA
4,4' - DDD	NE	NE	NE	NE	Y	NA	NA
4,4' - DDE	NE	NE	NE	NE	NE	NA	NA
4,4' - DDT	1 mg/m^3*	1 mg/m^3	NE	NE	NA	NA	NA
Dieldrin	0.25 mg/m^3	0.25 mg/m^3*	NE	450 mg/m^3	Y	NA	NA
1,2-dichlorobenzene	50 ppm**	25 ppm	50 ppm	1000 ppm	N	9.06	2.2/9.2
1,4-dichlorobenzene	75 ppm	10 ppm	NE	1000 ppm	Y	8.98	NA
Endrin	0.1 mg/m^3	0.1 mg/m^3*	NE	2000 ppm	N	NA	NA
Hexachlorobenzene	NE	0.025 ppm	NE	NE	N	NA	NA

TABLE 1
EXPOSURE LIMITS
SKINNER LANDFILL - CONTINUED

Compound	PEL	TLV	STEL	IDLH	Carcinogen	IP(eV)	LEL/UEL (%)
Hexachlorobutadiene	0.02 ppm	0.02 ppm*	NE	NE	Y	NA	NA
Heptachloronorborene	NE	NE	NE	NE	NE	NA	NA
Methane	NE	NE	NE	NE	N	12.6	5/15
Hydrogen Sulfide	20 ppm	10 ppm	15 ppm	300 ppm	N	10.46	4.0/44

NOTE: NA - Not Applicable/Not Available
NE - Not Established
PEL - Permissible Exposure Limits (OSHA)
TLV - Threshold Limit Values (ACGIH)
STEL - Short-Term Exposure Limits (ACGIH)
IDHL - Immediately Dangerous to Life or Health (NIOSH)
IP - Ionization Potential
LEL/UEL - Lower Explosive Limit/Upper Explosive Limit
* Skin Notation: Potential for dermal absorption
** Ceiling Limit
*** Includes the following on-site chemicals: anthracene, benzo (a) anthracene, benzo (b) fluorathene, benzo (k) fluoranthene. benzo (a) pyrene, benzo (g,h,i) perylene, chrysene, fluoranthene, indeno (1,2,3-cd) pyrene, pyrene

TABLE 2

AIR MONITORING PLAN ACTION LEVELS

WORK ZONE PERIMETER MONITORING

Potential Contaminant	Action Level	Action
Particulates (Real-Time)	150 ug/m^3 for 24-hour period	Contact PM; Institute dust control methods; halt work if particulates cannot be controlled.
Total Volatile Organics (Real-Time)	1 ppm	Monitor for vinyl chloride and benzene, if not present, raise action level to 5 ppm; if present, halt work until organics can be controlled; if uncontrollable, PM or SSO will make community contacts.
Explosive Gases	10% Lower Explosive Limit	Halt work until gas levels can be brought below action level; if uncontrollable, PM or SSO will make community contacts.

ANALYTICAL PERIMETER MONITORING

Potential Contaminant	Action Level	Action
Individual Contaminants as listed on Table 1	25% OSHA PEL	Contact PM; compare analytical data with real-time monitoring results and background data; Implement control measures as appropriate
	100% OSHA PEL	Contact PM; halt work; make community contacts
Particulates	150 ug/m^3 for 24-hour period	Contact PM; compare analytical data with real-time monitoring results and background data; Implement control measures as appropriate.

SUPPORT PLAN F

SKINNER LANDFILL SUPERFUND SITE
CONTINGENCY PLAN
WEST CHESTER, BUTLER COUNTY, OHIO

Rust Environment & Infrastructure of Ohio Inc.
PROJECT NO. 72680

May 20, 1996

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1.0 INTRODUCTION

Presented herein are plans for emergency occurrences that may arise on-site during remedial activities. This plan addresses responsibilities of plan implementation, emergency service contacts and protocols for implementation of the plan. Types of emergencies addressed include fire or explosion, serious personal injury, chemical exposure, release of hazardous materials and unsafe working conditions. This plan also references other applicable plans that may be implemented for emergency occurrences including the Spill Prevention and Countermeasures Plan (SPCC) Support Plan D, the Air Monitoring Plan (AMP) Support Plan E, and the site-specific Health and Safety Plan (HASP) Support Plan C. These plans are presented as separate documents for this submittal but will be maintained together in the same volume as they are interrelated.

2.0 SITE LOCATION AND DESCRIPTION

The Skinner Landfill is located approximately 15 miles north of Cincinnati, Ohio near West Chester, Butler County, Ohio in Township 3, Section 22, Range 2. The site is located along Cincinnati-Dayton Road. The site is bordered on the south by the East Fork of Mill Creek, on the north by wooded land, on the east by a Consolidated Railroad Corporation (Conrail) railroad right-of-way, and on the west by the Skinner Creek.

The site is located in a highly dissected area that slopes from a till-mantled bedrock upland to a broad, flat-bottomed valley that is occupied by the main branch of Mill Creek. Elevations on the site range from a high of nearly 800 feet above mean sea level (MSL) in the northeast, to a low of 645 feet MSL near the confluence of the Skinner Creek and the East Fork of Mill Creek. Both Skinner Creek and the East Fork of Mill Creek are small, shallow streams. Both of these streams flow to the southwest from the site toward the main branch of Mill Creek. A third on-site stream, Dump Creek, borders the landfill on the east. Dump Creek is intermittent and flows south into the East Fork of Mill Creek. Three shallow ponds are also located on the site.

In general, the site is underlain by relatively thin glacial drift over interbedded shales and limestones of Ordovician age. The composition of the glacial drift ranges from intermixed silt, sand and gravel, to silty, sandy clays; and its thickness ranges from zero to over 40 ft on the site. The sand and gravel deposits comprise the hills and ridges and are encountered near the surface of the central portion of the site. The silts and clays usually occur as lenses in the sands and gravel or directly overlie bedrock.

2.1 Site History and Background

The property was originally developed as a sand and gravel mining operation, and was subsequently used as a landfill from 1934 to 1990. According to U.S. EPA studies, materials deposited at the site include demolition debris, household refuse and a wide variety of chemical wastes. The waste disposal areas include a now-buried waste lagoon near the center of the site and a landfill. According to U.S. EPA studies, the buried waste lagoon was used for the disposal of paint wastes,

ink wastes, creosote, pesticides, and other chemical wastes. The landfill area, located north and northeast of the buried lagoon, received predominantly demolition and landscaping debris.

In 1976, the Ohio EPA (OEPA) initiated an investigation of the site in response to reports of a black oily liquid that was observed during a fire call to the site. Before the OEPA could complete the investigation, the landfill owners, the Skinners, covered the lagoon with a layer of demolition debris. Mr. Skinner further dissuaded the OEPA from accessing the site by claiming that nerve gas, mustard gas, and explosives were buried in the landfill. The OEPA requested the assistance of the U.S. Army after obtaining this information. Mr. Skinner later retracted his statements concerning buried ordnance, and an U.S. Army records review performed in 1992 did not reveal any evidence of munitions disposal at the site.

In 1982, the site was placed on the National Priority List by the U.S. EPA based on information obtained during a limited investigation of the site. The investigation indicated groundwater contamination had occurred as a result of the buried wastes. In 1986, a Phase I Remedial Investigation was conducted that included sampling of groundwater, surface water and soil, as well as a biological survey of the East Fork of Mill Creek and Skinner Creek. A Phase II Remedial Investigation was conducted from 1989 to 1991 and involved further investigation of groundwater, surface water, soils and sediments. A Baseline Risk Assessment and Feasibility Study (FS) were completed in 1992.

The Phase II Remedial Investigation revealed that the most contaminated media at the site is the soil from the buried waste lagoon. Lower levels of contamination were also found in soils on other portions of the site and in the groundwater, and very low levels were found in the sediments of the Mill Creek, the Skinner Creek, the Duck Pond, and the Diving Pond. Migration of the landfill constituents has been limited, and the Phase II Remedial Investigation concluded that there had been no off-site migration of landfill constituents via groundwater flow.

3.0 RESPONSIBILITIES

The Site Emergency Coordinator responsibilities will be performed by an individual appointed by the Project Manager and he/she will implement the emergency action plan as outlined (29 CFR 1910.38). It is assumed that the project manager will appoint the primary Site Safety Officer as the Site Emergency Coordinator and the Spill Coordinator as described in the SPCC Plan (Support Plan D). Any emergency occurrences will be reported to the Site Emergency Coordinator who will in turn communicate to the Project Manager. Those people responsible for the remedy implementation will make or direct the Site Coordinator to make contacts with agencies requiring notification of the particular occurrence. The exception to this will be any contacts required for immediate threats to health, human safety or property such as fire or emergency medical contacts; these contacts will be made immediately by the SSO or site personnel.

4.0 COMMUNITY INVOLVEMENT AND EMERGENCY SERVICE CONTACTS

Provided below is a description of how information will be provided to the community, a list of emergency service contacts and site emergency preparations.

4.1 Community Involvement

Prior to the initiation of site activities, key community personnel and public safety departments will be notified of the activities that will occur and will be informed of the need for emergency assistance and the potential emergency contingencies. The community contacts who will be informed of site activities will include (but will not be limited to): Union Township Administrative Assistant and the Union Township Trustees, Union Township Police Department, Union Township Fire Department, the Butler County Emergency Management Agency, and the Mercy Hospital Fairfield. These entities will be provided with copies of the Health and Safety Plan and Contingency Plan. The community will be informed of planned work days at the site. If site work is conducted when school is in session, a representative of Union Elementary School will also be informed when site activities will occur.

Two to three weeks prior to the initiation of site activities, Contractors and/or the representative(s) of the implementors will meet with the West Chester Coalition on the Skinner Landfill Site to review this plan. This will be followed by a meeting with the public safety departments, as applicable.

4.2 Emergency Service Contacts

The Emergency Coordinator will verify appropriate emergency service contacts within the community and communicate with these contacts before beginning work on-site. The Emergency Coordinator will inform the emergency service contacts about the nature and duration of work expected on the site and the type of contaminants and possible health or safety effects of emergencies involving these contaminants. Also at this time, the Emergency Coordinator and the emergency response contacts will make arrangements to handle any emergencies that might be anticipated.

EMERGENCY PHONE NUMBERS:

Police Department	911 (513) 777-5126 (Union Twsp. Non-emergency)
Fire Department	911 (513) 777-5216 (Union Twsp. Non-emergency)
Hospital	(513) 870-7000 Mercy Hospital Fairfield
Hospital Address	3000 Mack Road
National Response Center	(800) 424-8802
Project Manager	
Site Safety Officer	

Construction Quality Assurance Consultant Health & Safety Representative(s)	
Prime Contractor Health & Safety Representative(s)	
Implementor Representative	
U.S. EPA Representative	Jamey Bell (312) 886-6436
OEPA Representative	Greg Youngstrom (513) 285-6065
OEPA - Emergency Spills	(800) 282-9378
National Response Center Releases	(800) 424-8802
Butler County Emergency Management Agency	(513) 887-3472
Union Township Trustees	Nell Kilpatrick-Administrative Assistant (513) 777-5900
West Chester Coalition on Skinner Cleanup	(513) 779-4424
Union Elementary School	(513) 777-2201
Butler County Planning Commission	(513) 887-3413

HOSPITAL ROUTE:

From the site, turn right (north) on Cincinnati-Dayton Road to the I-75 intersection and take I-75 South. Proceed on I-75 to I-275 West. Take I-275 West to the Winton Road Exit (at Forest Fair Mall) and take the north exit. Travel north on Gilmore Road (Winton Road south of the freeway) to Mack Road. Turn right (east) on Mack Road and the Mercy Hospital Fairfield will be on the left (north) side of the road at 3000 Mack Road. A map to the

hospital is provided in the HASP. Approximate travel time is estimated to be 15 to 20 minutes from the site to the hospital.

4.3 Emergency Preparations

Once the Support Zone is established, and before the field activity start-up, the Site Emergency Coordinator will drive the route to the hospital, post directions and/or a map to the hospital, set up the first aid station, obtain a 10-pound Type A/B/C fire extinguisher and other emergency equipment.

5.0 IMPLEMENTATION

The Site Emergency Coordinator will implement the emergency action procedures whenever conditions at the site warrant such action. The Site Emergency Coordinator will be responsible for coordinating the evacuation, emergency treatment, and emergency transport of site personnel as necessary, and for notification of emergency response units and the appropriate management staff. The following conditions may require implementation of emergency action procedures:

- Fire or explosion on-site;
- Serious personal injury and/or chemical exposure;
- Release of hazardous materials, including gases or vapors at levels greater than the maximum use concentrations of respirators; and
- Unsafe working conditions, such as inclement weather, or tornado.

6.0 FIRE OR EXPLOSION

If a fire or explosion has taken place, emergency steps will include 1) evacuation of work area and venting, and 2) notification of the fire department and of other appropriate emergency response groups, as necessary. If a small fire occurs and the Site Emergency Coordinator deems that it is appropriate to attempt to fight the fire, a portable fire extinguisher will be used. The person attempting to extinguish the fire should start at least eight feet up wind of the fire, aim the extinguisher at the base of the fire, and sweep the extinguisher from side to side while slowly approaching the fire. Portable fire extinguishers will be maintained for each work zone.

7.0 FIRST-AID AND MEDICAL PROCEDURES

7.1 Physical Injury

Emergency first aid will be administered on-site as appropriate. Then, the individual will be decontaminated (if possible depending on the severity of the injury) and transported to the Mercy Hospital Fairfield, if needed.

7.2 Chemical Exposure

Typical response procedures for the anticipated contaminants of concern on the site include:

SKIN CONTACT: Use copious amounts of soap and water. Wash/rinse affected area thoroughly, then provide appropriate medical attention. Eye wash will be provided on-site at the CRZ and/or support zone as appropriate. Eyes should be rinsed for 15 minutes upon chemical contamination.

INHALATION: Move to fresh air and/or, if necessary, decontaminate/transport to hospital.

INGESTION: Decontaminate and transport to emergency at the Mercy Hospital Fairfield.

PUNCTURE WOUND OR LACERATION: Decontaminate and transport to emergency at the Mercy Hospital Fairfield. The SSO will provide medical data sheets and a copy of the HASP with MSDSs to medical personnel as requested.

Detailed first-aid procedures are provided in Appendix II of the HASP for individual contaminants.

8.0 HAZARDOUS MATERIALS OR VAPOR RELEASE

In the event that there is a release of hazardous materials above the limitations of the PPE in use, site personnel will move up wind until concentrations fall to a safe level. Monitoring will continue to determine if increased levels of contaminants will migrate beyond the site boundary. The Air Monitoring Plan will be followed concerning elevated levels of airborne contaminants at or near the site boundary provided as Support Plan E.

9.0 ADVERSE WEATHER CONDITIONS

In the event of adverse weather conditions, the Site Emergency Coordinator will determine if work can continue without endangering the health and safety of field workers. Some items to be considered before determining if work should continue are:

- Potential for heat stress and heat related-injuries;
- Potential for cold stress and cold-related injuries;
- Treacherous weather-related working conditions;
- Limited visibility; and
- Potential for electrical storms.

9.1 Heat Stress

The Site Emergency Coordinator will continuously monitor personnel visually for signs of heat stress. In addition, field personnel will be instructed to observe for symptoms of heat stress and methods on how to control it. One or more of the following control measures can be used to help control heat stress:

- Provision of adequate liquids to replace lost body fluids. Employees must replace water and salt lost from sweating. Employees must be encouraged to drink more than the amount required to satisfy thirst. Thirst satisfaction is not an accurate indicator of adequate salt and fluid replacement;

- Replacement fluids can be commercial mixes such as Gatorade. (Recommend mixing twice as much water as commercial mix suggests);

- Establishment of a work regime that will provide adequate rest periods for cooling down. This may require additional shifts of worker;

- Cooling devices such as vortex tubes or cooling vests can be worn beneath protective garments;

- All breaks are to be taken in a cool rest area;

- Employees will remove impermeable protective garments during rest periods;

- Employees will not be assigned other tasks during rest periods;

- Employees will be informed of the importance of adequate rest, acclimation, and proper diet in the prevention of heat stress; and

- Employees should not consume alcoholic or diuretic (e.g. coffee, tea) beverages during the work shift or breaks.

In extremely hot or humid conditions work/rest cycles to control heat stress on-site may be defined by Wet Bulb Globe Temperature Index (WBGT) technique. Adjustments to the work/rest cycles may be required when workers are wearing protective coveralls (i.e., tyvek). This method requires the use of a black globe thermometer, a natural wet-bulb and a dry bulb. The method is described

in detail in "Threshold Limit Values for Chemical Substances and Physical Agents" published by the American Conference of Governmental Industrial Hygienists (ACGIH).

9.2 Cold Exposure

If the field activities occur during a period when temperatures average below freezing, the following guidelines will be followed.

Persons working outdoors in temperatures at or below freezing may be subject to frostbite. Extreme cold for a short time may cause severe injury to the surface of the body, or result in profound generalized cooling of the body core, resulting in coma and death. Areas of the body which have high surface area-to-volume ratio such as fingers, toes, ears, are the most susceptible.

Two factors influence the development of a cold injury; ambient temperature and the velocity of the wind. Wind chill is used to describe the chilling effect of moving air in combination with low temperature. For instance, 10° F with a wind of 15 miles per hour (mph) is equivalent in chilling effect to still air at - 18° F.

As a general rule, the greatest incremental increase in wind chill occurs when a wind of 5 mph increases to 10 mph. Additionally, water conducts heat 240 times faster than air. Thus, the body cools suddenly when chemical-protective equipment is removed if the clothing underneath is perspiration-soaked.

Local injury resulting from cold is included in the generic term frostbite. There are several degrees of damage. Frostbite of the extremities can be categorized into:

- Frost nip or incipient frostbite: Characterized by suddenly blanching or whitening of skin;
- Superficial frostbite: Skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient; and
- Deep frostbite: Tissues are cold, pale, and solid, extremely serious injury.

Prevention of frostbite is vital. Keep the extremities warm. Wear insulated clothing as part of one's protective gear during extremely cold conditions. Check for symptoms of frostbite at every break. The onset is painless and gradual--you may never know you have been injured until it is too late.

To administer first aid for frostbite, bring the victim indoors and rewarm the areas quickly in water between 39°C and 41°C (102°F to 105° F). Give a warm drink--not coffee, tea, or alcohol. The victim should not smoke. Keep the frozen parts in warm water or covered with warm clothes for 30 minutes, even though the tissues will be very painful as it thaws. Then elevate the injured area and protect it from injury. Do not allow blisters to be broken. Use sterile, soft, dry material to cover the injured areas. Keep victim warm and get immediate medical care.

After thawing, the victim should try to move the injured areas a little, but no more than can be done alone (without help).

- Do not rub the frostbitten part (this may cause gangrene).
- Do not use ice, snow, gasoline, or anything cold on frostbite.
- Do not use heat lamps or hot water bottles to rewarm the part.
- Do not place the body part near a hot stove.

Systemic hypothermia is caused by exposure to freezing or rapidly dropping temperature. Its symptoms are usually exhibited in five stages: 1) shivering; 2) apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body to less than 95°F; 3) unconsciousness, glassy stare, slow pulse, and slow respiratory rate; 4) freezing of the extremities; and, finally, 5) death.

Effects arising from cold exposure will be minimized by providing workers with insulated clothing when the equivalent chill temperature as presented in the ACGIH booklet is less than 30°F. Furthermore, field activities will generally be curtailed or halted if the equivalent chill temperature is below -20°F. The ultimate responsibility for delaying work at a site due to inclement weather rests with the SSO.

9.3 Other Severe Weather

If threatening weather approaches, the SSO will be prepared to halt field activities. Rain, lightning and threat of tornado or flood are threatening conditions that should be considered. Heavy equipment operations and drilling typically do not occur when rain or lightning begins. Some field operations may continue during light rain at the SSO's discretion. If threatening weather is likely, the SSO should monitor a radio for weather information updates.

10.0 OTHER SAFETY ISSUES

10.1 Poison Ivy

If someone should come in contact with poison ivy, the individual should immediately wash the affected area with the Ivy Cleaner provided in the first aid kit. If a rash develops, it should be treated at a medical facility as soon as possible.

10.2 Snake Bite Prevention and First Aid

Precautions against the possible presence of snakes should be taken when walking through overgrown vegetation and when moving debris (i.e., lumber, scrap metals, etc.). If someone is bitten by a snake, and the snake bite occurs in a location that is within a 1-hour drive of a medical facility, such as at the Skinner site, a conservative approach is safest. Keeping the victim quiet, lying or sitting and reassuring him/her is all that is required. He/she should be transported safely (no speeding) to Mercy Hospital Fairfield. For the reassurance of both the victim and the first aider, a

snakebite is not nearly as dangerous as popular mythology would suggest. In North America, death from snakebite to healthy adults is very rare. Many bites, even from known poisonous snakes, do not result in a significant amount of venom being injected. Even when significant envenomation occurs, symptoms develop slowly over many hours and can be controlled with appropriate treatment. Field treatments advised against include ice, cutting and suction around the wound, and tourniquets. Studies indicate that ice leads to increased tissue destruction. Cutting and sucking out the wound can be shown to offer some help if it is done with the correct technique and equipment and if the victim has received a large dose of venom. In light of the damage that can be done, the risk of such a procedure is too high. It is best to transport the person immediately to a medical facility.

10.3 Tick Prevention and First Aid

Routinely check for ticks after being outdoors. Remove ticks as soon as possible before they embed. To minimize exposure, wear light-colored clothing so ticks can be detected. Tuck pants into boots or socks and wear longsleeved shirts. Apply tick/insect repellent to clothing, unless this may interfere with the integrity of samples collected for laboratory analysis.

When a tick is found embedded, remove it by grasping it with a tweezers as close to the skin as possible and gently pull it straight out. Do not twist or jerk the tick because the head may remain embedded. Once the tick is removed, wash the area and your hands with soap and water and apply an antiseptic. Save the tick in a jar labeled with the date and the place where the tick was acquired. A physician may find this information useful and the tick specimen helpful in diagnosis if an infection results.

11.0 COMMUNITY EXPOSURE AIR MONITORING

In addition to the on-site air monitoring that will be conducted during field activities for health and safety of site workers and for field screening, air monitoring will also be conducted for community exposure. Based on previous sampling data and monitoring, it is not anticipated that concentrations of site contaminants above background will occur. The activities that will occur as part of the air monitoring program are described in more detail in the Air Monitoring Program (AMP). The AMP is presented as Support Plan E.

If air monitoring indicates that volatile organics or explosive gases are present above background at the site perimeter, monitoring will be conducted and evaluated on a frequent basis by site personnel during site activities. If VOCs exceed 1 ppm above background, LEL readings exceed 10%, particulates exceed 150 ug/m^3, field activities will be halted until the source of these emissions can be controlled. The action level for VOCs will be raised to 5 ppm if no benzene or vinyl chloride is detected using detector tubes. If it is determined that the source of the elevated emissions cannot be controlled the following community entities will be notified: Union Elementary School, Union Township Administrative Assistant, the Butler County Emergency Management Agency, and the Union Township Fire Department.

If site conditions indicates that dust is being generated on-site from field activities that may potentially reach the perimeter, dust suppression methods will be utilized. The soil will be sprayed with enough potable water to reduce the dust, but not enough to produce surface runoff. If dust generation cannot be controlled in this manner, field activities will be halted until a successful method of dust control can be employed. Additional dust suppression methods are described in the AMP.

12.0 SPILLS AND RELEASES

In the event of a spill or release, the SPCC plan will be implemented. The SPCC Plan is presented as Support Plan D. In addition to outlining general spill procedures, this plan addresses notification procedures and spill prevention measures.

G

SUPPORT PLAN G

SKINNER LANDFILL SUPERFUND SITE
LONG-TERM PERFORMANCE PLAN
WEST CHESTER, BUTLER COUNTY, OHIO

Rust Environment & Infrastructure of Ohio Inc.
PROJECT NO. 72680

May 20, 1996

LIST OF ACRONYMS

AMP	Air Monitoring Plan
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirements
BZ	Breathing Zone
CD&D	Construction Demolition and Debris
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CGI	Combustible Gas Indicator
CHSD	Corporate Health and Safety Director
CLP	Contract Laboratory Program
cm/sec	Centimeters Per Second
CO	Carbon Monoxide
CQA	Construction Quality Assurance
CQAC	Construction Quality Assurance Consultant
CRZ	Contamination Reduction Zone
CSDI	Contaminated Soils Design Investigation
CZ	Control Zone
DSW	Division of Surface Water (OEPA)
DSR	Division Safety Representative
EPA	Environmental Protection Agency
EZ	Exclusion Zone
FID	Flame Ionization Detector
FML	Flexible Membrane Liner (low density polyethylene)
FSP	Field Sampling Plan
ft	Feet
ft/sec	Feet Per Second
GCL	Geosynthetic Clay Layer
gpd	Gallons Per Day
gpm	Gallons Per Minute
GWDI	Groundwater Design Investigation
HAP	Hazardous Air Pollutant
HASP	Health and Safety Plan
HSM	Health and Safety Manager
IDLH	Immediately Dangerous to Life or Health
IRM	Interim Remedial Measures
kg/d	Kilograms Per Day
lb/day	Pounds Per Day
LEL	Lower Explosion Limit
LTPP	Long Term Performance Plan
MSL	Mean Sea Level
NIOSH	National Institute for Occupational Safety and Health
NO_x	Oxides of Nitrogen
NWI	National Wetland Inventory

LIST OF ACRONYMS - CONT

O_3	Ozone
OAC	Ohio Administrative Code
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
ORC	Ohio Revised Code
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PID	Photoionization Detector
PLC	Programmable Logic Controller
PM-10	Particulate Matter less than 10 microns
PRP	Potentially Responsible Party
PPE	Personal Protective Equipment
psi	Pounds Per Square Inch
QAPP (QAPjP)	Quality Assurance Project Plan
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RHSS	Regional Health & Safety Specialist
ROD	Record of Decision
SI	Site Inspection
SO_2	Sulfur Dioxide
SOP	Standard Operating Procedure
SOW	Statement of Work
SPCC	Spill Prevention Control and Counter Measure Plan
SSO	Site Safety Officer
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
SZ	Support Zone
TDH	Total Dynamic Head
TLV	Threshold Limit Values
TSS	Total Suspended Solids
TWA	Time Weighted Average
u	Micron
ug/l	Microgram per Liter
USACE	United States Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Services
USGS	United States Geological Survey
VOC	Volatile Organic Compound
yr	Year
WBGT	Wet Bulb Globe Temperature
WZ	Work Zone

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1.0 INTRODUCTION

This document is the Remedial Action (RA) Long Term Performance Plan (LTPP) for the Skinner Landfill Superfund Site, West Chester, Butler County, Ohio (Figure 1). The LTPP has been prepared pursuant to the requirements of the Statement of Work (SOW) of the Administrative Order on Consent (AOC) between the United States Environmental Protection Agency (U.S. EPA) and the Skinner Landfill PRP Group (PRPs) dated June 4, 1993.

1.1 Applicability

The LTPP addresses the requirement for a groundwater and a surface water monitoring plan for the long-term as called for in the SOW, Sections II, g.1 and g.2, respectively. The monitoring activities for the LTPP start with the first regularly scheduled sampling event after the final RA sampling event.

1.2 Scope of Work

This LTPP provides the mechanism to ensure that remedial action meets the long-term performance standards set forth in the ROD and SOW. Sampling and chemical analysis of groundwater, surface water, and the measurement of groundwater elevations will occur as part of this project following completion of the RA. A description of these field activities are included in the sections that follow.

2.0 GROUNDWATER SAMPLING PLAN

2.1 Introduction

The point of compliance for the downgradient groundwater control system will be the line of monitoring wells between the interception system alignment and East Fork of Mill Creek (Drawing 1). Groundwater samples will be collected from 11 monitoring wells located between the groundwater interception system and East Fork of Mill Creek. The wells include GW06, GW07R, GW58, GW59, GW60, GW61, GW62, GW62B, GW63, GW64, and GW65. The monitoring wells will be sampled quarterly (every three months). The samples will be analyzed for the parameters shown in Table 1, which are the performance parameters identified in Table 2 of this document. However, the implementors may petition U.S. EPA and OEPA to modify the parameter list and sampling frequency based on four consecutive quarters of groundwater monitoring results.

Additionally, measurements of water levels and the presence or absence of DNAPLs will be recorded for piezometers and monitoring wells to be installed as part of the RA (see Field Sampling Plan). The elevations will be calculated using the data identified in Table 3. These measurements will be used to evaluate the potentiometric surface and the monitor for DNAPLs in the vicinity of the landfill cover, and interception system.

2.2 Sampling Procedure Summary

Groundwater sampling will include the following procedures:

- Pre-sampling Observations and Measurements (Section 2.3);
- Sample Collection (Section 2.4);
- Sample Preservation and Shipment (Section 5.2); and
- Chain-of-Custody control (Section 5.3).

Specific procedures, described in the sections that follow, include measurement of water levels; measurement of DNAPLs; purging of wells; field measurements of pH, specific conductance, temperature, sample collection (bottles, preservation and shipping), chain-of-custody control; and field QA/QC procedures. Operation and maintenance procedures for instruments used for field measurements are presented in Appendix I.

2.3 Pre-Sampling Observations and Measurements

Observations and measurements will be documented in the field notebook prior to sample collection at each monitoring well.

2.3.1 Well Integrity

The purpose of monitoring well integrity is to ensure that the physical integrity of all monitoring wells is maintained and that groundwater samples are representative of the groundwater quality of the monitored zone. The sampling team is responsible for assessing the following conditions surrounding the well and noting any potential problems in the field notebook:

- Condition of the surface seal;
- Erosion or ponding of surface water/runoff around the casing;
- Subsidence of the soil materials surrounding the casing;
- Animal or insect activity in or around the casing;
- Obstructions which preclude access to the well;
- Determination if flooding of the well has occurred; and
- Other conditions which affect access or obtaining samples or sample integrity.

The conditions near the casing are important to maintaining the integrity of the well. For example, the surface seal acts to prevent surface water from traveling along the casing to the groundwater. Any damage to the seal, including cracks, must be noted and subsequently corrected. Cracks in the surface seal may allow surface water near the well to seep around the plug and down the casing. Such seepage may allow undesirable mixing of surface water with the groundwater which is to be sampled.

The following observations of the external protective casing are to be noted and recorded by the sampling team in the field notebook:

- Locked external guard casing;
- Animal or insect activity in or on the external guard casing;
- Water in the annular space;
- Severe bends or cracks in the external guard casing;
- Cracks in the concrete pad;
- Blocked weep hole; and
- Other conditions affecting the external guard casing including damage caused by vandalism.

The external guard casing serves to protect the internal well casing. Water in the guard casing is undesirable because it may freeze and crush the PVC well casing. Weep holes in the guard casing must be kept clear to allow water to drain from the guard casing.

The sampling team will visually inspect the PVC well casing before each sampling event. The condition of each well will be noted in the field note book as follows:

- Loose casing;
- Bent or damaged casing;
- Any obstructions in the casing; and
- Condition of the well cap.

The field sampling team will report well integrity discrepancies to the Project Manager. The sampling team must immediately notify the Project Manager by telephone if it is impossible to sample a well, or if the sampling team thinks the sample integrity is compromised.

2.3.2 Measurement of Groundwater Elevations

Water-level and depth to well-bottom measurements will be recorded at each monitoring well using a portable electronic measuring tape. Water levels will also be measured in the piezometers and wells listed in Table 3. Measurements will be recorded to an accuracy of ± 0.01 feet and will be documented in the field notebook. The measurements will be made relative to a surveyed notch in the top of the PVC casing. The data will be used to calculate the volume of water in the respective well casings and to prepare a potentiometric surface map of the area along the interception system alignment. Additionally, the presence or absence of DNAPLs will be measured using an electronic solvent-water probe in each well and piezometer listed in Table 3. The water-level and solvent-water tapes and probes will be decontaminated between measurements in accordance with the procedures in Section 5.5.

2.4 Groundwater Sampling

Purging and sampling equipment will be dedicated to each well to prevent potential cross contamination. Groundwater samples from monitoring wells will be extracted using dedicated submersible electric pumps, positive air displacement pumps, or stainless steel and/or teflon bailers.

2.4.1 Well Purging

At least three water column volumes, measured from the top of water to the base of the well, will be purged from each monitoring well prior to sampling. Purging the wells assures that samples are drawn from the aquifer and not from stagnant water left in the well between sampling events. Stabilization of pH, specific conductance, and temperature during well purging must occur before sampling. Purging will be considered complete when the measurements of samples of consecutive water column volumes agree as follows: pH is $\pm$ 0.1 su, temperature is $\pm$ 1°C, and conductivity is $\pm$ 10 umhos). Purge volume calculations will be as follows: Depth to water will be subtracted from the total well depth, and the result multiplied by a conversion factor for well casing size (0.17 for 2.0-inch I.D. wells). This value will be one water column volume, in gallons, which will be multiplied by three to calculate the minimum required purge volume. A graduated five-gallon bucket will be used to measure the volume purged. Actual purge volumes and start and stop times will be recorded in the Field Notebook. Purge water will be collected and transported to the Decontamination Area where it will be poured onto the top of the landfill.

When a well bales dry during the well purging process, the well will be allowed to recharge. The samples will be collected as soon as sufficient volume has accumulated in the well.

2.4.2 Sample Collection

Samples will be withdrawn from the monitoring wells with the same equipment used for purging. Sample containers will be filled directly from the bailer (or pump) with minimal air contact and without allowing the sampling equipment to contact the containers.

When testing for the presence or absence of Dense Non-aqueous Phase Liquids (DNAPLs) is to be performed, this listing will be performed prior to sample collection. The presence of DNAPLs will be measured with the interface probe used to measure the wells' water levels. After the presence/absence of the DNAPLs have been determined, the groundwater samples will be collected from the wells.

Groundwater samples for Volatile Organic Compounds (VOC) analysis will be collected first. Care will be taken to slowly fill the sample containers to minimize volatilization of the VOCs. Each VOC sample container will be filled with no head-space in the sample container. After collecting the VOC samples, the sample containers for SVOCs, Pesticides/PCBs, Metals, and Cyanide will be filled, respectively.

Measurements of pH, temperature, and specific conductance will be recorded in the field notebook immediately upon sample collection. The analytical procedures for these field measurements are specified in the field measurement SOPs contained in Appendix I of this document. Field measurements will be made in accordance with proper operating procedures for the equipment.

3.0 SURFACE WATER MONITORING PLAN

3.1 Surface Water Monitoring Point Selection Criteria

Monitoring points were chosen to allow impacts from site run-off to be evaluated and include water entering the site upgradient of the landfill, points at and downstream of surface water discharges from the site, and water leaving the site.

3.2 Surface Water Monitoring Point Locations

Surface water samples will be collected for analysis from four monitoring points along East Fork of Mill Creek (Drawing 2). Sample point SW53 was chosen to monitor the quality of streamwater entering the site. Sample points SW51 and SW52 were chosen to monitor surface water runoff and groundwater entering the stream from the landfill cap area. Sample point SW50 was chosen to monitor stream water leaving the landfill area.

Surface water samples will be collected from SW50, SW51, SW52, and SW53 beginning the first quarter following final agency approval of the completed RA components. The samples will be collected quarterly and will be analyzed for parameters found in Table 2. However, the implementors may petition U.S. EPA and OEPA to modify the parameter list and sampling frequency based on four quarters of surface water monitoring results.

3.3 Sampling Procedure Summary

Surface water sampling will include the following procedures:

- Pre-sampling Observations and Measurements (Section 3.4);
- Sample Collection (Section 3.5);
- Sample Preservation and Shipment (Section 5.2); and
- Chain-of-Custody control (Section 5.3).

3.4 Pre-Sampling Observations and Measurements

Observations and measurements will be documented in the field notebook prior to sample collection at each sample point. These observations will include an estimate of stream surface-flow velocity, measurements of pH, specific conductance, and temperature. Visual observations will include any potential impact, such as silting, to Skinner Creek or East Fork of Mill Creek.

Stream samples will be collected at least 24 hours after a rainfall of 0.10 inch or greater. This is to assure that stream samples are representative of potential impacts by site activities and not excessive sediment loading originating from up stream, off-site sources during significant rainfall events. The time and amount of the most recent rainfall will be verified by measurements obtained from the National Weather Service. The National Weather Service at Greater Cincinnati Northern Kentucky International Airport will be contacted for rainfall data.

3.5 Sample Collection

Sampling will begin at the sample location most downstream and proceed progressively to the upstream locations. Samples will be collected as near to midstream (or midchannel) as possible. Sampling at midstream may be changed in the field due to practical considerations such as safety and minimizing disturbance of sediment by the sample team walking in the stream. The samples will be collected directly from the stream by immersing the sample bottle with its opening pointed down stream. Collecting substrate and floating debris will be avoided. Sample bottles containing preservative will not be immersed in the stream. Instead, they should be filled with an intermediate laboratory supplied bottle. Samples for field parameters will be collected in a clean sample bottle. Field parameters will not be measured directly in the stream unless a stilling well is installed. Stream flow may affect measurements reported by the instruments.

Samples for VOC analysis will be collected first. Care will be taken to slowly fill the sample containers to prevent volatilization of the VOCs. Each VOC sample container will be filled with no head-space in the sample container. After collecting the VOC samples, the sample containers for SVOCs, Pesticides/PCBs, Metals, and Cyanide will be filled, respectively.

Measurements of pH, temperature, specific conductance, and dissolved oxygen will be recorded in the field notebook immediately upon sample collection. The analytical procedures for these field measurements are specified in the field measurement SOPs contained in Appendix I of this document. Field measurements will be made in accordance with proper operating procedures for the equipment.

4.0 GROUNDWATER DEPRESSION EVALUATION

The design of an upgradient groundwater control system is not part of this remedial action. Instead, groundwater levels within and underneath the waste materials will be monitored after construction of the landfill cover, to determine whether the groundwater level depression (which is anticipated following installation of the cover) is sufficient to assure that contaminated materials are sufficiently separated from the groundwater table.

The presence of a groundwater depression will be evaluated based on periodic measurement of the potentiometric surface in the wells and piezometers listed in Table 3. These wells include eight piezometers to be installed inside of the proposed limits of the landfill cover. The construction and installation of these piezometers is described in Section 3.3.3 of the FSP. For long-term performance

monitoring, measurements will be made quarterly in conjunction with groundwater level measurements made during quarterly groundwater monitoring events. Procedures for collecting the measurement data will adhere to those procedures described in preceding sections.

The measurements from the various piezometers and wells will be used to develop a potentiometric surface map that will include the area under the landfill cover and in the vicinity of the collection trench and cut-off wall. Water levels from successive measurement events will be compared to identify any trends in the data. Furthermore, the potentiometric surface elevations will be compared to the elevation of the bottom of waste. The elevation of the bottom of waste will be identified during the installation of the piezometers to be located inside the limit of the landfill cover. It is anticipated that a minimum of one full year of groundwater level measurements will be required after completion of the construction of the landfill cover and the downgradient groundwater interception system, in order to perform the Groundwater Depression Evaluation.

The data and results of the groundwater depression evaluation will be presented with the quarterly groundwater monitoring results. The results will include a tabulation of data, historical presentation of data using graphs, and potentiometric surface maps. These reports will also include a discussion of data and results. The presentation of the report will be consistent with Section 8.0 of the QAPjP.

5.0 GENERAL FIELD PROCEDURES

5.1 Sample Preparation

As each sample is collected in the field, it will be placed in a labeled sample bottle with the appropriate chemical preservatives and stored in an iced cooler. Chain-of-custody documents will be prepared for all samples which will be shipped to the laboratory (per the RA QAPjP requirements). Since multiple analyses will be required, different types of containers and preservatives will be necessary. Sample containers and preservatives will be supplied by the laboratory. Containers for collecting samples for VOC analysis will be filled to slightly more than full before the cap is placed on the container to ensure that there is no head space or loss of VOCs from the sample. The number and frequency of the trip blanks, rinsate samples, duplicate samples, matrix spike and matrix spike duplicates are specified in Table 1 of this document. Samples will be shipped to the laboratory per Section 5.0 of the RA QAPjP and Section 5.3 of this document.

5.2 Sample Bottle Preparation and Sample Preservation

Appropriate sample containers and preservatives are presented in Table 4. Samples requiring preservatives shall be preserved in the field with the appropriate reagents supplied by the laboratory. All sample bottles will be certified precleaned. All sample bottles provided by the laboratory will be in accordance with current U.S. EPA guidelines (i.e., Specifications and Guidance for Obtaining Contaminant Free Sample Containers, April 1992).

5.3 Storage and Shipping

Samples which will be shipped to the laboratory for analysis will be prepared for shipment using the following procedures:

- Tighten each sample bottle lid hand tight. Place custody tape over the lid and the sample label;
- Place packing material (approximately 3") in the bottom of a waterproof cooler;
- Seal bottles in clear plastic bags and place them in a cooler in such a way that they do not touch;
- Place pre-cooled blue ice in plastic bags (minimum of 3) and arrange them in the cooler around the bottles;
- Fill the cooler with the sample bottles and packing material;
- Place the completed paperwork (i.e., chain-of-custody forms) in plastic bags and tape them to the inside of the cooler lid;
- Tape the cooler drain shut (if the cooler has a drain);
- Close the cooler and secure the lid by taping the cooler completely around the outside with strapping tape at two locations;
- Place the laboratory address on top of the cooler;
- Place "THIS SIDE UP" labels on all four sides and "FRAGILE" labels on at least two sides of the cooler;
- Affix custody seals on front right and back left corners of the coolers. Cover seal with wide clear tape and strapping tape as appropriate;
- Ship each sample cooler to the laboratory by Federal Express using "PRIORITY OVER-NIGHT DELIVERY"; and
- Contact the laboratory if shipment is on Friday or the day before a holiday to ensure laboratory personnel are available to receive the shipment on the following day.

All samples will be preserved on the day they are collected and will be shipped within 24 hours of their collection. All samples will be under chain-of-custody procedures from the moment the samples are collected until the samples have been analyzed, the data reported to the U.S. EPA and the samples properly disposed of.

5.4 Sample Identification Nomenclature

A sample nomenclature system will be used to permit easy identification of the sample types and sample locations when retrieving data, reviewing analytical results, or performing data manipulations. The system selected for this project will consist of the following:

- The two-letter site code will be "SK";
- The matrix code will be either SW for Surface Water and GW for Groundwater;
- The location number will be a two digit number unique to the sample location;

- The QA sample description will be either FB for field blank, FD for field duplicate, TB for trip blank, MS for Matrix Spike or MSD for Matrix Spike Duplicate;
- The sampling round will be designated with a three digit number starting with "200" to avoid potential confusion with prior sampling. Note that the "100" series will be utilized during the RA.

For example, a sample with the sample number SK-SW53-200 refers to the Skinner Landfill surface water sample from location SW53 collected during the first sampling event of the LTPP.

5.5 Decontamination Procedures

Field personnel will use the following six-step process for decontaminating sample devices to be in direct contact with samples:

- o Wash sampling equipment in a solution of potable water and non-phosphate detergent;
- o Rinse with clean potable water;
- o Rinse with hexane (if DNAPLs are present);
- o Rinse with methanol (if DNAPLs are present);
- o Rinse with organic-free deionized water; and
- o Air dry equipment and wrap in aluminum foil if sampling equipment is to be stored or transported.

All decontamination and other investigation-derived liquids will be collected and transported to the decontamination area. All investigation-derived liquids will be discharged in accordance with the procedures described in SOP-3.

5.6 Final Evidence Files

Custody of the PRP's final evidence files will be maintained by the PRPs Project Coordinator. The files will be kept in a secured, limited access area. The content of the evidence file will include at least all relevant records, reports, correspondence, logs, field log books, copies of laboratory sample preparation and analysis log books, data packages, pictures, project reports, chain-of-custody records/forms, data review reports, etc. Chain-of-custody procedures to be used during the RA Groundwater Monitoring Program are defined in Section 5.0 of the QAPjP.

5.7 Field Quality Assurance/Quality Control

5.7.1 Field QC Checks

Field instruments will be calibrated prior to each use or on a scheduled, periodic basis as recommended in the instrument's operation manual. QC checks on potential impacts to precision and accuracy from sample collection will be assessed through collection and analysis of field duplicates and field rinsate samples in accordance with the applicable procedures described in the

QAPjP. Field duplicate samples will be collected at the frequency defined in Table 1 of the QAPjP and Table 1 of this document.

QC checks for field measurement of pH, temperature, and specific conductance are limited to the following: (1) checking the reproducibility of the measurement by obtaining multiple readings on a single sample/standard or location, every 10 measurements and/or (2) by calibration of the instrument at the beginning of the day, at noon, and at the conclusion of the days sampling or measurement effort (or as specified in the equipment manuals). If the reproducibility of the field data is not within ±10% of the original measurement, all samples (if possible) since the last QC check will be remeasured.

5.7.2 Preventative Maintenance

The field instruments for this project include pH meters, thermometers, and specific conductance meters. The specific preventive maintenance procedures to be followed for field instruments are those recommended by the manufacturers. Field instruments will be checked and calibrated at the field team's office before they are shipped or carried to the field. These instruments will be checked and calibrated daily before use. Calibration checks of field instruments will be performed as needed daily and will be documented in a log book specifically dedicated to field instrument calibration. Critical spare parts such as probes, electrodes, batteries and standards will be available to the sampling personnel to minimize instrument down-time. Back-up instruments will be available or within one-day shipment to avoid delays in the field schedule.

6.0 SAMPLE PARAMETERS AND SCHEDULE

The groundwater monitoring wells will be sampled and analyzed for the parameters specified in Table 1. Sampling will be conducted quarterly (every 3 months) beginning approximately one quarter after final agency approval of the constructed RA components.

7.0 DATA REDUCTION, VALIDATION, AND REPORTING

Raw data from field measurements and sample collection activities will be appropriately recorded in the field log books. These data will be summarized in tabular form for attachment to the project reports. Any further reduction of the data for evaluation purposes in the reports will be documented therein. Chemical data reported by the laboratory will be independently validated per the QAPjP. Each report will include a discussion of the validated laboratory data and results, groundwater potentiometric measurement results, and DNAPL measurement results. A summary table of water level measurements and DNAPL measurements will be included. Also included, will be a potentiometric surface map for the area under the landfill cap and along the trench alignment. Detailed information regarding data reduction, validation, and reporting is presented in Section 8 of the QAPjP.

8.0 CORRECTIVE ACTIONS

Corrective actions must be taken any time a situation develops that threatens data quality. Corrective action may be required if field audits reveal unacceptable deviation from approved procedures. Corrective action may include immediate resampling and/or reanalysis of a few samples, or the cessation of all analyses with the subsequent resampling and/or reanalysis of all samples upon resolution of the problem.

Specific corrective action for field measurements may include the following:

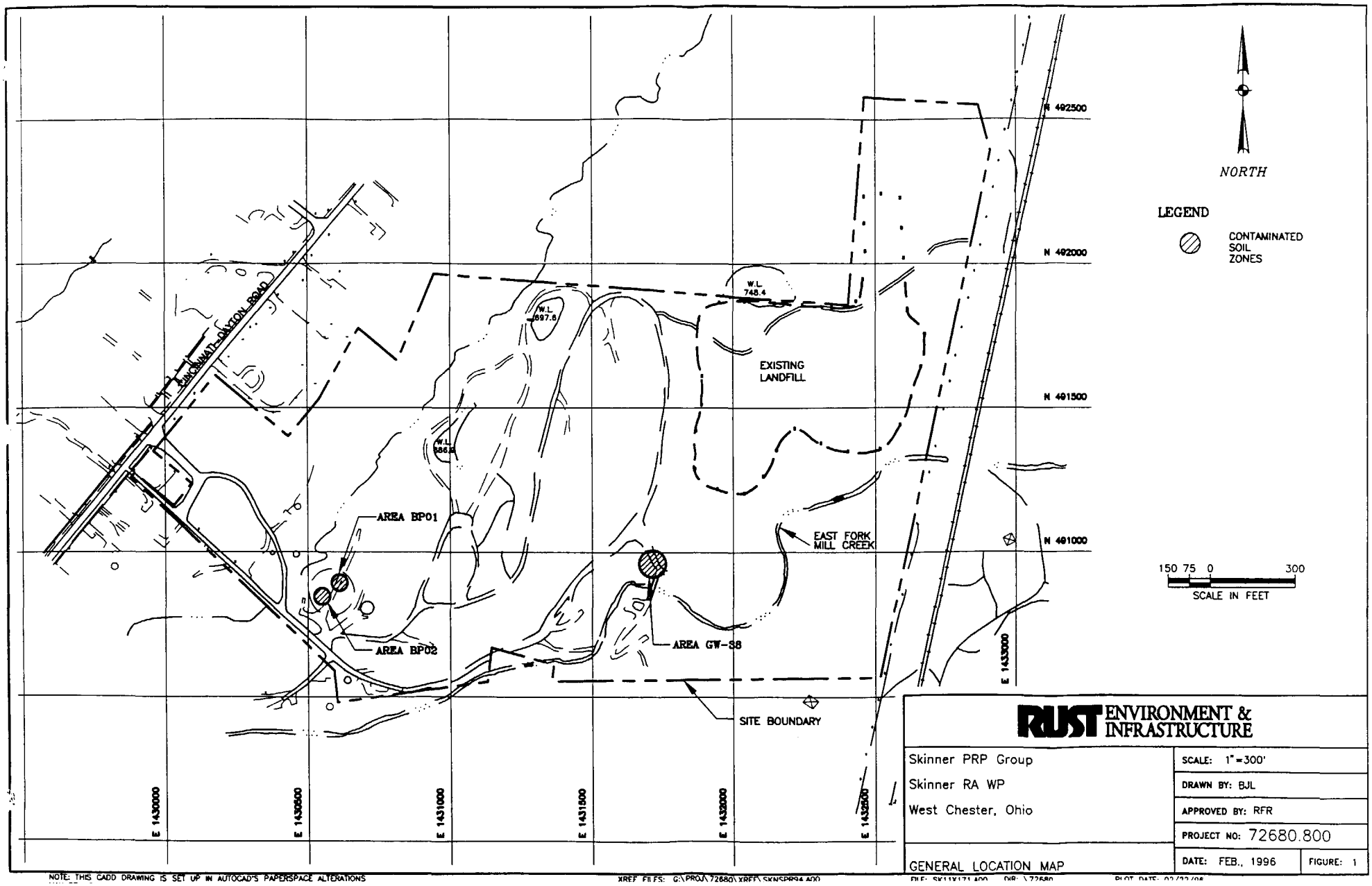
- Repeat the measurement to check the error;
- Check for all proper adjustments for ambient conditions such as temperature;
- Check the batteries;
- Check the calibration and adjust as necessary;
- Replace the instrument or measurement devices; and
- Stop work (if necessary).

Corrective actions during the field LTPP activities may involve:

- Field Team Leader;
- Field Team Members;
- LTPP Task Manager;
- Project Manager;
- PRPs Project Coordinator;
- U.S. EPA Personnel; and/or
- OEPA Personnel.

A QC problem that cannot be solved by immediate corrective action must be thoroughly investigated to determine the extent of the problem and to ensure that all samples affected by the problem are identified and analyzed. If a problem during field LTPP activities cannot be immediately solved, the Field Team Leader should contact the LTPP Task Manager or Project Manager.

Figures



RUST ENVIRONMENT & INFRASTRUCTURE

Skinner PRP Group	SCALE: 1"=300'
Skinner RA WP	DRAWN BY: BJL
West Chester, Ohio	APPROVED BY: RFR
	PROJECT NO: 72680.800
GENERAL LOCATION MAP	DATE: FEB., 1996 / FIGURE: 1

NOTE: THIS CADD DRAWING IS SET UP IN AUTOCAD'S PAPERSPACE ALTERATIONS

XREF FILES: G:\PROJ\72680\XREF\SKNSPR94.400

Tables

TABLE 1

SKINNER LANDFILL RD FIELD ACTIVITIES
SAMPLE ANALYSIS AND SCHEDULE(5)

Field Activity	Sample Points	No. of Samples	Field Dups.(2)	Field Blanks(2)	MS/MSD (3)	Trip Blanks (4)	Total Samples (1)	Sampling Frequency	Test Parameters
Surface Water (long term monitoring)	SW50, 51, 52, 53	4	1	1	1	1	8	Quarterly	Table 2
Groundwater Filtered (metals)	GW06, 07R, 58, 59, 60, 61, 62A, 62B, 63, 64 and 65	11	2	2	1	2	15	Quarterly	Table 2

Notes:
(1) All samples are considered low/medium concentration samples.
(2) One field duplicate and one field blank will be collected every 10 or fewer investigative samples.
(3) MS/MSD consists of extra volume collected for one of the investigative samples. They will be collected at the rate of one for every 20 or fewer investigative samples. (Triple ADDITIONAL volume for VOCs, double ADDITIONAL volume for SVOCs and Pesticides/PCBs).
* - TAL MS and laboratory duplicate analysis must be performed on an aliquot from the original (1 litre) investigative sample container; no extra volume is required.
(4) One trip blank will be included with each shipment of aqueous VOC samples.
(5) Field parameters include temperature, pH, and specific conductance.
(6) TCL, VOC, CRQL; TCL, SVOC, CRQL; TCL, Pesticides and PCBs, CRQL; TAL, CRQL.

TABLE 2

SKINNER LANDFILL REMEDIAL DESIGN
SITE-SPECIFIC GROUNDWATER INTERCEPTION PARAMETERS AND
REVISED MODIFIED TRIGGER LEVELS

Compound	Units	Modified Trigger Limit
Volatile Organic Compounds		
1,1,1-Trichloroethane	ug/l	88
1,1,2,2-Tetrachloroethane	ug/l	107
1,1,2-Trichloroethane	ug/l	418
1,2-Dichloroethane	ug/l	5
1,2-Dichloroethane(total)**	ug/l	70
1,2-Dichloropropane	ug/l	5
2-Butanone	ug/l	7.1
Benzene	ug/l	5
Carbon Tetrachloride	ug/l	5
Chlorobenzene	ug/l	26
Chloroform	ug/l	79
Ethylbenzene	ug/l	62
Styrene	ug/l	56
Tetrachloroethene	ug/l	5
Toluene	ug/l	1000
Trichloroethene	ug/l	5
Vinyl Chloride	ug/l	2
Xylene (total)	ug/l	10000
Semi-Volatile Organics		
1,2,4-Trichlorobenzene	ug/l	77
1,2-Dichlorobenzene	ug/l	11
1,3-Dichlorobenzene	ug/l	600
1,4-Dichlorobenzene	ug/l	75
2,2'-oxybis-(1-Chloropropane)#	ug/l	4360
2,4-Dimethylphenol	ug/l	2120
4-Nitrophenol	ug/l	150
Acenaphthene	ug/l	520

TABLE 2 - CONT

SKINNER LANDFILL REMEDIAL DESIGN
SITE-SPECIFIC GROUNDWATER INTERCEPTION PARAMETERS AND
REVISED MODIFIED TRIGGER LEVELS

Compound	Units	Modified Trigger Limit
Benzo(a)anthracene	ug/l	10
Benzo(a)pyrene	ug/l	10
Benzo(b)fluoranthene	ug/l	10
Benzo(g,h,i)perylene	ug/l	10
Benzo(k)fluoranthene	ug/l	10
bis(2-Chloroethyl)Ether	ug/l	13.6
bis(2-Ethylhexyl)phthalate	ug/l	49
Butylbenzylphthalate	ug/l	10
Chrysene	ug/l	10
Di-n-butylphthalate	ug/l	190
Dibenzo(a,h)anthracene	ug/l	10
Dimethylphthalate	ug/l	73
Fluoranthene	ug/l	10
Hexachloroethane	ug/l	10
Indeno(1,2,3-cd)pyrene	ug/l	10
Isophorone	ug/l	900
Naphthalene	ug/l	44
Nitrobenzene	ug/l	27000
Phenanthrene	ug/l	10
Phenol	ug/l	370
Inorganics		
Antimony	ug/l	60
Arsenic	ug/l	10
Barium	ug/l	1000
Beryllium	ug/l	5
Cadmium	ug/l	5
Chromium	ug/l	11
Copper	ug/l	25
Iron	ug/l	5000

TABLE 2 - CONT

SKINNER LANDFILL REMEDIAL DESIGN
SITE-SPECIFIC GROUNDWATER INTERCEPTION PARAMETERS AND
REVISED MODIFIED TRIGGER LEVELS

Compound	Units	Modified Trigger Limit
Lead	ug/l	4.2
Mercury	ug/l	0.2
Nickel	ug/l	96
Selenium	ug/l	5
Silver	ug/l	10
Thallium	ug/l	40
Zinc	ug/l	86
Cyanide	ug/l	10

Only parameters with existing Table 1 trigger levels were evaluated.
Previously known by the name bis(2-Chloroisopropyl)ether.
** Existing trigger for cis isomer is 70 ug/l, trans isomer is 100 ug/l.

TABLE 3

GROUNDWATER LEVEL MEASUREMENT LOCATIONS

Location	Reference Point	Reference Elevation (MSL) (ft)
*P1 through P9, GW58 through GW66	Top of Well Casing	To be Surveyed
GW06	Top of Well Casing	687.96
GW07R	Top of Well Casing	To be Surveyed
GW24	Top of Well Casing	696.12
GW26	Top of Well Casing	699.27
GW30	Top of Well Casing	678.92

* To be installed during RA.

TABLE 4

SKINNER LANDFILL REMEDIAL DESIGN
WATER SAMPLE BOTTLES, PRESERVATION AND TECHNICAL HOLDING TIMES

Parameters	Container	Preservative	Technical Holding Time	Amount
TCL Volatiles	40 mL VOA vials	HCl to pH<2	10 days	2 x 40 mL
TCL Semi-volatiles	1 L amber glass	Cool, 4 degrees C	5 days to extraction 40 days to analysis	2 x 1 L
TCL Pesticides/PCBs	1 L amber glass	Cool, 4 degrees C	5 days to extraction 40 days to analysis	2 x 1 L
TAL Inorganics (unfiltered/filtered)	1 L polyethylene	HCl to pH<2	180 days (except mercury 26 days)	1 L
TAL Cyanide	1 L polyethylene	NaOH to pH>12	12 days	1 L
Dissolved Oxygen - 4500-0G	1 L polyethylene	Cool, 4 degrees C	24 hours	1 L
BOD - EPA 405.1	1 L polyethylene	Cool, 4 degrees C	48 hours	1 L
COD - EPA 410.4	1 L polyethylene	H_2SO_4 to pH<2	28 days	1 L
TSS - EPA 160.2	1 L polyethylene	Cool, 4 degrees C	7 days	1 L
Oil & Grease - EPA 413.1	1 L amber glass	H_2SO_4 to pH<2	28 days	1 L
Ammonia Nitrogen - EPA 350.1	1 L amber glass	H_2SO_4 to pH<2	28 days	1 L
TDS - EPA 160.1	250 ml polyethylene	Cool, 4 degrees C	7 days	250 mL

APPENDIX I

RUST STANDARD OPERATING PROCEDURES

APPENDIX I

SOP TABLE OF CONTENTS

SOP-1	Well Purging
SOP-2	Groundwater Sampling
SOP-3	Containment and Disposal of Investigation Derived Waste
SOP-4	Standard Operating Procedure for the Measurement of Temperature in Water
SOP-5	Standard Operating Procedure for the Field Measurement of pH in Water
SOP-6	Standard Operating Procedure for the Field Measurement of Conductivity in Water
SOP-7	Standard Operating Procedure for the Measurement of Dissolved Oxygen in Water
SOP-8	Surface Water Sampling

1.0 PURPOSE

The purpose of this procedure is to provide general reference information on well purging by the pumping method prior to the sampling of groundwater wells. The methods and equipment described are for the purging of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This procedure applies to purging relatively large volumes of water in shallow to medium depth wells.

3.0 REQUIREMENTS

Methods for purging from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant.

4.0 REFERENCES

4.1 United States Environmental Protection Agency, 1989. *Groundwater Handbook:* EPA/625/6-87/016.

5.0 DEFINITIONS

None.

6.0 RESPONSIBILITIES

6.1 Project Manager

The Project Manager is responsible for reviewing the purging procedures used by the field crew and for performing in-field spot checks for proper purging procedures.

6.2 Site Geologist

The Site Geologist is primarily responsible for the proper well purging techniques. The Geologist will be responsible for purging of wells, performing necessary physical measurements and observations, and containment of purged water. He must record pertinent information including amount of water purged, pH, specific conductivity, temperature, and turbidity in the Field Log Book.

7.0 EQUIPMENT

1. Purge pump.
2. Power source.
3. Steel retractable engineer's measuring tape (Calibrated to 0.01 foot)
4. Water level indicators.
5. Swabbing equipment (as necessary).
6. pH meter.
7. Specific conductance meter.
8. Thermometer.
9. HNu photoionization detector.
10. Containers for the development water.
11. Field log book.

8.0 PROCEDURE

8.1 General

- The amount of flushing a well should receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions.

- For the volumetric method, generally three well volumes are considered effective for purging a well.

- An alternative method of purging a well is to purge continuously (using a low volume low flow pump) while monitoring specific conductance, pH, and water temperature until the values stabilize.

8.2 Calculations of Well Volume

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to determine the volume of standing water in the well pipe and the volume of water in the filter pack below the well seal. The volume can be easily calculated by the following method. Calculations shall be entered in the field logbook:

1. Obtain all available information on well construction (location, casing, screens, etc.).

2. Determine well or casing and diameter.

3. Measure and record static water level (Depth below ground level or top of casing reference point).

4. Determine depth of well.

5. Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

6. Calculate the volume of water in the casing.

$V_t =$ Pi $(di/2)^2$ (TD-H) (7.48)

Where:

Pi = 3.14
Vt = Total volume, gal
di = inside diameter of casing, ft
TD = total depth of well, ft
H = depth to water, ft, from ground surface

7. Determine the minimum number of volumes to be evacuated before sampling.

8.3 Well Purging by Pumping

- Lower the purge pump into the well until it is submerged. NOTE!!: If resistance is encountered when lowering the pump into the well, WITHDRAW THE PUMP FROM THE WELL and inform the Field Team Leader.

- Direct the pump discharge hose into the receptor bucket and start the pump in accordance with the manufacturer's operations manual.

- Record total volume of water removed.

- Collect at least three samples during purging and measure physical parameters including pH, conductivity, temperature, and turbidity.

- Whenever the receptor bucket is full, dispose of the purge water in accordance with the procedures specified in the IRM QAPjP for the Skinner Landfill.

- Purging will continue until the required volume of water has been removed and the physical parameters have stabilized so that pH is $\pm$ 0.1 su, conductivity $\pm$ 10 umhos, temperature is $\pm$ 1°C, within three successive intervals.

- Decontaminate the bailers per the project-specific work plan.

8.4 Purge Water Containment and Disposal

Purge water will be contained and disposed as detailed in SOP-5.

9.0 ATTACHMENTS

None.

1.0 PURPOSE

The purpose of this procedure is to obtain groundwater samples that are representative of the source from which they are taken and minimize sampler exposure to groundwater contaminants. The methods and equipment described are for the collection of water samples from the saturated zone of the substrata.

2.0 SCOPE

This procedure provides information on proper equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described should be followed whenever applicable, noting that site-specific conditions or project-specific work plans may require adjustments in methodology.

3.0 REQUIREMENTS

Generally, wells should be sampled within three hours of purging. However, wells with poor recharge should be sampled within 24 hours of purging. Poor recharge wells are those that cannot recharge 80% of the original volume within 8 hours.

Applicable preservatives must be added to the sample containers before the samples are collected.

4.0 REFERENCES

4.1 ASTM, 1986. *Annual Book of ASTM Standards,* Section 11. Volume 11.04, D4448-85A.

4.2 Barcelona, M.J., J.P. Gibb and R.A. Miller, 1983. *A Guide to the Selection of Materials for Monitoring Well Construction and Groundwater Sampling,* ISWS Contract Report 327, Illinois State Water Survey, Champaign, IL.

4.3 Johnson Division, UOP, Inc., 1975. *Groundwater and Wells, A Reference Book for the Water Well Industry.* Johnson Division, UOP, Inc., Saint Paul, MN.

4.4 Nielson, D.M. and G.L. Yeates, 1985. *A Comparison of Sampling Mechanisms Available for Small-Diameter Groundwater Monitoring Wells.* Groundwater Monitoring Review 5:38-98.

4.5 Scalf, M.R., J.F. McNabb, W.J. Dunlapp, R.L. Crosby and J. Fryberger, 1981. *Manual of Groundwater Sampling Procedures.* R.S. Kerr Environmental Research Laboratory, Office of Research and Development, USEPA, Ada, OK.

4.6 USEPA, 1980. *Procedures Manual for Groundwater Monitoring at Solid Waste Disposal Facilities.* Office of Solid Waste, United States Environmental Protection Agency, Washington, D.C.

4.7 USEPA, 1986. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, EPA SW-846.

4.8 USEPA, 1987. *Groundwater Handbook,* EPA/625/6-87/016.

4.9 USEPA, 1987. *A Compendium of Superfund Field Operations Methods,* EPA/540/P-87/001.

5.0 DEFINITIONS

None.

6.0 RESPONSIBILITIES

6.1 Project Manager

Responsible for reviewing the sampling procedures used by the field crew and for performing in-field spot checks for proper sampling procedures.

6.2 Site Geologist

The Site Geologist is primarily responsible for the proper acquisition of the groundwater samples.

7.0 EQUIPMENT

Sample containers shall conform with U.S. EPA regulations for preservation of appropriate contaminants.

Ideally, sampling equipment should be completely inert, economical, easily decontaminated, easily sterilized, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection. The sample withdrawal equipment (evacuation devices) to be used on this project are submersible pumps. Other equipment to be used include:

1. Sample Packing and Shipping Equipment.
2. Coolers for sample shipping and cooling.
3. Chemical preservatives.
4. Appropriate packing cartons and filler.
5. Labels.
6. Chain-of-custody documents.
7. Thermometer.

8. pH meter.
9. Portable HNu photoionization detector.
10. Specific conductivity meter.
11. Water-level indicator.
12. Flow meter.
13. Field sampling logbooks.
14. Pails.
15. Gamma and Beta Radiation Detector.

8.0 PROCEDURE

8.1 General

To be useful and accurate, a groundwater sample must be representative of the particular saturated zone of the substrata being sampled. The physical, chemical and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to keep any changes in water quality parameters to a minimum.

The groundwater sampling program should be developed with reference to ASTM D4448-85A, Standard Guide for Sampling Groundwater Monitoring Wells. The ASTM guide is not intended as a monitoring plan or procedure for a specific application, but rather as a review of methods.
The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well, and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing. Stratification may occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach should be followed during sample withdrawal:

1. All monitoring wells shall be purged prior to withdrawing a sample. Evacuation of three volumes is recommended for a representative sample. Purge water will be contained and disposed as detailed in SOP-5.

2. For wells that can be purged dry, the wells should be evacuated and allowed to recover prior to sample withdrawal.

3. For high-yield monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. The use of a pump and certain techniques of sample withdrawal may minimize this possibility.

Stratification of contaminants may exist in the groundwater either in terms of concentration gradients as a result of mixing and dispersion processes in a homogeneous layer, or due to layers of variable permeability into which a greater or lesser amount of the contaminant plume has flowed. Excessive

pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point. This can result in the collection of a non-representative sample. Water produced during purging shall be collected, stored or treated and discharged as allowed. Purge water will be disposed in accordance with the procedures specified in the IRM QAPjP for Skinner Landfill.

8.2 Calculations of Well Volume

To ensure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to determine the volume of standing water in the well casing and the volume of water in the filter pack below the well seal. The volume can be easily calculated by the following method. Calculations should be entered into the field logbook:

1. Obtain the available information on well construction (location, casing, screens, etc.).
2. Determine well or casing diameter.
3. Measure and record static water level (depth below ground level or top of casing reference point).
4. Determine depth of well.
5. Calculate number of linear feet of static water (total depth or length of well casing minus the depth to static water level).
6. Calculate the volume of water in the casing.

$Vt = Pi\ (di/2)^2(TD-H)(7.48)$

Where,

Pi = 3.14
Vt = Total volume, gal
di = inside diameter of casing, ft
TD = total depth of well, ft
H = depth to water, ft, from ground surface
P =

7. Determine the minimum number of volumes to be evacuated before sampling.

8.3 General

The amount of flushing a well should receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped sufficiently to remove the stagnant water but not long enough to induce significant groundwater.

8.4 Sampling

8.4.1 Sampling Methods

The collection of a groundwater sample is made up of the following steps.

1. Record the sample location, site, anticipated sample time, and field sample number using a indelible pen. Fill out sample labels for each of the required sample containers and place labels onto the appropriate sample containers. Labels must be waterproof to prevent water damage. The following information may be included on the sample label:

- site name;
- field identification or sample station number;
- date and time of sample collection;
- type of sample (matrix) and a brief description of the sampling location;
- printed full name of the sampler;
- sample preservative used; and
- types of analyses to be performed.

If a sample is split with another party, sample labels with identical information should be attached to each of the sample containers.

2. Open the well cap and use volatile organic detection meter (HNu) to monitor the escaping gases at the well head to determine the need for respiratory protection.

3. Sound the well for total depth and water level (using decontaminated equipment) and record these data in the field notebook. Calculate the fluid volume in the well.

4. Calculate depth from the casing top to the midpoint of the screen or well section open to the aquifer. Any dry wells encountered must be noted.

5. In the event that recovery time of the well is very slow (e.g., 24 hours), sample collection may be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.

6. To ensure that groundwater samples are representative of actual conditions, samplers must work efficiently to minimize the loss of groundwater contaminants and the introduction of foreign contaminants. To prevent contamination of samples, the sample bottles should be opened only when receiving sample preservatives or groundwater samples and closed immediately afterwards.

The sampler should quickly add the sample into the sample containers, while minimizing aeration and loss of volatile contaminants. Samples collected for analysis of volatile constituents will be collected first, followed by samples collected for analysis of SVOCS, pesticides/PCBs, metals, and cyanide. Additional water from the well will be divided among the remaining sample bottles. For analysis that requires filtered samples, it is preferred that the samples be allowed to settle in a separate sample container, followed by decanting and then filtration. Field filtration may also be accomplished using an in-line filter. Consult the specific analytical procedure for details. Large volume samples for extractable organic compounds, total metals, etc., should be collected last.

When a sample bottle is filled, the bottle must be tightly capped as soon as possible.

7. Efficiency and care must be utilized to obtain representative samples for volatile organic analysis. Unnecessary delays or poor sampling technique will lead to loss of the volatile constituents from the sample.

Add the required preservatives to the sample containers immediately prior to or after collecting the sample, label all containers and stage the collection setup before collecting the sample to minimize sampling time.

Prevent unnecessary stripping of volatile constituents from the sample by minimizing turbulence and aeration when filling the sample container. Quickly fill the sample container until a positive meniscus is achieved above the rim of the container and cap the container immediately. Gently tap the sample container to dislodge any air bubbles and verify that no bubbles are present. If bubbles are detected, immediately uncap the sample, add additional sample from the bailer until a positive meniscus is reestablished, immediately recap the sample and check the sample for bubbles. Repeat this step until the sample contains no bubbles and all required samples are obtained.

8. After sampling, replace the well cap.

9. As soon as all samples are collected, promptly prepare the samples for shipment in accordance with the FSP, and store the samples collected for volatile organic analysis in a cooler with pre-packaged ice. Attach a custody seal to the shipping package as described in the FSP. Make sure that the chain-of-custody forms are properly filled out and enclosed or attached.

10. Record all sampling information in the field log book.

11. Decontaminate all equipment.

8.4.2 Sample Containers

Use the laboratory-supplied sample containers which are pre-cleaned and appropriate for the analytical method for which you are sampling.

8.4.3 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. The Skinner Landfill QAPjP describes the sample preservation and volume requirements for the chemicals that will be analyzed.

8.4.4 Field Filtration

All filtration must occur in the field immediately upon collection. Filters must be prerinsed with organic-free water.

Samples for organic analyses must never be filtered.

8.4.5 Handling and Transporting Samples

After collection, samples should be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If natural ice is used, it should be bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged and possibly cross-contaminated. All sample containers should be enclosed in plastic bags or cans to prevent cross-contamination. Samples should be secured in the ice chest to prevent movement of sample containers and possible breakage.

8.4.6 Sample Holding Times

Holding times (i.e., allowed time between sample collection and analysis) for routine samples are given in Table 6.

8.5 Records

Records will be maintained for each sample that is taken. Record the following information:

- Sample identification (site name, location, project number; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method).
- Sample disposition (analyses to be run; number and size of bottles; preservatives added).

- Additional remarks - (e.g., sampled in conjunction with regulatory authorities; samples for specific conductance value only; samples for key indicator; etc.).

9.0 ATTACHMENTS

None.

1.0 PURPOSE

The purpose of this procedure is to define the methods to be followed to contain and dispose of Investigation Derived Wastes (IDW) to prevent runoff from IDW from impacting any surface waters.

2.0 SCOPE

Investigation Derived Waste will be generated during purging of monitoring wells for development and for sampling, during decontamination procedures occurring on site, and during drilling operations. This SOP should be consulted during any of the above procedures to ensure that the proper precautions are taken.

3.0 REQUIREMENTS

It is important to ensure that the surface waters located on and near the site are not impacted by Investigation Derived Waste.

4.0 REFERENCES

None.

5.0 DEFINITIONS

None.

6.0 RESPONSIBILITIES

6.1 Field Team Leader

The Field Team Leader is primarily responsible for ensuring that the proper procedures are followed to contain and dispose of Investigation Derived Waste. He is responsible for training the field personnel in the proper procedures for the individual tasks.

6.2 Field Geologist

The Field Geologist will be responsible for documenting the disposition of all Investigation derived waste in the field notebook.

7.0 EQUIPMENT

1. Drums.
2. Other containers as appropriate.
3. Personnel protective equipment as needed.

8.0 PROCEDURE

Three field procedures are expected to generate Investigation Derived Waste; purging and development of monitoring wells, decontamination of field equipment, and drilling operations.

8.1 Purge and Development Fluids

Prior to emplacement of the landfill cap, fluids generated during purging or development of monitoring wells will be containerized at the well site transported to the top of the landfill and deposited on the ground surface of the landfill (see Figure 2). Any fluids generated after cap emplacement will be containerized for off-site disposal.

8.2 Decontamination Water

The decontamination zone will be located on top of the landfill. Heavy equipment will be decontaminated there. Bailers, split spoons and other small sampling devices may be decontaminated at the work site as long as the decontamination water is containerized, transported to the decontamination zone and deposited on the ground surface of the landfill. Decontamination fluids generated after the emplacement of the landfill cap will be containerized for off-site disposal.

8.3 Drill Cuttings

Drill cuttings will be drummed at the drill site and transported to the drum storage area located on top of the landfill. The drummed waste will later be incorporated beneath the cap during the RD.

9.0 ATTACHMENTS

None.

1.0 Title: Standard Operating Procedure for the Measurement of Temperature in Water

2.0 Location

This SOP may be used anywhere on or off the Skinner site as long as the requirements of the SOP are met.

3.0 Purpose

This SOP will be used to measure the temperature of influent, effluent, groundwater, and surface water samples.

4.0 Scope

This SOP describes the calibration check and use of an alcohol, bimetallic, or electronic thermometer to measure the temperature of influent, effluent, groundwater, and surface water samples. A thermometer which is properly calibrated may also be used to indicate ambient temperature.

5.0 References

5.1 Waste Management, Inc. Manual for Groundwater Sampling.

6.0 Sample Handling and Preservation

Temperature measurements must be made in-situ, or as soon as possible after a portion of the sample is transferred to a beaker, to avoid temperature changes due to environmental factors.

7.0 Apparatus and Materials

1. alcohol, bimetallic, or electronic thermometer with a range of at least 0 °C to 100°C, with at least 0.1 °C intervals
2. ice bath
3. boiling water bath
4. small (100-200 ml) beakers
5. Chemwipes or equivalent

8.0 Analytical Procedures

1. Ensure that the thermometer calibration has been checked within 30 days of use. If not, suspend the sensing probe of the thermometer directly into an ice bath which has been equilibrating for at least 5 minutes. If the thermometer reads 0 ± 1 °C, record 0.0°C. If the calibration check was satisfactory, complete the calibration check by signing and dating the record.

2. Suspend the sensing probe directly into the sample, or into a portion of the sample which has been collected in a small beaker. Ensure that the probe does not contact anything other than the sample medium.

3. Allow the thermometer to stabilize, and then record the temperature.

4. Remove the thermometer and wipe dry.

9.0 Quality Control

Calibration data should be maintained and available for reference or inspection. The thermometer must be calibrated daily or prior to use, whichever is more frequent.

10.0 Data Analysis

Since the thermometer is a direct-reading instrument, the data is recorded directly.

11.0 Documentation

Record all measurement values.

1.0 Title: Standard Operating Procedure for the Field Measurement of pH in Water

2.0 Location

This SOP may be used anywhere on or off the Skinner Landfill Site as long as the requirements of the SOP are met.

3.0 Purpose

This SOP will be used to measure pH of influent, effluent, groundwater, and surface water samples.

4.0 Scope

This SOP describes the use of a portable, temperature compensating pH/conductivity meter for field use. The instrument is calibrated using commercially available buffer reference solutions at or near 25°C, and the instrument reading is adjusted to equal the pH of the standard at 25°C.

5.0 References

1. "Test Methods of Evaluating Solid Wastes", Third Edition (1986), SW-846, Procedure 9040.

2. Cole Parmer Model DspH-3 Operating Instructions.

6.0 Sample Handling and Preservation

This procedure can be used to measure the pH of the water samples in-situ or in a beaker which has been triple-rinsed with distilled water and at least once with sample. If the measurement is to be made at some later time, the sample must be placed in a laboratory supplied bottle, filled to overflowing, and capped immediately to avoid dissolution of atmospheric gases. In such cases, the sample should be stored at 4 °C and analyzed within 24 hours.

Standard pH buffers should be stored below 30 degrees C to minimize the likelihood of error due to evaporation or microbial growth. The standard should be discarded if the expiration date is past, or if color, turbidity, or visible microbial growth develops.

7.0 Apparatus and Materials

1. Cole Parmer pH/Conductivity meter (DspH-3) or equivalent

2. pH 4, 7, and 10 buffer solutions

3. Distilled water

4. Small screw driver

5. Beakers (100 ml or larger)

6. Bottle labeled "waste pH buffer solution"

8.0 Analytical Procedure

1. Slide back the electrode compartment to release pH and conductivity electrodes.

2. Deploy electrodes in either the 90 or 180 degree measurement position.

3. Remove the bottom section of the protective pH probe cap.

4. Thoroughly rinse the pH probe and remaining parts of the probe cap with distilled water.

5. Energize the instrument be depressing the on/off switch once. (Ensure the instrument is in the pH mode by pressing the pH/PPM microswitch as needed).

6. Slide back the bottom compartment cover to the first stop, exposing the adjustment pots.

7. Transfer enough pH-7 buffer solution to cover at least ½ of the pH probe into a beaker that has been either triple-rinsed with distilled water and once with the same buffer solution, or a disposable beaker that has been rinsed once with the buffer solution. Measure the buffer temperature and record. Using the attached Table, record the corresponding temperature-adjusted pH value.

8. Immerse the sensing portion of the probe at least ½ its length into the buffer solution. Allow the reading to stabilize while slightly agitating the solution.

9. Adjust the CAL pot until the instrument indicated the correct temperature-compensated pH value.

10. Remove the probe from the test solution and rinse with distilled water.

11. Discard the used pH buffer into the collection bottle for subsequent disposal.

12. Select the appropriate pH4 or pH10 buffer solution (choice of buffers should be such that this buffer and the pH 7.0 buffer bracket the sample pH).

13. Immerse the sensing portion of the probe at least ½ its length into the buffer solution. Allow the reading to stabilize while slightly agitating the solution.

14. Adjust the SLOPE pot until the instrument indicates the correct temperature-compensated pH value.

15. Remove the probe from the test solution and rinse with distilled water.

16. Discard the used pH buffer into the collection bottle for subsequent disposal.

17. Immerse the sensing portion of the probe at least ½ its length into the sample. (This measurement can be made in-situ, or a portion of the sample can be transferred into a beaker that has been triple-rinsed with distilled water and once with the sample solution). Allow the reading to stabilize while slightly agitating the solution.

18. Read the sample pH and record. (NOTE: If the sample pH is outside the range of the calibration standards, repeat the instrument calibration using the correct buffer solution prior to remeasuring the sample pH. Remove the probe from the sample and rinse thoroughly with distilled water before repeating the instrument calibration).

19. Remove the probe from the sample and rinse thoroughly with distilled water.

20. Measure and record the sample temperature.

21. If no further measurements are being made, de-energize the instrument, and replace to the protective pH probe cap filled with fresh pH 4 buffer or deionized water.

9.0 Quality Control

Calibration data should be maintained and available for reference or inspection. Recalibrate the instrument per project requirements. Duplicate samples should be measured per project requirements.

10.0 Data Analysis

Since this meter is a direct-reading instrument, the data is recorded directly.

11.0 Documentation

Record all measurement values.

Temperature Adjusted Buffer pH Values Table

Temp (°C)	pH 4 Buffer*	pH 7 Buffer*	pH 10 Buffer**
0	4.01	7.12	
1		7.11	
2		7.11	
3		7.10	
4	4.01	7.10	
5		7.09	
6		7.08	
7		7.08	
8		7.07	
9		7.07	
10	4.00	7.06	10.15
11		7.06	10.14
12		7.05	10.13
13		7.05	10.12
14		7.04	10.11
15	4.00	7.04	10.10
16		7.04	10.09
17		7.03	10.08
18		7.03	10.07
19		7.02	10.06
20	4.00	7.02	10.05
21		7.02	10.04
22		7.01	10.03
23		7.01	10.02
24		7.00	10.01
25	4.01	7.00	10.00
26			9.99
27			9.98
28			9.97
29			9.97
30	4.01		9.96

*Cole Parmer Instruments
**VWR Scientific

1.0 Title: Standard Operating Procedure for the Field Measurement of Conductivity in Water

2.0 Location

This SOP may be used anywhere on or off the Skinner site as long as the requirements of the SOP are met.

3.0 Purpose

This SOP will be used to measure conductivity of influent, effluent, groundwater, and surface water samples. This SOP is not applicable to solid samples.

4.0 Scope

This SOP describes the use of a portable, temperature-compensating pH/conductivity meter for field use. The instrument is calibrated using a commercially available KCL reference solution at or near 25°C, and the instrument reading is adjusted to be equal to the conductivity of the standard (at 25°C). A zero-conductivity adjustment is also made.

Because field measurements may be made at temperatures other than 25°C, and the temperature coefficient of the internal compensator may be different than the sample being measured, the temperature of the water sample shall be measured and recorded as well as the conductivity.

5.0 References

1. "YSI Conductivity Calibrator Solutions Instructions," YSI Inc., Yellow Springs, Ohio.

2. "Standard Methods for the Examination of Water and Wastewater," 16th Edition (1985), Method 205.

3. "Test Methods for Evaluating Solid Waste," Third Edition 91986), SW-846, Procedure 9050.

6.0 Sample Handling and Preservation

This procedure can be used to measure the conductivity of water samples in-situ or in a beaker which has been triple-rinsed with distilled water and at least once with sample water. If the measurement is to be made at some later time, the sample must be placed in a pre-cleaned laboratory bottle, filled to overflowing, and capped immediately to avoid dissolution of atmospheric gases. In such cases, the samples should be stored at 4°C and analyzed within 24 hours.

Conductivity standards should be stored below 30°C to minimize the likelihood of error due to evaporation or to microbial growth. The standard should be discarded if the expiration date is past, or if color, turbidity, or visible microbial growth develops.

7.0 Apparatus and Materials

1. Cole Parmer pH/Conductivity meter (DspH-3) or equivalent
2. Conductivity standards
3. Small screw driver
4. Chemwipes or equivalent
5. Beakers (100 ml or larger)
6. Laboratory supplied sample jars with labels and seals

8.0 Analytical Procedure

1. Slide back the electrode compartment to release pH and conductivity electrodes.
2. Deploy electrodes in either the 90 or 180 degree measurement position.
3. Remove the protective cap.
4. Rinse the conductivity probe thoroughly with distilled water.
5. Pat dry the probe with a chemwipe.
6. Energize the instrument by depressing the on/off switch once. (Ensure the instrument is in the conductivity mode.) For each range change desired, depress the pH/PPM microswitch once. The YSI unit utilizes 3 ranges for conductivity. The range sequence is pH-200K-20K-2K. In most cases the 2K range will be used. Only the 200K range uses the X10 enunciator.
7. Slide back the bottom compartment cover to the first stop, exposing the adjustment pots.
8. The dried probe should read 0 in air; if not, adjust the ZERO pot until the instrument reads 0. If the conductivity meter cannot zero, it may indicate dried solids on the sensor. If so, clean the probe with a mild detergent solution, thoroughly rinse with distilled water, let the probe air-dry, and repeat this step.

9. Immerse the probe in a solution of known conductivity (normally 1000+/-0.5% umhos/cm), and record the value. Also measure and record the temperature of the conductivity standard.

10. Adjust the SPAN pot until the instrument indicates the conductivity value of the known solution.

11. Remove the probe from the test solution and thoroughly rinse with distilled water and pat the probe dry.

12. Rinse the probe with the sample by placing the probe into a beaker containing an aliquot of the sample and dip in and out several times. Then, place the probe into another aliquot of the sample.

13. Read the sample conductivity. If the value exceeds the value of the calibration standard by more than a factor of 10, repeat the instrument calibration using a standard conductivity solution in the same range as the sample, then repeat Steps 8.12 through 8.13. Also measure the sample temperature to the nearest °C.

14. Record the measured conductivity reading and sample temperature.

15. Rinse the probe thoroughly with distilled water.

16. If no further measurements are being made, de-energize the instrument, remove the probe and replace the protective cap.

9.0 Quality Control

This procedure is specifically designed for survey-type field measurements, and is not capable of generating results of high precision or accuracy. If results of higher quality are desired, measurements must be made at 25 ± 0.1 °C using a calibrated conductivity meter-cell combination. Method 9050 of SW-846 is appropriate for those cases.

Calibration data should be maintained and available for reference or inspection. Recalibrate the instrument per project requirements. Duplicate samples should be measured per project requirements.

10.0 Data Analysis

Since this meter is a direct-reading instrument, the data is recorded directly.

11.0 Documentation

Record all measurement values.

1.0 Title: Standard Operating Procedure for the Measurement of Dissolved Oxygen in Water

2.0 Location

This SOP may be used anywhere on or off the PRL as long as the requirements of the SOP are met.

3.0 Purpose

This SOP will be used to measure the dissolved oxygen content of groundwater and leachate samples.

4.0 Scope

This SOP describes the calibration and use of an electronic meter to measure the dissolved oxygen of groundwater and other aqueous samples.

5.0 References

YSI Dissolved Oxygen Meter Operators Manual.

6.0 Sample Handling and Preservation

Dissolved Oxygen measurements must be made in-situ, or as soon as possible after a portion of the sample is transferred to a beaker. Dissolved oxygen measurements should be made within 5 minute of sample collection to avoid changes in the dissolved oxygen content of the sample due to changes in the environmental factors (i.e., temperature, CO_2 content, pressure, etc.).

7.0 Apparatus and Materials

1. YSI Dissolved Oxygen Meter
2. small (100-200 ml) beakers
3. Chemwipes or equivalent

8.0 Analytical Procedure

8.1 Calibration Check

Check calibration of dissolved oxygen meter once a day using the following procedures:

- Turn unit on.

- Place dissolved oxygen probe in distilled water.

- Record the temperature of the water and air pressure.
- Calibrate the meter to the percent oxygen saturation based on the temperature and pressure measurements.
- Zero the meter.
- Place the dissolved oxygen probe in the water, bubble air through the water for 5 minute, and record the dissolved oxygen content using the procedures described in Section 8.2 of this SOP.
- Compare the accuracy of the dissolved oxygen measurement to the measurement last recorded. If the measurement is greater than ± 10% repeat the measurement. If the measurement is still greater than ± 10% replace unit with another meter.

8.2 Sample Measurement Procedures

- Turn the meter on.
- Record air temperature and pressure.
- Calibrate the meter to the percent oxygen saturation based on the temperature and pressure measurements.
- Zero the meter.
- Submerse the probe in the liquid sample.
- Wait for the dissolved oxygen measurements to stabilize and then record the measurement.

9.0 Quality Control

The calibration check data should be maintained and made available for reference or inspection. Check the calibration of the meter daily.

Duplicate measurements will be collected every 10 samples or fewer. If the duplicate measurement is greater than ± 20%, recheck the calibration of the meter. If the meter measurement is greater than ± 20% of the last calibration check measurement, replace the unit and remeasure all samples (if possible) since the last duplicate measurement.

10.0 Data Analysis

Since the meter is a direct-reading instrument, the data is recorded directly.

11.0 Documentation

Record all measurement values.

1.0 PURPOSE

The purpose of this procedure is to define the requirements necessary for surface water sampling.

2.0 SCOPE

Surface water sampling is applicable to almost any site that has surface drainage on it or at any location located hydraulically downgradient from the site.

3.0 REQUIREMENTS

Many factors must be considered in developing a sampling program for surface water including study objectives; accessibility; site topography flow, mixing and other physical characteristics of the water body; point and diffuse sources of contamination; and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water.

4.0 REFERENCES

4.1 Feltz, H.R., 1980. *Significance of Bottom Material Data in Evaluating Water Quality in Contaminants and Sediments.* Ann Arbor, Mich., Ann Arbor Science Publishers, Inc., V.i, p. 271-287.

4.2 Kittrell, R.W., 1969. *A Practical Guide to Water Quality Studies of Steams.* U.S. Federal Water Pollution Control Administration, Washington, D.C., 135 p.

4.3 USEPA, 1980. *Standard Operating Procedures and Quality Assurance Manual.* Water Surveillance Branch, USEPA Surveillance and Analytical Division, Athens, GA.

4.4 US Geological Survey, 1977. *National Handbook of Recommended Methods for Water-Data Acquisition.* Office of Water Data Coordination, USGS, Reston, VA.

5.0 DEFINITIONS

Environmental Sample - low concentration sample typically collected offsite and not requiring DOT hazardous waste labeling as a high hazard sample.

6.0 RESPONSIBILITIES

6.1 Field Geologist

The Field Geologist has overall responsibility for the correct implementation of surface water sampling activities, including review of the Field Sampling Plan.

7.0 EQUIPMENT

1. Sampling bottles treated with preservatives if necessary.
2. Specific conductivity meter.
3. pH meter.
4. Thermometer.
5. D.O. meter.
6. Beta-gamma radiation meter.
7. Dip sampler.
8. Weighted bottle sampler.
9. Hand pump.

8.0 PROCEDURE

The following section outlines commonly used procedures for collecting surface water samples. Surface water sampling will begin at the most downstream location and proceed progressively to the upstream locations. It is anticipated that Dip Sample will be used to collect surface water samples during the RA.

8.1 Water Sampling Techniques

8.1.1 Dip Sampling

Water is often sampled by filling a container, either attached to a pole or held directly, from just beneath the surface of the water (a dip or grab sample). Constituents measured in grab samples are only indicative of conditions near the surface of the water column and in the cross section.

8.1.2 Weighted Bottle Sampling

A grab sample can also be taken using a weighted holder that allows a sample to be lowered to any desired depth, opened for filling, closed and returned to the surface. This allows discrete sampling with depth. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface.

A closed weighted bottle sampler consists of a stoppered glass or plastic bottle, a weight and/or holding device, and lines to open the stopper and to lower or raise the bottle. The procedure for sampling is:

1. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
2. Pull out the stopper with a sharp jerk of the sampler line.
3. Allow the bottle to fill completely, as evidenced by the cessation of air bubbles.
4. Raise the sampler and cap the bottle.

5. Decontaminate the outside of the bottle. The bottle can be used as the sample container (as long as the original bottle is an approved container).

8.1.3 Hand Pumps

Hand pumps may be operated by peristaltic, bellows, diaphragm, or siphon action. Hand pumps which operate by a bellow, diaphragm, or siphon action should not be used to collect samples which will be analyzed for volatile organics because the slight vacuum applied may cause loss of these contaminants.

Tubing used for the inlet hose should be nonreactive (preferably Teflon). The tubing and liquid trap must be thoroughly decontaminated between uses (or disposed of after one use).

When sampling, the tubing is weighted and lowered to the desired depth. The sample is then obtained by operation of the pump and subsequently transferred from the trap to the sample container.

9.0 ATTACHMENTS

None.

SKINNER LANDFILL
REMEDIAL DESIGN
FINAL DESIGN (100%) PHASE I REPORT

VOLUME IV OF IV, PART 2

THE FOLLOWING MAPS MAY BE VIEWED AT THE U.S. EPA RECORD CENTER, 77 WEST JACKSON BLVD., 7TH FLOOR, CHICAGO, ILLINOIS

1) **LONG TERM PERFORMANCE PLAN: GROUNDWATER MONITOR LOCATIONS**
2) **LONG TERM PERFORMANCE PLAN: SURFACE WATER MONITOR LOCATIONS**

SUPPORT PLAN H

SKINNER LANDFILL SUPERFUND SITE
REMEDIAL ACTION WORK PLAN
WEST CHESTER, BUTLER COUNTY, OHIO
PROJECT NO. 72680

Rust Environment & Infrastructure of Ohio Inc.

May 20, 1996

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1.0 INTRODUCTION

This document presents the Remedial Action Work Plan (RAWP) for the Skinner Landfill Superfund Site (Site) located in West Chester, Butler County, Ohio.

1.1 General

The purpose of this RAWP is to address the required actions set forth in the Record of Decision (ROD) for the Site. The ROD was signed by the Regional Administrator of U.S. EPA Region V on June 4, 1993. There are four primary components that make up the remedial action. These components are:

- Excavation of the contaminated soil and placement under the landfill cover;
- Construction of the landfill cover;
- Construction of a ground water interceptor trench, and;
- Discharge of the collected groundwater.

Details of the design for these components are provided in the Remedial Design report for the Skinner Landfill, Sections 2.0 through 4.0, and are incorporated herein by reference.

Section 2.0 of this work plan presents the project administration for the remedial action. Section 3.0 presents an overview of the remedial action and the performance standards for implementation, while Section 4.0 includes a project schedule for submission of deliverables generated during the Remedial Action.

1.2 Site Location and Description

The Skinner Landfill is located approximately 15 miles north of Cincinnati, Ohio near West Chester, Butler County, Ohio in Township 3, Section 22, Range 2. The site is located along Cincinnati-Dayton Road. The site is bordered on the south by the East Fork of Mill Creek, on the north by wooded land, on the east by a Consolidated Railroad Corporation (Conrail) railroad right-of-way, and on the west by the Skinner Creek.

The site is located in a highly dissected area that slopes from a till-mantled bedrock upland to a broad, flat-bottomed valley that is occupied by the main branch of Mill Creek. Elevations on the site range from a high of nearly 800 feet above mean sea level (MSL) in the northeast, to a low of 645 feet MSL near the confluence of the Skinner Creek and the East Fork of Mill Creek. Both Skinner Creek and the East Fork of Mill Creek are small, shallow streams. Both of these streams flow to the southwest from the site toward the main branch of Mill Creek. A third on-site stream, Dump Creek, borders the landfill on the east. Dump Creek is intermittent and flows south into the East Fork of Mill Creek. Three shallow ponds are also located on the site.

In general, the site is underlain by relatively thin glacial drift over interbedded shales and limestones of Ordovician age. The composition of the glacial drift ranges from intermixed silt, sand and gravel, to silty, sandy clays; and its thickness ranges from zero to over 40 ft on the site. The sand and gravel deposits comprise the hills and ridges and are encountered near the surface of the central portion of the site. The silts and clays usually occur as lenses in the sands and gravel or directly overlie bedrock.

1.3 Site History and Background

The property was originally developed as a sand and gravel mining operation, and was subsequently used as a landfill from 1934 to 1990. According to U.S. EPA studies, materials deposited at the site include demolition debris, household refuse and a wide variety of chemical wastes. The waste disposal areas include a now-buried waste lagoon near the center of the site and a landfill. According to U.S. EPA studies, the buried waste lagoon was used for the disposal of paint wastes, ink wastes, creosote, pesticides, and other chemical wastes. The landfill area, located north and northeast of the buried lagoon, received predominantly demolition and landscaping debris.

In 1976, the Ohio EPA (OEPA) initiated an investigation of the site in response to reports of a black oily liquid that was observed during a fire call to the site. Before the OEPA could complete the investigation, the landfill owners, the Skinners, covered the lagoon with a layer of demolition debris. Mr. Skinner further dissuaded the OEPA from accessing the site by claiming that nerve gas, mustard gas, and explosives were buried in the landfill. The OEPA requested the assistance of the U.S. Army after obtaining this information. Mr. Skinner later retracted his statements concerning buried ordnance, and an U.S. Army records review performed in 1992 did not reveal any evidence of munitions disposal at the site.

In 1982, the site was placed on the National Priority List by the U.S. EPA based on information obtained during a limited investigation of the site. The investigation indicated groundwater contamination had occurred as a result of the buried wastes. In 1986, a Phase I Remedial Investigation was conducted that included sampling of groundwater, surface water and soil, as well as a biological survey of the East Fork of Mill Creek and Skinner Creek. A Phase II Remedial Investigation was conducted from 1989 to 1991 and involved further investigation of groundwater, surface water, soils and sediments. A Baseline Risk Assessment and Feasibility Study (FS) were completed in 1992.

The Phase II Remedial Investigation revealed that the most contaminated media at the site is the soil from the buried waste lagoon. Lower levels of contamination were also found in soils on other portions of the site and in the groundwater, and very low levels were found in the sediments of the Mill Creek, the Skinner Creek, the Duck Pond, and the Diving Pond. Migration of the landfill constituents has been limited, and the Phase II Remedial Investigation concluded that there had been no off-site migration of landfill constituents via groundwater flow.

2.0 PROJECT ADMINISTRATION

The following sections describe the methods and reporting structure that will be used during the Remedial Action.

2.1 Project Organization

Rust Environment & Infrastructure of Ohio Inc. (Rust) is the primary consultant to the Skinner Landfill PRP Group for the Remedial Design. Rust may provide support as the design and CQA engineer, and may conduct well installation and any sampling required by the Field Sampling Plan. Analytical services may be provided by Nytest Environmental Inc. (NEI). Topographic mapping of the site may be completed by Aero-Metric Engineering, Inc. (AME). Surface surveying may be performed by J.T. King and Associates, Inc. (King). Additional subcontractors and/or sub-consultants may be required and may be selected to perform specific tasks during the Remedial Action.

The general contractor for construction may be selected based upon submission of bid documents and may be selected by the U.S. EPA or implementors based upon the contractors ability to perform the project in a timely, professional and cost-effective manner. The general contractor may select additional subcontractors for performance of specific tasks within the scope of work of the construction. The Implementor will reserve the right to review and approve these subcontractors.

The following are the key personnel involved in the Remedial Action of the Skinner Landfill Site:

- Mr. Jamey Bell, U.S. EPA Remedial Project Manager;
- Mr. Greg Youngstrom, OEPA Site Coordinator;
- The Implementor's Representative and;
- Implementor Project Managers.

A Project Organization flowsheet is given in Figure 1 which presents the relationship and reporting requirements among the various entities.

2.2 Project Reporting

Monthly progress reports will be submitted to U.S. EPA during the course of the Remedial Action. The monthly progress reports will include the following:

1. A description of the work completed in the reporting period and work planned for the upcoming period.

2. Target and actual completion dates for each element of the Remedial Action, including an explanation of any deviation or anticipated deviation from the established schedule, and proposed actions to mitigate such deviation.

3. Description of any difficulties encountered in the reporting period and any actions taken to rectify problems.

4. Any changes in the key personnel serving the project.

The monthly progress reports will be submitted by the fifth business day of each month following commencement of the remedial activities presented in this document.

In addition to monthly reports, submission of various field data (groundwater monitoring data, CQA reports, completion reports, etc.) will be required as part of the Remedial Design. Itemization of these submissions and their respective due dates are detailed in Section 4.0.

3.0 DESCRIPTION OF THE REMEDIAL ACTION AND PERFORMANCE STANDARDS

The following sections present the remedial actions in the order in which they will be implemented. The contaminated soil excavation will be dealt with separately, but will be performed during the landfill cap construction activities. Performance standards include cleanup standards, quality criteria, and other substantive requirements, criteria or limitations, and Applicable or Relevant and Appropriate Requirements (ARARs) set forth in the ROD, SOW, and/or Administrative Order on Consent. These activities will be performed according to the schedule provided as Figure 2.

These sections provide a summary of the remedial actions undertaken. Specific information regarding methods and criteria for construction can be found in the Remedial Design report.

3.1 Support Activities

Support activities are identified as those functions or actions that occur before, during or after the Remedial Action, but are not directly related or a part of the primary remedial components (groundwater interception and landfill cover).

3.1.1 Mobilization

Mobilization includes those functions that occur prior to construction.

Site Utilities Installation

In order to operate the groundwater interceptor trench, it will be necessary to have permanent electrical service at the location of the trench. This service will be extended from its current terminus to the location of the trench.

The alarm system will utilize public telephone lines for notification of alarm conditions. Telephone service will be extended to the location of the interceptor trench.

Both utilities will be extended underground.

Establish On-Site Facilities

Placement of site trailers, site services, upgrade/clearing of site roads, and removal or relocation of scrapped equipment will be undertaken.

3.1.2 Monitoring Programs

Various site management and/or media sampling and analysis will be conducted during the RA according to protocols established in separate plans. The sampling and monitoring programs to be implemented are provided in the Field Sampling Plan, Air Monitoring Plan, Contingency Plan, Health and Safety Plan, and Construction Quality Assurance Plan.

3.1.3 Demobilization

After completion of construction activities, removal of all construction-related facilities will occur. The Operation and Maintenance Plan and Long-Term Performance Plan will be implemented.

3.2 Groundwater Interception

The first component of the remedial action will be the construction of the groundwater interceptor trench. This feature will be completed first as it is the least susceptible to ambient temperature variations.

3.2.1 General Site Preparation

In preparation for the interceptor trench construction, several minor but necessary items will need to be addressed. These items include:

- Relocation of the security fence;
- Placement of creek bank erosion protection;

- Construction of a small diversion berm;
- Site clearing/vegetation grubbing, and;
- Construction of the soil platform for the trench/wall construction activities.

Relocation of Security Fence

Prior to the initiation of construction activities, the security fence will be relocated to facilitate the construction of the groundwater interceptor trench. This fence will eliminate access to the trailer located on the south side of the East Fork of Mill Creek. Gates will be installed to allow for vehicular traffic required for the construction of the interceptor trench. The fence will not inhibit traffic along the gravel entrance road.

Minimization of Creek Bank Erosion

There has been severe erosion at one of the steeper bends of the East Bank of Mill Creek. The creek bank in this area has appeared to have stabilized over the past several months. Recently the erosion has increased. Bank/erosion protection will be provided for this area.

Construction will require minimal dressing of the slope to smooth out the bank and remove major vegetation. It is anticipated that rip-rap will be placed on selected areas of the construction to minimize erosion.

Well Abandonment

Those wells designated by the Field Sampling Plan to be abandoned will be removed prior to trench construction.

Construction of Diversion Berm

An earthen diversion berm will be constructed along the south side of the area where the interceptor trench and cut-off wall will be constructed. The berm will be placed at the top of the creek bank, approximately one foot north of the security fence. The intent of the berm is to contain the soil-water-biopolymer-slurry materials used to establish the cut-off wall.

Site Clearing/Vegetation Grubbing

Some grading work will be required to establish the platform for the trench/wall construction activities. Grading will be required along the toe of several of the slopes. The grading will be temporary and appropriate slopes will be restored after the trench/wall construction is complete.

Construction of Work Platform

For the construction of the trench, it will be necessary for the stretch of trench under construction to have a relatively flat ground surface. The surface is required to be "flat" to maintain the slurry within the trench. There are two locations within the interceptor trench alignment where the grade exceeds the normal tolerance for slope (approximately 4%) for slurry trench construction. Temporary platforms will be constructed to facilitate the trench construction in these areas. These platforms will be removed after the construction activities are complete.

3.2.2 Construction of Collection Trench

The collection trench consists of three separate sections of different length. The trench will extend vertically to the depth as defined on Drawing 2.5. The trench construction will consist of:

- Trench excavation
- Slurry preparation
- Slurry pumping into trench
- Geotextile wrap preparation
- Wrap insertion into the trench
- Granular backfill placement
- Extraction and inspection well placement
- Cap placement, and
- Bio-polymer degradation.

This will be a typical slurry trench construction project. Verification of actual construction techniques will be performed in accordance with the CQA document. The collection trench specifications also identify required action by the contractor to ensure quality of construction.

3.2.3 Construction of Cut-Off Wall

There is to be one length of cut-off wall for the project. This cut-off wall will also be constructed of a soil-bentonite slurry. Activities include trench excavation and addition of the slurry. Trench depth will be measured to be in conformance with the cut-off wall specifications and verified by methods defined in the CQA document. Material certifications will be collected, and trip tickets collected to verify the quantity of material delivered

3.2.4 Installation of Force main and Gravity Sewer

An extraction well will be placed at the low point of the base in each of the three collection trenches. Each well will be connected to the force main that runs along the north side of the interceptor trench. The force main crosses the trench and cut-off wall at a point approximately 100 feet from the west end of the trench. Where the force main crosses the trench and cut-off wall, it is encased in a larger

diameter pipe and then extends to a manhole at the top of the creek bank. From the manhole at the creek bank, flow is by gravity.

The observation of the construction of the force main, and the documentation of the materials used will be in accordance with specifications and CQA manual for the force main.

3.2.5 Startup

Startup of the interceptor trench will include testing of pumping systems, monitoring the force main for leaks, and verifying operation of the monitoring system. Installation of the groundwater monitoring well network and piezometers will occur.

3.3 Landfill Cap

3.3.1 Site Prep

The construction of the cap will begin with the pullback and relocation of debris along the southern limit of waste. This will be followed by placement, compaction and proof rolling of the subgrade. The subgrade will be constructed of soil from borrow sources on site. The subgrade will be placed in lifts to achieve the grades identified in the subgrade plan with a minimum 5% grade to a maximum 3H:1V (33%) grade.

3.3.2 Remediation of Contaminated Soils

Two areas of contaminated soil on the site that will be excavated and moved to a location which will be protected by the landfill cap. The quantity of soil to be excavated from the two sites is approximately 875 cubic yards. These soils will be removed and hauled to the landfill during the subgrade placement operation. The soils will be placed on the top of the landfill in the area designated on the subgrade drawing. These soils will be leveled and compacted, then covered with at least 12 inches of clean soil.

The excavations where the contaminated soils are removed will be backfilled with clean material from onsite. All work will be done in accordance with the Health and Safety Plan. Sampling to determine the extent of the contaminated soil will be done in accordance with the Field Sampling Plan.

3.3.3 Cap Construction

After establishing the subgrade, the gas collection/vent layer will be installed. This layer will be a geocomposite consisting of a geonet and between layers of geotextile. Vent pipes will be installed as part of the vent layer prior to installation of the geocomposite. The vents will consist of a 6-foot long gravel trench and perforated piping positioned just below the geocomposite layer. There will be 15 gas vents distributed throughout the landfill.

After the collection/vent layer is installed, the secondary barrier layer will be constructed. This layer will consist of an 18-inch-thick compacted cohesive soil barrier and a Geosynthetic Clay Layer (GCL). Above the secondary barrier is the primary barrier which will consist of a 40 mil textured Very Low Density Polyethylene (VLDPE) geomembrane. This layer will be seamed and tested prior to being covered. Geomembrane pipe boots will be installed around all planned penetrations (piezometers and gas vents) and welded to the geomembrane layer.

A drainage layer will be installed above the primary barrier layer and will consist of a geocomposite consisting of a geonet and one layer of geotextile. This barrier will be covered by 30 inches of soil consisting of clayey soil and topsoil which will support vegetation. The cap will be vegetated with a seed mix of tall fescues that will deter animals from burrowing into the landfill cover.

All of the items that are part of the cap construction will be constructed in accordance with approved specifications and drawings.

3.3.4 Provision of Surface Water Drainage Controls

Surface water features will be incorporated above and around the cap structure. Drainage swales will intercept flow from the cap slopes and divert it to drainage flumes for conveying the water down the slope(s). The drainage swales that convey the surface water to the creek will be constructed to accommodate the flow. The swales will have structures such as check dams that will slow the flow to minimize erosion and promote settling of soil particles. Other erosion control measures will include erosion matting installed in the swales and an erosion control blanket installed on the southern 3H:1V slope. The location and configuration of these features are shown on the drawings and the materials and method of construction are defined in the specifications.

4.0 DELIVERABLES SCHEDULE

A summary of the project deliverables schedule and reporting requirements contained in this RAWP follows:

REMEDIAL ACTION WORK PLAN DELIVERABLES SCHEDULE	
Submission	**Due Date**
1. Project Initiation	
a. Contract Issuance	
Bid Release	60 days after Notice to Proceed
Bid due date	30 days after bid release
Contract Award	30 days after bid due date
Notify U.S. EPA of Contractor Selection	10 days after contract award
b. Site Mobilization	
Contractor Site Walk	30 days after contract award
Contractor Move on Site	30 days after site walk
Initiation of Construction	45 days after site walk (subject to weather/time of year delays)
c. Public Notification	
Notice of Contract Award (U.S. EPA)	20 days after contract award
Public Meeting (U.S. EPA)	10 days after contractor site walk
2. Groundwater Interception	
a. Collection Trench Construction	
Materials Certification	60 days after completion of construction
CQA Documentation	60 days after completion of construction
Trench Base As-Built Drawings	60 days after completion of construction
b. Cut-Off Wall	
Materials Certification	60 days after completion of construction
CQA Documentation	60 days after completion of construction
Material Delivery Trip Tickets	60 days after completion of construction
Documentation of elevations of bedrock and the base of the cut-off wall	60 days after completion of construction
c. Force main	
Materials Certification	60 days after completion of construction
CQA Documentation	60 days after completion of construction
Operation & Maintenance Manual	60 days after completion of construction
As-Built Drawings of Force main and Sanitary Sewer Connection	60 days after completion of construction

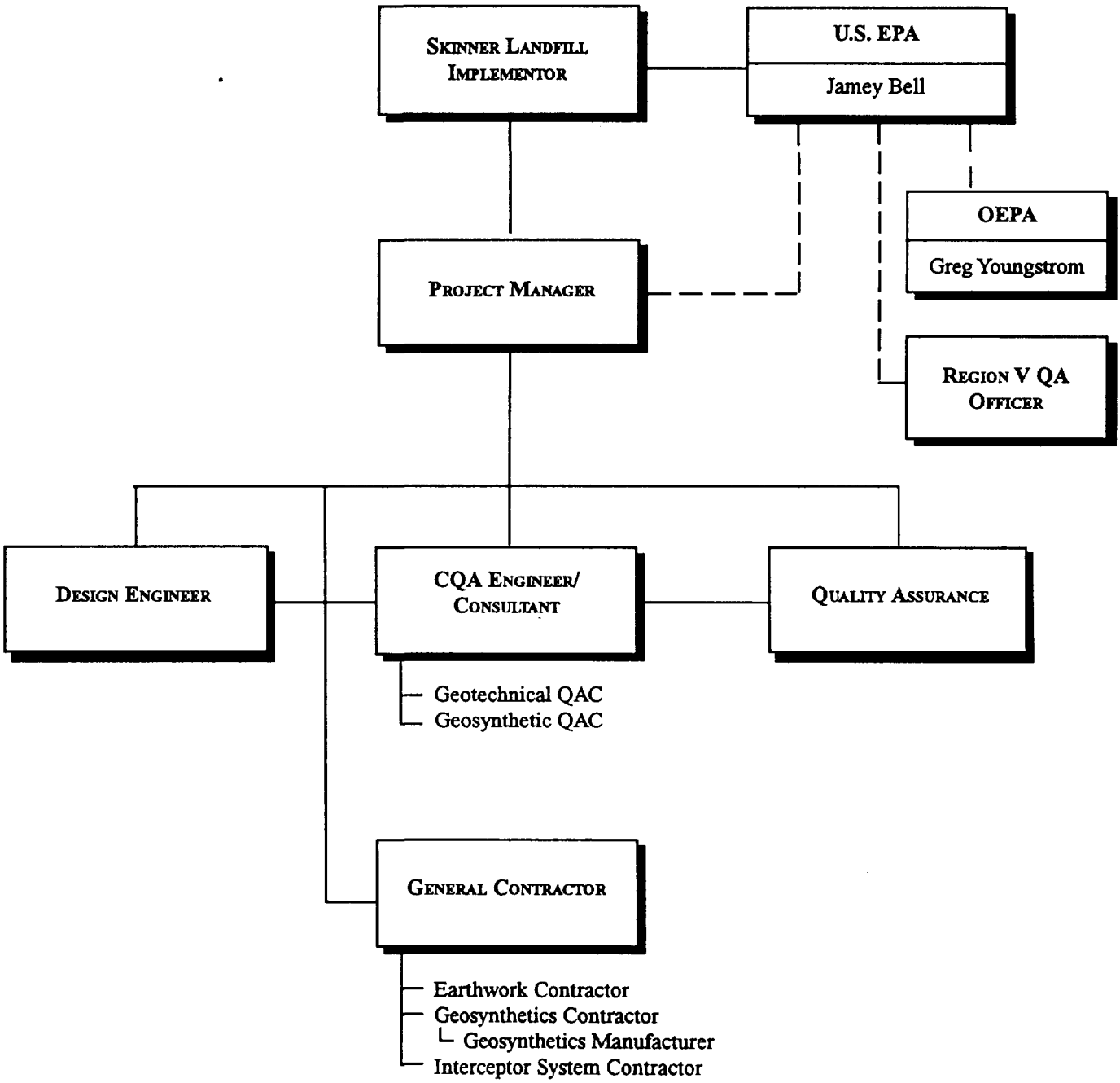
REMEDIAL ACTION WORK PLAN DELIVERABLES SCHEDULE	
Submission	**Due Date**
d. Discharge to Sanitary Sewer Discharge Monitoring Reports	Submitted per BCDES permit requirements
3. Landfill Cap Construction	
a. Fencing	Weekly reports of inspection to be submitted quarterly
b. Landfill Construction Report Materials Certification Laboratory Results of Geo.Mat./Soils Testing Results of Geo.Mat./Soils Field Testing Survey Records of Grades & Thicknesses	 60 days after completion of construction 60 days after completion of construction 60 days after completion of construction 60 days after completion of construction
c. Surface Water Drainage Slope and Alignment of Features Laboratory Testing Results for Materials	 60 days after completion of construction 60 days after completion of construction
d. Contaminated Soils Report of Excavation Activities CQA and Analytical Verification Documentation	 60 days after completion of construction 60 days after completion of construction
4. Performance Monitoring	
a. Boring Logs and Construction Details for wells, piezometers, and gas probes	60 days after completion of construction
b. Survey Location Data for wells, piezometers, and gas probes	60 days after completion of construction
c. Analytical Results of Groundwater and Surface Water Monitoring	60 days after receipt of data from first sampling and quarterly thereafter.

Figures

Figure 1

Skinner Landfill Remedial Action

PROJECT ORGANIZATION



SKINNER LANDFILL REMEDIAL ACTION PLAN CONSTRUCTION SCHEDULE

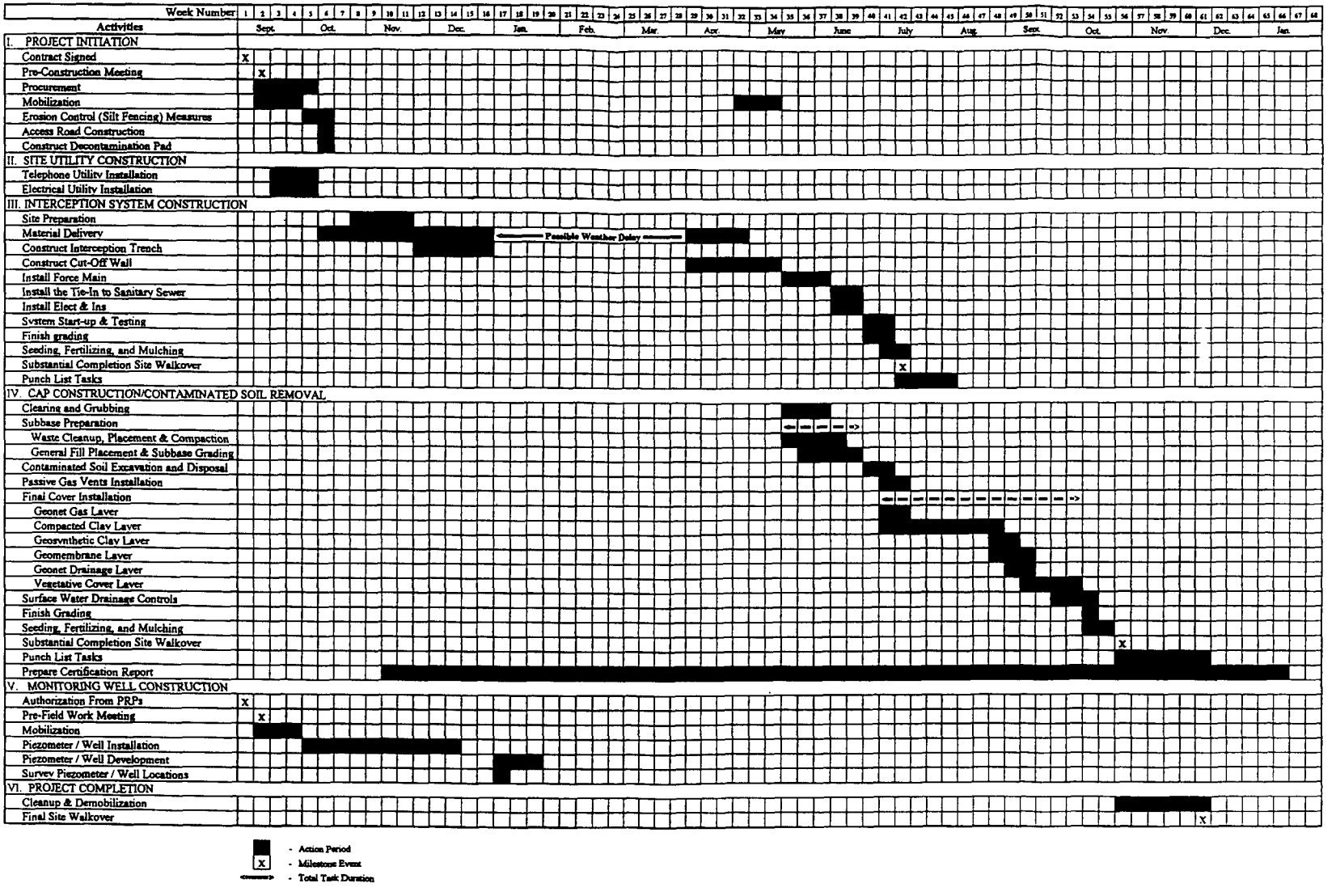
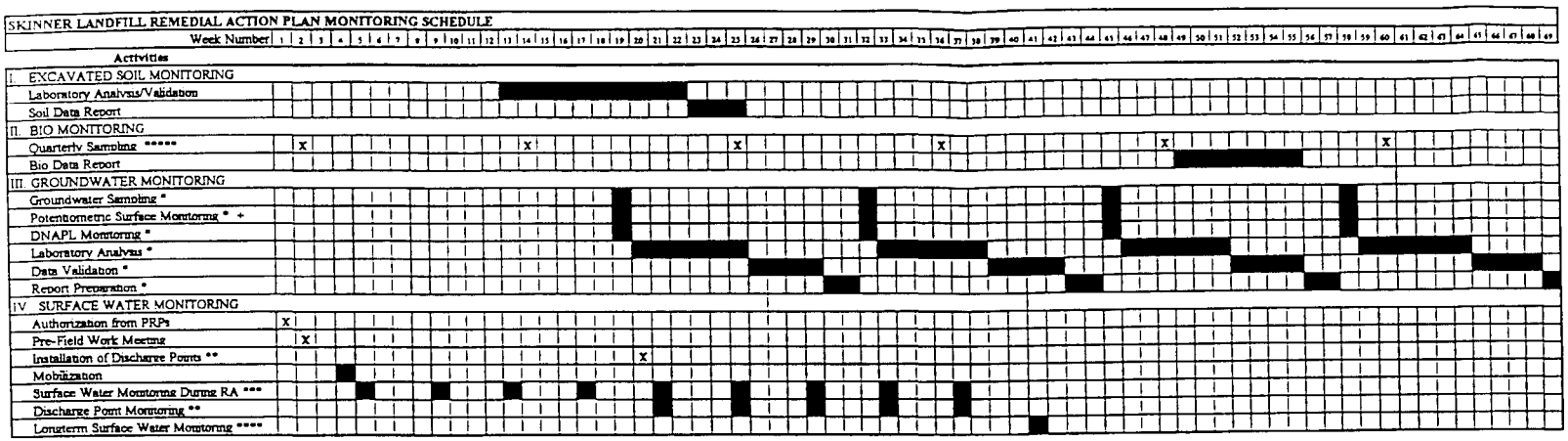


FIGURE 2



* - These activities will be performed once every three months.

\+ - Potentiometric Surface monitoring will be performed monthly for the first year and then quarterly thereafter.

** - Will be conducted monthly throughout the RA Construction. Sampling will begin 30 days following construction of the surface water discharge points.

*** - Will be conducted monthly throughout RA construction. Sampling will begin 30 days following initiation of RA construction.

**** - Will be conducted on 1/4 year intervals beginning 30 days after Agency approval of final construction.

***** - Will be conducted for three additional quarters beyond end of timeline at sproximately weeks 72, 84, and 96

FIGURE 3 CONTINUED

SUPPORT PLAN I

SKINNER LANDFILL SUPERFUND SITE
CONSTRUCTION QUALITY ASSURANCE PLAN
WEST CHESTER, BUTLER COUNTY, OHIO

Rust Environment & Infrastructure of Ohio Inc.
PROJECT NO. 72680

May 20, 1996

LIST OF ACRONYMS

AMP	Air Monitoring Plan
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirements
BCDES	Butler County Department of Environmental Services
BZ	Breathing Zone
CD&D	Construction Debris and Demolition Waste
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CGI	Combustible Gas Indicator
CHSD	Corporate Health and Safety Director
CLP	Contract Laboratory Program
cm/sec	Centimeters Per Second
CO	Carbon Monoxide
CQA	Construction Quality Assurance
CQAC	Construction Quality Assurance Consultant
CRZ	Contamination Reduction Zone
CSDI	Contaminated Soils Design Investigation
CZ	Control Zone
DSW	Division of Surface Water (OEPA)
DSR	Division Safety Representative
EPA	Environmental Protection Agency
EZ	Exclusion Zone
FID	Flame Ionization Detector
FML	Flexible Membrane Liner (low density polyethylene)
FSP	Field Sampling Plan
ft	Feet
ft/sec	Feet Per Second
GCL	Geosynthetic Clay Layer
gpd	Gallons Per Day
gpm	Gallons Per Minute
GWDI	Groundwater Design Investigation
HAP	Hazardous Air Pollutant
HASP	Health and Safety Plan
HSM	Health and Safety Manager
IDLH	Immediately Dangerous to Life or Health
IRM	Interim Remedial Measures
kg/d	Kilograms Per Day
lb/day	Pounds Per Day
LEL	Lower Explosion Limit
MSL	Mean Sea Level
NIOSH	National Institute for Occupational Safety and Health
NO_x	Oxides of Nitrogen
NWI	National Wetland Inventory
O_3	Ozone
OAC	Ohio Administrative Code
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
ORC	Ohio Revised Code
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PID	Photoionization Detector
PLC	Programmable Logic Controller
PM-10	Particulate Matter less than 10 microns
PRP	Potentially Responsible Party
PPE	Personal Protective Equipment
psi	Pounds Per Square Inch
QAPP (QAPjP)	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design

LIST OF ACRONYMS - CONT

RHSS	Regional Health & Safety Specialist
ROD	Record of Decision
SI	Site Inspection
SO_2	Sulfur Dioxide
SOP	Standard Operating Procedure
SOW	Statement of Work
SPCC	Spill Prevention Control and Counter Measure Plan
SSO	Site Safety Officer
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
SZ	Support Zone
TDH	Total Dynamic Head
TLV	Threshold Limit Values
TSS	Total Suspended Solids
TWA	Time Weighted Average
u	Micron
ug/l	Microgram per Liter
USACE	United States Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Services
USGS	United States Geological Survey
VOC	Volatile Organic Compound
yr	Year
WBGT	Wet Bulb Globe Temperature
WZ	Work Zone

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1.0 INTRODUCTION

This Construction Quality Assurance Plan (CQAP) is prepared in conjunction with the Remedial Design for the Skinner Landfill, West Chester, Butler County, Ohio. This CQAP addresses quality assurance for construction of the final cover and installation of the interceptor trench, cut-off wall, force main system and tie-in to the sanitary sewer. Extreme care and detailed documentation are required in the selection and installation of all materials used in these lining systems.

Quality assurance refers to means and actions employed to provide conformity of the remedial action with contractual and regulatory requirements. An independent party shall provide quality assurance of production and installation.

Quality control refers to those actions taken to provide for materials and workmanship that meet the requirements of the design plans and specifications. The manufacturers, suppliers, contractors, and installers of the various components of the remedial action shall provide quality control.

This CQAP describes the procedures and components necessary to carefully document the construction quality control process, from the selections of materials through implementation of the remedial action. The scope of this CQAP applies to manufacturing, shipping, handling, installing, and design guidelines.

It is anticipated that a single prime contractor will be selected for the project. In the text where the earthwork contractor, geosynthetics contractor or interceptor contractor are referred to, it is considered that these contractors may be either the prime contractor or a subcontractor to the prime. For the geosynthetics and interceptor system contractors, a level of experience is required in this document.

2.0 RESPONSIBILITY, AUTHORITY, AND QUALIFICATIONS

The parties discussed in this section are associated with the ownership, design, supply, manufacture, transportation, installation, and quality assurance of a lining system. The definitions, responsibilities, qualifications, and submittals of these parties are outlined in the following subsections.

2.1 Owner

The Owner is the implementor of the remedial action. For the remedial design, the Skinner Landfill PRP Group Technical Committee chairman is Dr. Larry Bone.

2.1.1 Responsibility and Authority

The Owner is responsible for all construction contracts. The Owner is responsible for coordinating communications with the regulatory agencies, Engineer, and Contractor for the project; and initiating the preconstruction, pre-final, and final inspections. The Owner serves as a liaison between all parties involved in construction to see that communications are maintained.

The Owner has the ultimate responsibility to ensure that the remedial action is constructed in accordance with the design plans and specifications.

2.1.2 Qualifications

The Owner's representative has direct responsibility to represent the Implementor.

2.1.3 Submittals

The Owner is responsible for submitting required information to the U.S. Environmental Protection Agency (U.S. EPA) and the Ohio Environmental Protection Agency (OEPA). Submittals include:

- Design drawings and specifications;
- Progress reports;
- Record drawings; and
- Construction Completion Report.

2.2 Project Manager

A single representative will be designated by the Owner as the representative for the construction activities.

2.2.1 Definitions

The Project Manager is the official representative of the Owner. In this manual, the term Project Manager shall apply equally to "Construction Coordinator", defined as the individual who coordinates construction and quality assurance activities for the project.

2.2.2 Responsibilities

The Project Manager is responsible for coordination of all construction quality assurance activities. The Project Manager is responsible for the organization and implementation of the CQAP for the project. Other responsibilities include selection or approval of Earthwork Contractor, Geosynthetic Installer, Groundwater Interception System Contractor, Quality Assurance Consultant and the Quality Assurance Laboratory.

The Project Manager shall serve as communications coordinator for the project, initiating the resolution, pre-construction, construction, and final meetings outlined in Section 3.0. As communications coordinator, the Project Manager shall serve as a liaison between all parties involved in the project to ensure that communications are maintained. The Project Manager shall also be responsible for proper resolution of all quality assurance issues that arise during construction.

2.2.3 Qualifications

The selection of the Project Manager is the direct responsibility of the Owner. Qualifications for this position include familiarity with the following:

1. Sections of this CQAP or other applicable CQAPs;
2. General earthwork construction techniques;
3. General geosynthetic installation techniques;
4. Groundwater interception system techniques;
5. All applicable regulatory requirements; and
6. Owner policies and procedures for project management.

2.3 Design Engineer

2.3.1 Definitions

The Design Engineer is the individual and/or firm who prepares the design, including project plans and specifications for the lining system and groundwater interception system.

2.3.2 Responsibilities

The Design Engineer is responsible for performing the engineering design and preparing the associated project plans and specifications for the groundwater interception system and landfill cover system. The Design Engineer is responsible for approving all design and specification changes and making design clarifications necessitated during construction of the lining system. Upon the request of the Project Manager, the Design Engineer shall attend the resolution and pre-construction meetings.

2.3.3 Qualifications

The Design Engineer shall be certified or licensed in the State of Ohio and as required by regulation. The Design Engineer shall be familiar with the use of soils and/or geosynthetics, groundwater interception systems, including detailed design methods and procedures as well as slurry trench methods. In addition, the Design Engineer should be familiar with applicable regulatory requirements.

2.3.4 Submittals

The Design Engineer shall submit the project plans, specifications and associated engineering reports to the Project Manager. The Design Engineer shall also submit completed design clarification forms to the Project Manager in a timely manner upon request. Other information may also be required by the Owner.

2.4 Geosynthetics Manufacturer

2.4.1 Definitions

The Geosynthetics Manufacturer is the firm which produces any of the various geosynthetic lining system components outlined in this CQAP. In the case of a geocomposite, the Geosynthetics Manufacturer is the firm which combines the components into the final product.

2.4.2 Responsibilities

Each Geosynthetics Manufacturer is responsible for the production of its geosynthetic product. In addition, each Geosynthetics Manufacturer is responsible for the condition of the geosynthetic

product until the material is accepted by the Project Manager upon delivery. Each Geosynthetics Manufacturer shall produce a consistent product that meets the project specifications. Each Geosynthetics Manufacturer shall provide quality control documentation for its product as specified in this CQAP.

2.4.3 Qualifications

Each Geosynthetics Manufacturer shall:

1. Be pre-qualified and approved by the Owner;

2. Provide sufficient production capacity and qualified personnel to meet the demands of the project; and

3. Have an internal quality control program for its product that meets the requirements presented in this CQAP.

2.4.4 Submittals

Pre-qualification: At a minimum, the Geosynthetics Manufacturer shall meet the following requirements and submit the following information to the Project Manager to be considered for pre-qualification:

1. Corporate background and information;

2. Manufacturing capabilities:

    a. Information on plant size, equipment, personnel, number of shifts per day, and capacity per shift.
    b. Daily production quantity of the specified product available for the Owner's facilities.
    c. A list of material properties including certified test results with attached geosynthetic samples.
    d. A list of at least 15 completed landfill or surface impoundment facilities totaling a minimum of 15,000,000 ft^2 (1,500,000 m^2), for which the Geosynthetics Manufacturer has manufactured a geosynthetic. For each facility, the following information shall be provided:

        (1) Name and purpose of facility, its location and date of installation;
        (2) Name of Owner, Project Manager, Design Engineer, Installer and Fabricator (if any);
        (3) Type of geosynthetic and surface area of geosynthetic manufactured; and
        (4) Available information on the performance of the lining system;

3. The Geosynthetics Manufacturer's quality control manual, including a description of the quality control laboratory facilities; and

4. The origin (supplier's name and production plant) and identification (brand name and number) of resin used to manufacture the product.

Additional information may need to be submitted if requested by the Project Manager.

Pre-installation: Prior to the installation of any geosynthetic material, the Geosynthetics Manufacturer shall submit to the Project Manager all quality control documentation required by the appropriate section of this CQAP. This documentation shall be reviewed by the Geosynthetic Quality Assurance Consultant before installation can begin.

2.5 Interception Trench System Manufacturer

2.5.1 Definitions

The Manufacturer is the firm which produces any of the various groundwater interception system components outlined in this CQAP.

2.5.2 Responsibilities

Each Manufacturer is responsible for the production of its product. In addition, each Manufacturer is responsible for the condition of the product until the material is accepted by the Project Manager upon delivery. Each Manufacturer shall produce a consistent product that meets the project specifications. Each Manufacturer shall provide quality control documentation for its product as specified in this CQAP.

2.5.3 Qualifications

Each Manufacturer shall:

1. Be pre-qualified and approved by the Owner.

2. Provide sufficient production capacity and qualified personnel to meet the demands of the project.

3. Have an internal quality control program for its product that meets the requirements presented in this CQAP.

2.5.4 Submittals

Pre-qualification: At a minimum, the Manufacturer shall meet the following requirements and submit the following information to the Project Manager to be considered for pre-qualification:

1. Corporate background and information.

2. Manufacturing capabilities:

    a. Information on plant size, equipment, personnel, number of shifts per day, and capacity per shift.
    b. Daily production quantity of the specified product available for the Owner's facilities.
    c. A list of material properties including certified test results with attached samples.

3. The Manufacturer's quality control manual, including a description of the quality control laboratory facilities.

Additional information may need to be submitted if requested by the Project Manager.

Pre-installation: Prior to the installation of any geosynthetic material, the Manufacturer shall submit to the Project Manager all quality control documentation required by the appropriate section of this CQAP. This documentation shall be reviewed by the Quality Assurance Consultant as outlined in Section 2.9 of this CQAP before installation can begin.

2.6 Earthwork Contractor

2.6.1 Definitions

The Earthwork Contractor is the firm which performs the site earthwork preparation and construction of the soil components of the lining system. The Earthwork Superintendent is the individual responsible for the Earthwork Contractor's field crew. The Earthwork Superintendent represents the Earthwork Contractor at all site meetings and acts as the Earthwork Contractor's spokesman on the project.

2.6.2 Responsibilities

The Earthwork Contractor is responsible for constructing soil components of the lining systems in conformance to the project plans and specifications. The Earthwork Contractor may also be responsible for locating and transporting the required earth and granular materials, concrete, piping, and other work, as outlined in the project specifications.

2.6.3 Qualifications

The Earthwork Contractor shall be:

1. Pre-qualified and approved by the Owner;

2. Able to provide qualified personnel to meet the demands of the project; and

At a minimum, the Earthwork Contractor shall provide a Superintendent as described below.

The Superintendent must be qualified based on previously demonstrated experience, management ability, and authority. The Superintendent shall be approved by the Project Manager.

2.6.4 Submittals

Pre-qualification: At a minimum, the Earthwork Contractor shall meet the following requirements and submit the following information to the Project Manager to be considered for prequalification:

1. Company background and information;

2. Demonstration of bonding and insurance capability;

3. List of outstanding contracts;

4. List of readily available equipment required to perform the work (i.e., scrapers, graders, scarifiers, compactors, discing equipment, water trucks, and admixing equipment, if required); and

5. List of at least five comparable projects with the following information for each project:

    a. Name of the facility, its location, date of installation;
    b. Name of project manager or contact person for the installation;
    c. Description and purpose of installation and definition of contractor's scope of work; and

Additional information may need to be submitted if requested by the Project Manager.

Pre-installation: Prior to commencement of the earthwork activities, the Earthwork Contractor shall submit to the Project Manager:

1. Resume of the Earthwork Superintendent to be assigned to this project, including the dates and duration of employment;

2. Schedule of construction activities.

3. List of specific equipment and personnel to be used on the project.

Installation: During the installation, the Earthwork Contractor shall submit to the Project Manager:

1. Subgrade acceptance certificates for each area to be covered by the lining system signed by the Earthwork Contractor.

Completion: Upon completion of the installation, the Earthwork Contractor shall submit a Certificate of Completion.

2.7 Geosynthetic Installation Contractor

2.7.1 Definitions

The Geosynthetic Installation Contractor (Installer) is the firm which installs the geosynthetic components of the lining system. The Geosynthetic Superintendent is the individual responsible for the Installer's field crew. The Geosynthetic Superintendent shall represent the Installer at all site meetings and act as the Installer's spokesman on the project. The Master Seamer shall be an experienced seamer on the Installer's field crew who shall provide direct supervision over less experienced seamers.

2.7.2 Responsibilities

The Installer is responsible for field handling, storing, deploying, seaming, temporary restraining and all other aspects of the geosynthetics installation. The Installer may also be responsible for transportation of these materials to the site and for anchor systems, if required by the project specifications. The Installer shall be responsible for submittal of the documentation listed in Section 2.6.4.

2.7.3 Qualifications

The Installer shall be pre-qualified and approved by the Owner. The Installer shall be able to provide qualified personnel to meet the demands of the project. At a minimum, the Installer shall provide a Geosynthetic Superintendent and a Master Seamer.

The Geosynthetic Superintendent shall be qualified based on previously demonstrated experience, management ability and authority. The Geosynthetic Superintendent shall be approved by the Project Manager.

For geomembrane installation, all personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests. The Master Seamer shall have experience seaming and be approved by the Project Manager.

2.7.4 Submittals

Pre-qualification: At a minimum, the Installer shall submit the following information to the Project Manager to be considered for pre-qualification:

1. Corporate background and information.

2. Description of installation capabilities:

    a. Information on equipment (numbers and types), and personnel (number of Superintendents, number of crews).
    b. Average daily production anticipated.
    c. Samples of field geomembrane seams and a list of minimum values for geomembrane seam properties.

3. A list of at least ten completed facilities, totalling a minimum of 2,000,000 ft^2 (200,000 m^2) for which the Installer has installed geosynthetics. For each installation, the following information shall be provided:

    a. Name and purpose of facility, its location, and date of installation.
    b. Name of owner, project manager, design engineer, geosynthetic manufacturer, fabricator (if any), and name of contact at the facility who can discuss the project.
    c. Name and qualifications of the Superintendent(s) of the Installer's crew(s).
    d. Type of geosynthetic, and surface area installed.
    e. Type of seaming and type of seaming apparatus used.
    f. Duration of installation.
    g. Available information on the performance of the lining system.

4. The Installer's quality control manual.

5. A copy of a letter of recommendation supplied by the geomembrane manufacturer.

Pre-installation: Prior to commencement of the installation, the Installer must submit to the Project Manager:

1. Resume of the Geosynthetic Superintendent to be assigned to this project, including dates and duration of employment.

2. Resume of the Master Seamer to be assigned to this project, including dates and duration of employment.

3. A panel layout drawing showing the installation layout identifying field seams as well as any variance or additional details which deviate from the project plans or specifications. The layout shall be adequate for use as a construction plan and shall include dimensions and details as appropriate.

4. Installation schedule.

5. A list of personnel performing field seaming operations along with pertinent experience information.

6. All geosynthetic quality control certificates as required by this CQAP, unless submitted directly to the Project Manager by the Geosynthetics Manufacturer.

7. Certification that extrudate to be used is comprised of the same resin as the geomembrane to be used.

This documentation shall be reviewed by the Geosynthetic Quality Assurance Consultant before installation of the geosynthetic can begin.

Installation: During installation, the Installer shall be responsible for the submission of:

1. Quality control documentation recorded during installation.

2. Subgrade surface acceptance certificates signed by the Installer for each area to be covered by the lining system.

Completion: Upon completion of the installation, the Installer shall submit:

1. The warranty obtained from the Geosynthetics Manufacturer.

2. The installation warranty.

2.8 Interceptor Trench Contractor

2.8.1 Definitions

The Contractor is the firm which performs the site earthwork preparation and construction of the groundwater interception system. The Superintendent is the individual responsible for the Contractor's field crew. The Superintendent represents the Contractor at all site meetings and acts as the Contractor's spokesman on the project.

2.8.2 Responsibilities

The Contractor is responsible for constructing components of the lining systems in conformance to the project plan and specifications. The Contractor may also be responsible for locating and transporting the required earth and granular materials, concrete, piping, and other work, as outlined in the project specifications.

2.8.3 Qualifications

The Contractor shall be:

1. Pre-qualified and approved by the Owner;

2. Able to provide qualified personnel to meet the demands of the project; and

At a minimum, the Contractor shall provide a Superintendent as described below.

The Superintendent must be qualified based on previously demonstrated experience, management ability, and authority. The Superintendent shall be approved by the Project Manager.

2.8.4 Submittals

Pre-qualification: At a minimum, the Contractor shall meet the following requirements and submit the following information to the Project Manager to be considered for prequalification:

1. Company background and information;

2. Demonstration of bonding and insurance capability;

3. List of outstanding contracts;

4. List of readily available equipment required to perform the work (i.e., scrapers, graders, scarifiers, compactors, discing equipment, track hoes, water trucks, and admixing equipment, if required); and

5. List of at least five comparable projects with the following information for each project:

    a. Name of the facility, its location, date of installation;
    b. Name of project manager or contact person for the installation; and
    c. Description and purpose of installation and definition of contractor's scope of work.

Additional information may need to be submitted if requested by the Project Manager.

Pre-installation: Prior to commencement of the construction activities, the Contractor shall submit to the Project Manager:

1. Resume of the Superintendent to be assigned to this project, including the dates and duration of employment;

2. Schedule of construction activities; and

3. List of specific equipment and personnel to be used on the project.

Installation: Following the installation, the Contractor shall submit to the Project Manager:

1. Upon completion of the installation, the Contractor shall submit a Certificate of Completion

2.9 Construction Quality Assurance Consultant/Engineer

2.9.1 Definition

The Construction Quality Assurance (CQA) Consultant/Engineer is the firm/individual responsible for confirming the work is performed to the project plans and specifications, and assembling the record of the work. The CQA Consultant is the firm or project representatives (Resident Project Observers, RPO), that work under the direction of the CQA Engineer. The CQA Engineer is a registered Professional Engineer licensed to practice in the State of Ohio.

The CQA Consultant may be referred to as Geosynthetics Quality Assurance Consultant (QAC) for quality assurance activities associated with geosynthetics. This is an attempt to indicate the different areas of expertise required by the CQA Consultant. A similar designation will be used for groundwater interception system QAC.

2.9.2 Responsibility and Authority

The CQA Engineer is responsible for:

- Assigning quality assurance personnel to observe and document construction activities, requiring certification.

- Preparing a Construction Completion Report as outlined in Section 4.0 - Documentation, of this CQAP.

- Overseeing the geotechnical and geosynthetic laboratory testing and the testing of materials for the groundwater interception system.

- Review the calibration certificates of testing equipment.

- Establishing a program of quick and ready access to the Project Manager at all times. Communications shall be frequent, and the lines of communication shall be followed as established at the preconstruction meeting.

The CQA Engineer and/or the RPO is responsible for:

- Reviewing the results of geotechnical and geosynthetic laboratory testing.
- Verifying that installation requirements are met and that all submittals are provided.
- Performing and repeating tests, as necessary, to provide a high degree of certainty that the physical/mechanical characteristics of the earthwork components of the landfill cover system meet or exceed specifications.
- Attending all quality assurance related meetings, including pre-construction and weekly.

The RPO is responsible for:

- Maintaining field filing system and providing copies to the CQA Engineer.
- Acting as on-site (resident) representative to the CQA Engineer.
- Observing and recording activities related to the construction of the remedial action.
- Implementing the field sampling and testing components of this CQAP.
- Preparing a daily summary of quantity estimates (soil, geosynthetics and other materials).
- Observing and recording the activities of the Contractor to ensure that the work product complies with the remedial design plans and specifications. Keeping a photo log of project activities with dates accurate and up-to-date.
- Maintaining daily reports of construction and quality control activities as outlined in Section 4.1 of this CQAP. Construction reports summarizing significant events, as well as addressing problems encountered and their solutions, shall be documented. The RPO shall submit these daily reports to the CQA Engineer.
- Preparing a weekly summary of construction activities at the end of each week.

Any differences between the CQA Engineer's interpretation of the remedial design plans and specifications from the Contractor's or Project Manager's interpretation shall be resolved by the Design Engineer.

If such assessment indicates any actual or suspected work deficiencies, the CQA Engineer shall inform the Project Manager and the Contractor of these deficiencies.

2.9.3 Qualifications

The CQA Consultant, Engineer and RPO shall be experienced in the installation of landfill covers, and groundwater interception systems and the procedures of quality assurance documentation including quality assurance forms, reports, and record drawings. The CQA Engineer shall be a licensed professional engineer in the State of Ohio.

2.9.4 Submittals

The CQA Engineer, in conjunction with the Design Engineer, shall be responsible for submitting the Construction Completion Report to the Owner and U.S. EPA. The RPO shall be responsible for submitting daily field reports to the CQA Engineer and compiling information for the Construction Completion Report throughout the construction period.

The CQA Engineer will summarize activities of the past week indicating problems encountered and there resolution, delays and anticipated activities that require CQA involvement for the upcoming week. These items will be presented in a weekly report to the Project Manager.

2.10 Interceptor Trench Quality Assurance Consultant

2.10.1 Definitions

The Interceptor Trench Quality Assurance Consultant (QAC) is the firm which observes and documents activities related to the quality assurance of the installation of the groundwater interception system on behalf of the Owner. This firm may be the same as the Construction CQA firm.

In this CQAP, the term Quality Assurance Engineer (QAE) refers to the engineer employed by the QAC who is personally in charge of the quality assurance work. In some cases, the duties of the QAE may be shared by two individuals: a Quality Assurance Certifying Engineer and a Quality Assurance Resident Engineer. Although not located at the site, the Quality Assurance Certifying Engineer shall visit the site often enough to be familiar with the details of the project. The Quality Assurance Certifying Engineer may also be known as the Quality Assurance Officer.

The personnel of the QAC may also include Quality Assurance Monitors (QA Monitors) who are located at the site for construction observation and documentation. Quality Assurance Engineer may also serve as quality assurance monitor.

The CQA Consultant may be referred to as Geosynthetics QAC for quality assurance activities associated with geosynthetics. This is an attempt to indicate the different areas of expertise required

by the CQA Consultant. A similar designation will be used for groundwater interception system QAC.

2.10.2 Responsibilities

The QAC is responsible for observing and documenting activities related to the quality assurance of the construction of the components of the groundwater interception system. The QAC is responsible for the implementation of this project CQAP. The QAC is also responsible for issuing a final Quality Assurance Report, sealed by a licensed Professional Engineer, as outlined in Section 2.0 of this CQAP. Other duties of the QAC shall include overseeing the laboratory testing.

The specific duties of the QAC personnel are as follows:

1. The QAE:

    a. Reviews all project plans and specifications.
    b. Reviews other site-specific documentation.
    c. Develops site-specific addenda for quality assurance of components with the assistance of the Project Manager as necessary.
    d. Administers the CQAP, including assigning and managing all quality assurance personnel, reviews all field reports, and provides engineering review of all quality assurance related issues.
    e. Familiarizes himself with all applicable changes to project plans and specifications as issued by the Designer.
    f. Acts as on-site representative of the QAC.
    g. Familiarizes all QA Monitors with the site and the project CQAP.
    h. Assigns QA Monitors to observe and document all activities requiring monitoring.
    i. Attends all quality assurance related meetings, including resolution, pre-construction, daily, weekly meetings.
    j. Reviews the Contractor's personnel qualifications for conformance with those qualifications pre-approved for work on-site.
    k. Reviews the calibration certification of the on-site and off-site testing equipment.
    l. Manages the preparation of the record drawings.
    m. Reviews the QA Monitors' daily reports, logs, and photographs.
    n. Notes any on-site activities that could result in damage to the installed components.
    o. Reports to the Project Manager, and logs in the daily report, any relevant observations reported by the QA Monitors.
    p. Prepares his own daily report.
    q. Prepares a daily summary of the component quantity estimates installed each day of construction activity.
    r. Prepares a weekly summary of quality assurance activities at the end of each week of the construction activity.
    s. Oversees marking, packaging and shipping of all laboratory test samples (if required).

t. Reviews the results of laboratory testing and makes appropriate recommendations.
u. Recommends the approval of the final acceptance of the groundwater interception system to the Project Manager.
v. Designates a QA Monitor to be his representative whenever he is absent from the site while operations are ongoing.
w. Reports any unapproved deviations from the CQAP to the Project Manager.
x. Maintains field files of all logs and reports.
y. Maintains qualifications of all personnel and calibration of equipment.
z. Prepares the final Quality Assurance Report.

2. The QA Monitor:

a. Monitors, logs, photographs and/or documents all component installation operations. Photographs shall be taken routinely and in critical areas of the installation sequence. These duties shall be assigned by the QAE.
b. Monitors and documents the following operations for all components:
   (1) Material delivery
   (2) Unloading and on-site transport and storage
   (3) Sampling and conformance testing
   (4) Deployment operations
   (5) Condition of the components as placed
   (6) Visual observation, by walkover, of the finished components
   (7) Repair operations, if and when necessary
c. Conducts sampling and testing.
d. Documents any on-site activities that could result in damage to the constructed components. Any problems noted shall be reported as soon as possible to the QAE.

Any differences of the QAC's interpretation of the project plans and specifications from the Contractor's interpretation shall be properly and adequately assessed by the QAC through discussion with the Contractor. If such assessment indicates any actual or suspected work deficiencies, the QAC shall inform the Contractor of these issues.

2.10.3 Qualifications

The QAC shall be pre-qualified and approved by the Owner. The QAC shall be experienced in the preparation of quality assurance documentation including quality assurance forms, reports, certifications and manuals.

The QAE shall hold a B.S., M.S., or Ph.D. degree in civil engineering or related fields and be licensed as a Professional Engineer in the State of Ohio. If the duties of the QAE are shared by two parties, only the Quality Assurance Certifying Engineer shall be required to be a licensed Professional Engineer in the State of Ohio. The QAE shall be specifically experienced in the installation of groundwater interception system and shall have the necessary training and certifications to perform the duties of a QAE. The QAE shall be approved by the Project Manager.

QA Monitors shall have specific training in construction quality assurance of engineered features and be so designated by the QAE. The Monitors shall also be approved by the Project Manager.

2.10.4 Submittals

Pre-qualification: At a minimum, the QAC shall submit the following information in writing to the Project Manager to be considered for pre-qualification:

1. Corporate background and information:

    a. General company information
    b. Proof of insurance
        (1) Professional liability
        (2) "Umbrella" coverage
        (3) Other coverages as required by statute and/or proposed contractual agreement: and

2. Quality assurance capabilities:

    a. A summary of the firm's experience in quality assurance, specifically quality assurance of groundwater interception system.
    b. A summary of quality assurance documentation and methods used by the firm, including sample quality assurance forms, reports, certifications, and manuals prepared by the firm.
    c. Resumes of key personnel.

Additional information may need to be submitted if required by the Project Manager.

2.11 Geotechnical Quality Assurance Laboratory

2.11.1 Definitions

The Geotechnical Quality Assurance Laboratory (Geotechnical QAL) is the firm which conducts tests on soil samples taken from the site. The Geotechnical QAL and Geosynthetic QAL may be the same party.

2.11.2 Responsibilities

The Geotechnical QAL is responsible for conducting the appropriate laboratory tests as directed by the CQA Engineer. The test procedures shall be performed in accordance with the test methods outlined in this CQAP. The Geotechnical QAL shall be responsible for providing tests results as outlined in Section 2.11.4.

2.11.3 Qualifications

The Geotechnical QAL shall be pre-qualified by the Owner and approved by the Project Manager. The Geotechnical QAL shall have properly maintained and periodically calibrated appropriate testing equipment. The Geotechnical QAL shall also ensure that laboratory soil testing is performed by personnel with experience and/or training in soil testing fundamentals. The laboratory personnel shall be familiar with American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), Federal Test Method Standard (FTMS) and other applicable test standards. The Geotechnical QAL shall be capable of providing test results within project deadlines throughout the soil prequalification, installation phase of the soil components and well installation.

The Geotechnical QAL shall submit sample data and analysis to be used during the lab tests to the Project Manager.

2.11.4 Submittals

The Geotechnical QAL shall submit all written test results within project deadlines to the CQA Engineer. Test results shall be provided to the CQA Engineer as soon as possible after test completion. Written test results shall be in an easily readable format and include references to the standard test methods used.

2.12 Geosynthetic Quality Assurance Laboratory

2.12.1 Definitions

The Geosynthetic Quality Assurance Laboratory (Geosynthetic QAL) is the firm which conducts tests on samples of geosynthetics taken from the site. The Geosynthetic QAL and the Geotechnical QAL may be the same party.

2.12.2 Responsibilities

The Geosynthetic QAL is responsible for conducting the appropriate laboratory tests as directed by the CQA Engineer. The test procedures shall be done in accordance with the test methods outlined in this CQAP. The Geosynthetic QAL shall be responsible for providing test results as outlined in Section 2.9.4.

2.12.3 Qualifications

The Geosynthetic QAL shall be pre-qualified by the Owner and approved by the Project Manager. The Geosynthetic QAL shall have properly maintained and periodically calibrated appropriate testing equipment. The Geosynthetic QAL shall also ensure the laboratory testing is performed by personnel with experience and/or training in geosynthetic testing fundamentals.

The Geosynthetic QAL shall be familiar with ASTM, FTMS, National Sanitation Foundation (NSF), and other applicable test standards. The Geosynthetic QAL shall be capable of providing results of destructive seam tests within 24 hours of receipt of test samples and shall maintain that standard throughout the installation. On-site laboratory facilities may be used by the Geosynthetic QAL, provided they are appropriately equipped and approved by the CQA Engineer and Project Manager.

2.12.4 Submittals

The Geosynthetic QAL shall submit all destructive seam test results to the CQA Engineer in written form within 48 hours of receipt of test samples unless otherwise specified by the Project Manager. Geomembrane destructive test results shall typically be provided to the CQA Engineer within 24 hours of receipt of test samples. Written test results shall be in an easily readable format and include references to the standard test methods used.

3.0 MEETINGS AND COMMUNICATION

To help ensure a high degree of quality during installation and assure a final product that meets all project specifications, clear, open channels of communication are essential between all parties. This section discusses appropriate lines of communication and describes all meetings that will be necessary to achieve project goals.

3.1 Lines of Communication

The typical lines of communication necessary during a project are illustrated in Appendix II. The CQA Engineer shall be capable of direct communication with the Project Manager at all times.

3.2 Resolution Meeting

Following RD approval and the completion of the project plans and specifications, a resolution meeting may be held. If the Project Manager determines a resolution meeting is necessary, it shall be held prior to bidding the construction work and include all parties involved. Typically these meetings may include the Project Manager, Design Engineer, CQA Engineer, QAE, and the Owner's representative. If appropriate, this meeting may be held in conjunction with the pre-bid meeting.

The purpose of the resolution meeting is to establish lines of communication, review project plans and specifications for completeness and clarity, begin planning for coordination of tasks and anticipate any problems which might cause difficulties and delays in construction. The design shall be discussed during this meeting so that clarification may be made before the construction work is bid. In addition, the guidelines regarding quality assurance testing and problem resolution must be known and accepted by all. Any recommended design changes will be evaluated and presented to U.S. EPA for approval.

A recommended agenda for the resolution meeting is presented in Appendix III. The meeting shall be documented by the project manager, and minutes shall be transmitted to all parties.

3.3 Pre-Construction Meeting

A pre-construction meeting shall be held at the site prior to beginning work on this project. The pre-construction meeting must be attended by the Owner, Project Manager, Design Engineer, Contractor (Earthwork Contractor and/or Geosynthetic Installation Contractor and/or Interceptor Trench Contractor and Subcontractors), CQA Engineer, RPO, and QAE, U.S. EPA, and OEPA. This CQAP shall be reviewed as well as the responsibility of each party. A recommended agenda with specific topics for the pre-construction meeting is presented in Appendix IV. The meeting shall be documented by the Project Manager and minutes shall be transmitted to all participants.

3.4 Progress Meetings

A weekly progress meeting shall be held between the Owner, Project Manager, CQA Engineer/QAE, Earthwork Contractor's/Geosynthetic Installation Contractor/Interceptor Trench Contractor, and any other concerned parties. This meeting shall discuss current progress, planned activities for the next week, issues requiring resolution, and any new business or revisions to the work. The CQA Engineer/QAE shall log any problems, decisions, or questions arising at this meeting in his weekly report. If any matter remains unresolved at the end of this meeting, the Project Manager shall be responsible for the resolution of the matter and the communication of the decision to the appropriate parties. The Project Manager may require daily progress meetings at his discretion.

3.5 Pre-Final Meeting

As the project is nearing completion, a pre-final meeting shall be held at the site. This meeting shall be attended by the Owner, Project Manager, Contractors, Design Engineer, CQA Engineer, Interceptor Trench QAC, U.S. EPA, and OEPA. It shall consist of a walk-through of the entire project area to determine whether the project is substantially complete and consistent with the contract documents. Any outstanding construction items noted during the prefinal inspection shall be recorded. A report prepared by the Project Manager shall outline the outstanding construction items, actions required to resolve items, completion dates for these items, and the date for the final meeting. All attendees will receive a copy of the report.

3.6 Final Meeting

Upon completion of outstanding construction items, a final meeting shall be held at the site. The final meeting must be attended by the Owner, Project Manager, Contractors, Design Engineer. CQA Engineer, Interceptor Trench QAC, U.S. EPA, and OEPA. The meeting shall consist of a walk-through of the project site. The prefinal meeting report shall be used as a checklist to focus on the outstanding construction items.

4.0 DOCUMENTATION

An effective CQAP depends largely on identification of those construction activities that require monitoring, and on assigning responsibilities for the monitoring of each activity. This is most effectively verified by the thorough documentation of quality assurance activities. The CQA Engineer shall document that all requirements in the lining portions of the project CQAP have been addressed and satisfied.

The CQA Engineer shall provide the Project Manager with signed descriptive remarks, data sheets, and checklists to verify that required monitoring activities have been carried out. The CQA Consultant shall also maintain at the job site a complete file of all documents which comprise the CQAP, including plans and specifications, checklists, test procedures, daily logs, and other pertinent documents.

4.1 Daily Reports

4.1.1 Soils Reports

Each Soils RPO shall complete a daily report and/or logs on prescribed forms outlining all monitoring activities for that day. The report at a minimum shall consist of field notes, observations, test data sheets, construction problems and solution data sheets. A summary of all supporting data sheets along with final testing results and CQA Engineer's approval of the work shall be required upon completion of construction.

The Project Manager shall immediately be made aware of any nonconformance with the project specifications. In particular, the Project Manager shall be informed before the work in question is covered by overlying system layers. The Project Manager shall then determine its cause and direct appropriate changes or recommend the appropriate changes. When this type of evaluation is made, the results shall be documented, and any revision to procedures or project specifications shall be approved in writing by the Owner and Design Engineer.

4.1.2 Geosynthetic Reports

Each Geosynthetic RPO shall complete a daily report and/or logs on prescribed forms outlining all monitoring activities for that day. The precise areas worked on, panel numbers, seams completed and approved, measures taken to protect unfinished areas overnight and other appropriate data and information shall be identified. Failed seams, other panel areas, or other geosynthetics requiring remedial action shall be identified with regard to nature of action, required repair, and precise location. Repairs completed must also be identified. Any problems or concerns with regard to operations on site should be noted. The report should also include information regarding the weather conditions. This report must be completed at the end of each monitor's shift, prior to leaving the site, and submitted to the CQA Engineer.

The CQA Engineer shall review the daily reports submitted by the RPOs, and incorporate a summary of their reports into the weekly report. Any matters requiring action by the Project Manager shall be identified. The report shall include a summary of the quantities of all material installed that week. This report must be completed weekly, summarizing the previous week's activities, and a copy submitted to the Project Manager at the beginning of the following week.

4.1.3 Interceptor Trench Reports

Each Quality Assurance Monitor shall complete a daily report and/or logs on prescribed forms (see Sample CQA Forms in Appendix I) outlining all monitoring activities for that day. The report at a minimum shall consist of field notes, observations, test data sheets, construction problems and solution data sheets. A summary of all supporting data sheets along with final testing or measurements and QAE's approval of the work shall be required upon completion of construction.

The Project Manager shall immediately be made aware of any nonconformance with the project drawings and specifications. In particular, the Project Manager shall be informed before the work in question is covered by subsequent construction activities. The Project Manager shall then determine its cause and recommend appropriate changes. When this type of evaluation is made, the results shall be documented, and any revision to procedures or project specifications shall be approved in writing by the Owner and Designer.

4.2 Test Reports

4.2.1 Soils Testing Reports

Records of field and laboratory testing performed on the soil components for the project shall be collated. A summary list of test results shall be prepared by the CQA Consultant (Engineer) on an ongoing basis, and submitted with the weekly progress reports.

4.2.2 Geosynthetic Testing Reports

The destructive test reports from all sources shall be collated. This includes field tests, Installer's laboratory tests (if performed), and Geosynthetic QAL tests. A summary list of test samples pass/fail results shall be prepared by the CQA Consultant on an ongoing basis, and submitted with the weekly progress reports. The report shall also contain resolution on failed tests clearly documenting complete quality assurance conformance with established procedures.

4.2.3 Interceptor Trench Testing Reports

Records of field and laboratory testing performed on the components of the groundwater interception system shall be collated by the CQAE. A summary list of test results shall be prepared by the CQAE on an ongoing basis, and submitted with the weekly progress reports.

4.3 Progress Reports

4.3.1 Landfill Cover Progress Reports

The Owner must submit to the U.S. EPA and the OEPA signed monthly progress reports during the construction phase. These progress reports must include as a minimum (and as appropriate):

- A description and estimate of the percentage of the RA completed;
- Summary of findings;
- Summary of changes made in the RA during the reporting period;
- Summary of contacts with representatives of the local community, public interest groups, or State government during the reporting period;
- Summary of problems or potential problems encountered during the reporting period;
- Actions being taken to address these problems;
- Changes in key personnel during the reporting period;
- Projected work for the next reporting period;
- Copies of weekly reports, inspection reports, and laboratory/monitoring data (if available);
- Comparisons of working schedule to project schedule; and
- Summaries of conference calls and meetings held during the reporting period between the Respondents and the U.S. EPA and/or the OEPA.

4.3.2 Interceptor Trench Progress Reports

Progress reports shall be prepared by the QAE and submitted to the Project Manager. These reports shall be submitted every week, starting the first Friday of material delivery or other day as approved by the Project Manager. These reports shall include an overview of progress to date and an outline of any deviation from the project plans or specifications. Revisions to the construction schedule provided by the Contractor will be summarized. The report shall also include any problems or deficiencies in installation at the site, an outline of any action taken to remedy the situation. and a brief description of activities anticipated for the next week. All daily reports for the period should be appended to each progress report.

4.4 Record Drawings

Drawings that document the locations and/or elevations of the remedial actions will be required. The extent and quantity of documentation will vary by feature as discussed below.

4.4.1 Soils Drawings

Record drawings for the Remedial Action shall be prepared by the CQA Consultant and included in the Construction Completion Report. The information shall be presented on scaled drawings both in plan view and in cross-section as necessary. At a minimum, the drawings shall include the following:

- Measured grade of the finished surface of each soil component
- Location of field tests and samples obtained for laboratory testing
- Details

4.4.2 Geosynthetic Drawings

Record drawings shall be prepared by the CQA Consultant (or surveyor under contract to the Owner). The record drawings shall include, at a minimum, the following information for geomembranes:

1. Dimensions of all geomembrane field panels.

2. Location, as accurately as possible, of each panel (panel layout) relative to the site survey grid furnished by the Project Manager.

3. Identification of all seams and panels with appropriate numbers or identification codes.

4. Location of all patches and repairs.

5. Location of all destructive testing samples.

The record drawings shall illustrate each layer of geosynthetics and soil, and if necessary, other drawings shall identify problems or unusual conditions of the geosynthetics. In addition, applicable cross sections shall show layouts of geonets, geotextiles, geomembranes or geosynthetic clay liners in areas which are unusual or differ from the design drawings. All surveying for record information shall be performed by a licensed land surveyor in the State of Ohio.

4.4.3 Interception System Drawings

Record drawings shall be prepared by the QAC. The record drawings shall include, at a minimum, the following information for components:

1. Surveyed grade of the base of interceptor trench and cut-off wall.
2. Surveyed grade of the top of rock.
3. Locations of field measurements.
4. Locations of the interceptor trench and cut-off wall alignment at 50' intervals.
5. Locations and elevations of manholes.
6. Locations and elevations of wells and piezometers.
7. Force main and electrical conduct.

If necessary, for the purpose of clarity in the drawings, separate sheets shall be used to illustrate the locations of test sampling points. The drawings shall be shown in both plan and in cross-section views as applicable. All surveying shall be performed by a licensed land surveyor in the State of Ohio.

4.5 Landfill Cover Construction Completion Report

Following the final meeting, a Construction Completion Report shall be prepared by the CQA Consultant and submitted to the Owner for submittal to the U.S. EPA and OEPA. The Construction Completion Report shall confirm and document that the work was performed in substantial compliance with the design plans and specifications. The Construction Completion Report must include the following:

- Parties and personnel involved with the project;
- Scope of work;
- Survey Benchmark information;
- Summary of construction activities;
- Weekly reports;
- Observation and Testing Data Sheets, including sampling locations;
- Test results (conformance, destructive, non-destructive, and other laboratory tests);
- Construction problems and solutions;
- Photographic documentation;
- Changes from design and material specifications;
- Signature page, sealed and signed by the CQA Engineer; and
- Record drawings, sealed and signed by a licensed Professional Engineer, or licensed Registered Land Surveyor in the State of Ohio.

The CQA Engineer shall state in the report that the installation has proceeded in accordance with the CQAP except as noted to the Project Manager. A recommended outline for the final construction completion report is given in Appendix V. The items shown in Appendix V shall be considered the minimum content. The CQA Engineer may expand the content as required.

4.6 Interceptor Trench Final Quality Assurance Report

Upon completion of the work, the QAC shall submit a final Quality Assurance Report to the Project Manager. This report shall summarize the activities of the project, and document all aspects of the quality assurance program performed.

The final Quality Assurance Report shall include, at a minimum, the following information:

1. Parties and personnel involved with the project.
2. Scope of work.
3. Outline of project.
4. Quality assurance methods.
5. Test results (conformance, pressure tests, including laboratory tests).
6. Signature page, sealed and signed by a licensed Professional Engineer.
7. Record drawings, sealed and signed by a licensed Professional Engineer/Surveyor.
8. Weekly reports.
9. Plan and/or specification deviations and resolutions.

The QAC shall state in the report that the installation has proceeded in accordance with the project CQAP except as noted to the Project Manager. See Appendix V for a recommended outline of the final construction completion report. Upon approval by the Project Manager, the Construction Completion Report will be submitted to U.S. EPA and OEPA.

4.7 Final Storage of Records

Final records of the construction of the remediation shall be maintained in the CQA Consultant's files. Copies of reports and other submittals shall be retained by the Owner, the U.S. EPA, and the OEPA.

5.0 FINAL COVER SYSTEM ACCEPTANCE

5.1 Soil Components Acceptance

Upon written recommendation by the CQA Engineer, the Project Manager shall consider accepting the soil components of the remedial actions. The Earthwork Contractor will retain all ownership and responsibility for the soil capping components until acceptance by the Project Manager. At the Project Manager's discretion, the system components may be accepted in sections or at points of substantial completion.

The Project Manager will accept the soil components of the capping system when:

1. The installation of the soil components is finished;

2. Verification of the adequacy of the constructed components, including repairs, if any, is completed in accordance with the project-specific CQAP;

3. All documentation of installation is completed; and

4. The CQA Consultant is able to recommend acceptance.

The CQA Engineer shall certify that installation of the soil components has proceeded in accordance with the applicable portions of the project-specific CQAP except as noted to the Project Manager. This certification shall be provided in the final Construction Completion Report as outlined in Section 4.5.

5.2 Geosynthetic Components Acceptance

Upon written recommendation by the CQA Engineer, the Project Manager shall consider accepting the geosynthetic components of the lining system. The Installer will retain all ownership and responsibility for the geosynthetics in the lining system until acceptance by the Project Manager. At the Project Manager's discretion, the lining system may be accepted in sections or at points of substantial completion.

The Project Manager will accept the geosynthetic components of the lining system when:

1. The installation of the geosynthetic components is finished;

2. Verification of the adequacy of all seams including associated testing and repairs, if any, is completed in accordance with the project-specific CQAP;

3. All documentation of installation is completed; and

4. The CQA Engineer is able to recommend acceptance.

The CQA Engineer shall certify that installation has proceeded in accordance with the geosynthetic portions of the project-specific CQAP except as noted to the Project Manager. This certification shall be provided in the final Construction Completion Report as outlined in Section 4.5.

5.3 Interception System Acceptance

The interception system is an operating system. As such, its acceptance is dependent on its construction in accordance with project documents and successful demonstration of its operation.

5.4 Interception System

Upon written recommendation by the CQA Engineer, the Project Manager shall consider accepting the soil components of the remedial actions. The Contractor will retain all ownership and responsibility for the components until acceptance by the Project Manager. At the Project Manager's discretion, the system components may be accepted in sections or at points of substantial completion.

The Project Manager will accept the interception system components when:

1. The installation of the interception system components is finished;

2. Verification of the adequacy of the constructed components, including repairs, if any, is completed in accordance with the project-specific CQAP;

3. All documentation of installation is completed;

4. The CQA Consultant is able to recommend acceptance; and

5. After the system has been demonstrated to be in accordance with the project specification.

The CQA Engineer shall certify that installation of the interception system components has proceeded in accordance with the portions of the CQAP except as noted to the Project Manager. This certification shall be provided in the final Construction Completion Report as outlined in Section 4.5.

5.5 Geosynthetic Components Acceptance

Upon written recommendation by the CQA Engineer, the Project Manager shall consider accepting the geosynthetic components of the lining system. The Installer will retain all ownership and responsibility for the geosynthetics in the lining system until acceptance by the Project Manager.

At the Project Manager's discretion, the lining system may be accepted in sections or at points of substantial completion.

The Project Manager will accept the geosynthetic components of the lining system when:

1. The installation of the geosynthetic components is finished;

2. Verification of the adequacy of all seams including associated testing and repairs, if any, is completed in accordance with the project-specific CQAP;

3. All documentation of installation is completed; and

4. The CQA Engineer is able to recommend acceptance.

The CQA Engineer shall certify that installation has proceeded in accordance with the geosynthetic portions of the project-specific CQAP except as noted to the Project Manager. This certification shall be provided in the final Construction Completion Report as outlined in Section 4.5.

6.0 SITE PREPARATION

Site Preparation includes:

- Clearing and grubbing the landfill surface and areas along the East Fork of Mill Creek by removing and stockpiling trees, roots, brush, stumps and vegetation, and disposing by hauling to the designated area on site.
- Regrading of exposed debris to conform to cap grades.
- Preparation of groundwater interception system work platform.
- Relocation of fence.
- Installation of fence gates.
- Construction/installation of erosion and sedimentation controls.
- Construction of Diversion Berm.
- Installation of Rip-Rap along East Fork of Mill Creek.

6.1 Observation and Quality Control

Observation and quality control of site preparation includes the following:

- Visual observation and photographic record of the landfill surface following clearing and grubbing.
- Visual observation and photographic record of erosion and sedimentation controls.
- Visual observation and photographic record of debris which was moved to the center of the landfill for cap grading conformance.
- A written record of the surface area cleared and grubbed.

7.0 SUBBASE PREPARATION

Subbase preparation includes:

- Shaping the landfill surface to closely follow the subbase contours as illustrated in the design drawings. (Contours are based on achieving a minimum slope of 5% and limiting the grade to a maximum of 33% (3H:1V slope);
- Excavating in-place waste including soil from the two contaminated soil areas, where necessary, and placing the waste in areas of the site receiving the final landfill cover;

7.1 Observation and Quality Control

Observation and quality control of subbase preparation includes:

- Visual and photographic records of the removal and placement of excavated waste.
- Visual and photographic record of the placement of general earthfill used for subbase grading (see Section 9.0).
- Soil testing (field and laboratory including strength data per Table 1).
- A written record of the quantities involved for subbase preparation.

7.2 Confirmation

The Earthwork Contractor shall be responsible for preparing the subgrade soil for placement of overlying materials. Upon completion of the subgrade preparation work, the CQA Consultant shall examine the subgrade and prepare a certificate of acceptance to be submitted to the Project Manager. In this certificate of acceptance, the CQA Engineer shall verify, at a minimum, that:

1. A licensed land surveyor in the State of Ohio has verified all lines and grades.
2. The subgrade soil meets the criteria in the project specifications.

8.0 FINAL COVER

Final cover includes:

Constructing the final cover which is made up of the following components (from top to bottom):

- Vegetative growth
- Topsoil layer
- Vegetative soil cover material
- Geocomposite drainage layer
- 40 mil geomembrane
- Geosynthetic clay liner
- Compacted cohesive soil layer
- Geocomposite gas venting layer

Constructing and shaping the surface water drainage features as specified in the remedial design specifications and design drawings including:

- Perimeter swales
- Interceptor swales
- Rip-rap
- Erosion and sediment control features

8.1 Observation and Quality Control

Observation of the compacted cohesive soil layer construction shall be coordinated with construction testing. Acceptance criteria for construction work shall be as identified in the project specifications. At a minimum, the CQA Engineer/Resident Project Observer shall observe and record the following during the construction of the compacted cohesive soil layers:

1. Moisture content and consistency of the soil during placement, and compaction.

2. Type and level of compactive effort
   a. Roller type
   b. Roller weight
   c. Number of coverages

3. Action of compaction equipment on the soil surface (sheepsfoot penetration, pumping, cracking, etc.).

4. Maximum clod size.

5. Loose and compacted lift thickness.

6. Method of bonding lifts together.

7. Stones which may damage overlying geosynthetic components.

8. Areas where damage due to excess moisture, insufficient moisture, or freezing may have occurred.

The CQA Consultant will be present on-site full-time during construction to verify that construction of the final cover system (including surface water drainage features) is in accordance with the remedial design plans and specifications. The CQA Consultant will be responsible for the following items:

- Perform field density tests for each 8-inch-thick lift of compacted cohesive soil layer placed at a rate of five tests/lift/acre;
- Visually observe soil used for the topsoil, and vegetative soil cover, and the compacted cohesive soil layer so that unsuitable soil is not used for these layers;
- Obtain soil samples at a frequency noted on Table 1 for geotechnical laboratory testing;
- Maintain daily field notes regarding project construction;
- Provide photographic record of major construction activities; and
- Survey grade and thickness on 100 foot grid spacing.

8.2 Construction Testing

Both in-field and laboratory testing shall be performed to document materials used and the method of placement as described on the following pages. Sample quantities, containers, preservatives and packaging requirements are summarized in Table 2.

8.2.1 Compacted Cohesive Soil Layer

Compacted cohesive soil layer material generally consists of cohesive soils with low hydraulic conductivity (less than 1×10^{-7} cm/s) as barriers in lining systems. Soils used shall consist of clean, select material, free of debris, excessive coarse particles or other deleterious matter. Soils with a visibly identifiable organic content, or soils classified according to the Unified Soil Classification System as organic silt or organic clay (OL, OH) shall not be used. Material requirements are further defined in the project specification.

The CQA Consultant shall document the compacted cohesive soil layer placement and material through field and laboratory testing. In-field testing shall consist of field moisture content and

density testing (ASTM D3017 and D2922) performed at the frequency shown in Table 1. The geotechnical laboratory testing will be performed at the frequency shown in Table 1 and shall consist of the following tests:

- Natural Moisture Content (ASTM D2216);
- Moisture-Density Relationship, Standard Proctor (ASTM D);
- Atterberg Limits (liquid limit and plasticity index) (ASTM D4318);
- Grain-Size Distribution through hydrometer (ASTM D422); and
- Recompacted Hydraulic Conductivity (ASTM D5084).

8.2.1.1 Defects and Repairs

8.2.1.1.1 Identification

Acceptability criteria for testing is identified in the project specifications. Recommended maximum percentage of failing material tests and maximum allowable variations are specified. At locations where the testing indicates the requirements of the project specifications are not met, the CQA Consultant shall determine the extent and the nature of the defect and recommend corrective actions to the Project Manager.

At any time during construction of the compacted cohesive soil layer, the CQA Consultant shall indicate to the Earthwork Contractor any locations which are not adequate for placement of the compacted cohesive soil layer. The Earthwork Contractor shall repair defects in the subgrade soil, such that the properties of the repaired areas meet the project specifications.

The CQA Consultant shall confirm that no stones are present which may damage overlying geosynthetic components. If the compacted clay capping layer has been subject to adverse weather conditions, the CQA Consultant shall reexamine the soil for possible damage.

8.2.1.1.2 Notification

After determining the extent and nature of any defect, the CQA Engineer shall promptly notify the Earthwork Contractor and the Project Manager. A work deficiency meeting shall be held as needed between the Earthwork Contractor, CQA Engineer, Design Engineer, Project Manager and other appropriate parties to assess the problem, review alternative solutions, and implement an action plan.

8.2.1.1.3 Repairs and Retesting

The Earthwork Contractor shall correct all deficiencies to meet the project specifications. If a project specification criteria cannot be met, or unusual weather conditions hinder work, the CQA Engineer and Design Engineer shall develop and present to the Project Manager suggested solutions for his approval.

The CQA Engineer shall schedule appropriate retests when the work defect is corrected. All retests by the CQA Consultant shall verify that the defect is corrected in the area of the deficiency and work can proceed.

The CQA Consultant shall observe any repair and report any noncompliance with the above requirements in writing to the Project Manager.

8.2.2 Geocomposite Gas Venting Layer

Perform Conformance testing for the geocomposite as described in Section 12.

8.2.3 Geosynthetic Clay Layer (GCL)

Perform Conformance testing for the GCL as described in Section 10.

8.2.4 Geomembrane Layer

Perform Conformance testing for the geomembrane, as described in Section 11.

8.2.5 Geocomposite Drainage Layer

Perform Conformance testing for the geocomposite as described in Section 12.

8.2.6 Vegetative Soil Cover Material

Vegetative soil cover material generally consists of medium-textured soils capable of supporting vegetative growth and topsoil. Establishment of vegetation reduces cover erosion due to water and wind, and protects the soil and geosynthetic materials against damage. The vegetation also enhances the aesthetic appearance of the landfill.

Site-specific criteria for the vegetative soil cover layer is specified in the project specifications.

No field or laboratory testing is proposed for the general earthfill portion of the vegetative soil cover layer. This soil, which will promote root development, will be placed uncompacted. Field testing of the topsoil portion, which should be the top six (6) inches, will include USDA soil classification by visual observation. Laboratory testing shall be performed at the frequency shown in Table 1 and includes pH, potassium, phosphorus, and total nitrogen. Verify the actual thickness of the vegetative soil cover by direct measurements.

8.3 Failing Tests or Materials

If failing laboratory or field tests occur for any of the final cover system components, the area shall be reworked and retested to achieve passing tests. If the material is incapable of achieving passing results, the material shall be removed and replaced with acceptable material.

8.4 Final Cover Confirmation

Confirmation of the final cover layer thicknesses and elevations shall be made by topographic surveys on 100 ft grids for the following:

- Bottom of compacted cohesive soil layer;
- Top of compacted cohesive soil layer; and
- Top of vegetative soil cover.

Confirmation of the placement of these layers shall be made by visual observations and photo documentation.

8.5 Vegetation Confirmation

Confirmation of the vegetation layer shall be made by submittal of seed and fertilizer certifications and bag tags from products utilized. Confirmation of placement shall be made by visual observations and photo documentation.

8.6 Drainage Features Confirmation

Confirmation of construction and installation of the drainage swales and control structures shall be made by visual observation, photo documentation, and topographic survey of location and elevation.

9.0 GENERAL EARTHFILL

General earthfill will be used as fill material to achieve the proposed subbase grades and vegetative cover soil over the barrier layers. It will be obtained from on-site sources.

9.1 Description and Applicability

General earthfill consists of random, granular or cohesive material taken from on-site, approved off-site excavations or stockpiles and used for non-critical applications. General earthfill material consists of a broad range of soils, relatively free of organics, debris, or other deleterious matter, which can be used for the purpose of earthfill construction. Specific tests to determine the suitability of earth materials for use in general earthfill are specified in the project specifications.

9.2 Quality Control Documentation

Prior to construction of the general earthfill, required tests listed in Table 1 shall be performed to determine conformance with the project specifications. Laboratory testing shall be performed by the Geotechnical QAL. Field density and moisture content testing will be performed by the CQA Consultant.

If required, the general fill material shall be processed such that it does not contain particles exceeding the maximum size established in the project specifications. The Earthwork Contractor shall submit the results of these tests to the Project Manager. The Project Manager shall accept or reject the material based on these tests.

9.3 Construction Observation

The CQA Consultant shall verify that the requirements of the project specifications are met and report any nonconformance to the Project Manager and Contractor.

9.4 Defects and Repairs

9.4.1 Identification

If a defect is identified in the finished general earthfill, the CQA Consultant shall determine the extent and the nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Consultant shall determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Consultant deems appropriate.

9.4.2 Notification

After determining the extent and nature of the defect, the CQA Engineer shall promptly notify the Earthwork Contractor and the Project Manager. A work deficiency meeting shall be held as needed between the Earthwork Contractor, CQA Engineer, Design Engineer, Project Manager and other necessary parties to assess the problem, review alternative solutions, and implement an action plan.

9.4.3 Repairs and Retesting

The Earthwork Contractor shall correct all deficiencies to meet the project specifications. If a project specification criteria cannot be met, or unusual weather conditions hinder work, the Design Engineer shall develop and present to the Project Manager suggested solutions for his approval.

The CQA Consultant shall schedule appropriate retests, if required, when the work defect is corrected. Retests by the CQA Consultant must verify that the defect is corrected and work can proceed in the area of the deficiency.

The CQA Consultant shall observe any repair and report any noncompliance with the above requirements in writing to the Project Manager.

10.0 GEOSYNTHETIC CLAY LAYERS

10.1 Definitions and Applicability

Geosynthetic Clay Layers (GCLs) are geocomposite materials that consist of a low hydraulic conductivity montmorillonite-rich expansive clay (bentonite) core which is bonded to a geotextile backing. GCLs are used as barriers in lining and capping systems.

10.2 Manufacturing Plant Inspection

If desired, the Owner or appropriate representative can conduct an inspection of the Geosynthetics Manufacturer's plant. In addition, the Project Manager, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary. If possible, the project-specific inspection shall be prior to or during the manufacturing of the GCL rolls for that particular project. The purpose of the plant inspection is to review the manufacturing process and quality control procedures.

The manufacturing plant inspection shall include:

1. Verification that properties guaranteed by the Geosynthetics Manufacturer are met and meet all project specifications.

2. Verification that the measurement of properties by the Geosynthetics Manufacturer is properly documented and test methods used are acceptable.

3. Spot inspection of the rolls and verification that they are free of imperfections or contamination by foreign matter.

4. Review of handling, storage, and transportation procedures, and verification that these procedures will not damage the GCL.

5. Verification that roll packages have a label indicating the name of the Geosynthetics Manufacturer, roll number, and roll dimensions.

6. Verification that overlap lines are printed on the rolls.

10.3 Quality Control Documentation

Prior to the installation of any GCL, the Geosynthetics Manufacturer or Installer shall provide the CQA Consultant with the following information:

1. The origin (supplier's name and location of material source) and identification of the bentonite used for production of the GCL.

2. Copies of dated quality control information issued by the bentonite supplier.

3. Results of quality control tests conducted by the GCL Geosynthetics Manufacturer to verify that the bentonite supplied met the GCL Geosynthetics Manufacturer's specifications.

4. Copies of dated quality control information provided by the geotextile Geosynthetics Manufacturer.

5. A specification for the GCL which includes all properties contained in the project specifications for the GCL.

6. Written certification that the minimum values given in the project specifications are guaranteed by the Geosynthetics Manufacturer.

7. Quality control certificates, signed by a responsible party employed by the Geosynthetics Manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. At a minimum, results shall be given for:

   a. Moisture content (ASTM D4643) for every 10,000 ft^2 (1,000 m^2) of material
   b. Hydraulic conductivity (GRI GCL-2) for every 100,000 ft^2 (10,000 m^2) of material
   c. Swell index (GRI GCL-1) for every 10,000 ft^2 (1,000 m^2) of material
   d. Mass per unit area (ASTM D3776) for every 10,000 ft^2 (1,000 m^2) of material

The Geosynthetics Manufacturer shall identify all rolls of GCL with the following:

1. Geosynthetics Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

The CQA Consultant shall review these documents and shall report any discrepancies with the above requirements to the Project Manager and Manufacturer. The CQA Consultant shall verify that:

1. Property values certified by the Geosynthetics Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Geosynthetics Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Rolls are appropriately labeled.

5. Certified minimum properties meet the project specifications.

6. Project specifications and the CQAP were submitted by Project Manager to the Installer.

7. Geosynthetics Manufacturer confirms a field drying shrinkage potential to allow proper seam overlap in the field.

10.4 Conformance Testing

10.4.1 Sampling Procedures

Upon delivery of the rolls of GCL, the CQA Consultant shall examine all rolls and obtain samples for conformance testing. The rolls to be sampled shall be selected by the CQA Consultant. Samples shall not be taken from any portion of a roll which has been damaged. Unless otherwise specified, samples shall be 1 ft (0.3 m) long by the roll width. The CQA Consultant shall mark the machine direction on the samples with an arrow.

A lot shall be defined as a group of consecutively numbered rolls from the same manufacturing line. Alternatively, a lot may be designated by the CQA Consultant based on a review of all roll information including quality control documentation and manufacturing records. If the Project Manager desires, the CQA Consultant can perform the conformance test sampling at the manufacturing plant. This may expedite the installation process for remedial action.

Samples shall be taken at a rate of one per lot, not to be less than one per 100,000 ft^2 (10,000 m^2) of GCL. Samples for hydraulic conductivity conformance tests shall be taken at least every 250,000 ft^2 (25,000 m^2). These samples shall then be forwarded to the Geosynthetic QAL for testing to verify conformance to the project specifications.

10.4.2 Conformance Tests

At a minimum, the following conformance tests shall be conducted on the GCL as a unit:

1. Moisture content (ASTM D4643)
2. Hydraulic conductivity (GRI GCL-2)
3. Mass per unit area (ASTM D3776)

10.4.3 Test Results

All conformance test results shall be reviewed and accepted or rejected by the CQA Consultant prior to the deployment of the GCL. The CQA Consultant shall examine all results from laboratory conformance testing and shall report any nonconformance to the Project Manager. The CQA Engineer shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications.

If the Geosynthetics Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Geosynthetics Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Geosynthetics Manufacturer present during the testing. Alternatively, the Geosynthetics Manufacturer may have the sample retested at two different Owner-approved Geosynthetic QALs. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Project Manager.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of the Project Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out-of- specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

10.5 GCL Deployment

During shipment and storage, the GCL shall be protected from ultraviolet light exposure, moisture, excessive humidity, puncture, cutting, or any other damaging conditions. GCL rolls shall be shipped and stored in relatively opaque and watertight wrappings. GCL rolls shall be stored away from wet ground and be covered with a watertight tarp or under a roof to protect the stored rolls from hydration. The roll wrappings shall be removed shortly before deployment.

The CQA Consultant shall observe rolls upon delivery and prior to deployment at the site and report any deviations from the above requirements to the Project Manager.

Prior to deployment, the Contractor shall prepare and supply to the CQA Consultant, Design Engineer, and Project Manager a panel layout drawing. The CQA Consultant shall review the GCL panel deployment progress and advise the Project Manager on its conformance with the actual field conditions. The CQA Consultant shall verify that the Installer handles the GCL material in such a manner as to not damage the materials, and that the following are complied with:

1. On slopes, the GCL rolls is securely anchored and the GCL material is deployed down the slope in such a manner as to keep the GCL panel in tension.

2. The GCL is installed with the proper side of the material facing upward. The proper orientation of the material is as specified by the manufacturer's specifications.

3. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the GCL.

4. During placement of the GCL, care shall be taken not to entrap beneath the GCL any stones, excessive dust or moisture that could damage the GCL.

5. After installation, a visual examination of the GCL shall be carried out over the entire surface to ensure that no potentially harmful foreign objects, contaminated soil or damaged areas are present.

6. Loss of bentonite on edges during deployment should be minimized.

The CQA Consultant shall verify that no more GCL material is deployed during one working day than can be covered by the end of that day. Exceptions to this requirement may be given by the Project Manager if dry weather is forecast for several consecutive days. GCL deployment shall not be undertaken during precipitation or when there is an immediate threat of precipitation.

The CQA Engineer shall note any noncompliance and report it to the Project Manager.

10.6 Seaming Procedures

10.6.1 Seam Overlap

Adjacent GCL panels shall be joined according to remedial design plans and specifications. At a minimum, the CQA Consultant shall verify the Installer complies with the following requirements:

1. Edge seam overlaps shall be a minimum of 6 in (150 mm).

2. Roll end seam overlaps shall be a minimum 12 in (.3 m).

3. The addition of powdered bentonite to seam locations shall be in accordance with the manufacturer's recommendations.

4. End to end seams on slopes shall be minimized. If they are required, the CQA Engineer shall contact the Design Engineer to verify the method used to attach the GCLs will result in adequate tensile strength.

Prior to approval of the GCL by the CQA Engineer, the following requirements should be visually verified.

1. The required overlaps are provided. The overlap shall be continuously monitored since the panels may be subjected to shrinkage.

2. The amount of the powdered bentonite placed on the seam is as required by the project specifications.

The CQA Engineer shall note any noncompliance and report it to the Project Manager.

10.7 Defects and Repairs

Any portion of the GCL exhibiting flaws shall be repaired. Prior to acceptance of the installed GCL, the Installer and CQA Consultant shall locate damaged areas and the Installer shall complete repairs as directed by the CQA Consultant. Defects or damage can be identified by either rips, tears, premature hydration of the GCL or delamination of the geotextiles.

Rips or tears in the GCL shall be covered by another piece of material meeting the project specifications. The material shall extend over the entire damaged area with a minimum six inch overlap in all directions. Addition of bentonite to patches shall be in accordance with the project specifications.

Where the GCL has been exposed to moisture and has prematurely hydrated prior to placement of overlying material, the material shall be removed and replaced with material meeting the project specifications. All defects and repairs shall be reported to the Project Manager.

10.8 GCL Protection

All soil materials located on top of the GCL shall be deployed in such a manner as to ensure:

1. The GCL is not damaged.
2. Minimal slippage of the GCL on underlying soil layer occurs.
3. No excess tensile stress occurs in the GCL.

Any noncompliance with these guidelines or the project specifications shall be noted by the CQA Engineer and reported to the Project Manager.

11.0 GEOMEMBRANES

11.1 Description and Applicability

Geomembranes are the 40-mil-thick low permeability geosynthetic barriers used in the capping system. This Section is applicable to textured, low density polyethylene geomembranes.

11.2 Manufacturing Plant Inspection

If desired, the Owner or other appropriate representative can conduct an inspection of the Geosynthetics Manufacturer's plant. In addition, the Project Manager, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary. If possible, the project-specific inspection shall be prior to or during the manufacturing of the geomembrane rolls for that particular project. The purpose of the plant inspection is to review the manufacturing process and quality control procedures.

A manufacturing plant inspection shall include:

1. Verification that properties guaranteed by the Geosynthetics Manufacturer are met and meet all the project specifications.

2. Verification that the measurement of properties by the Geosynthetics Manufacturer is properly documented and test methods used are acceptable.

3. Spot inspection of the rolls and verification that they are free of imperfections or any sign of contamination by foreign matter.

4. Review of handling, storage, and transportation procedures, and verification that these procedures will not damage the geomembrane.

5. Verification that roll packages have a label indicating the name of the Geosynthetics Manufacturer, type of geomembrane, thickness, roll number, and roll dimensions.

6. Verification that extrusion rods and/or beads are produced from the same base resin type as the geomembrane.

11.3 Quality Control Documentation

Prior to the installation of any geomembrane, the Geosynthetics Manufacturer or Installer shall provide the CQA Consultant with the following information:

1. The origin (supplier's name and production plant) and identification (brand name and number) of the resin used to manufacture the geomembrane.

2. Copies of dated quality control certificates issued by the resin supplier.

3. Results of tests conducted by the Geosynthetics Manufacturer to verify that the resin used to manufacture the geomembrane meets the project specifications.

4. A statement indicating that the amount of reclaimed polymer added to the resin during manufacturing does not exceed the specifications.

5. A list of the materials which comprise the geomembrane, expressed in the following categories as percent by weight: polyethylene, carbon black, other additives.

6. A specification for the geomembrane which includes all properties contained in the project specifications measured using the appropriate test methods.

7. Written certification that minimum values given in the remedial design specifications are guaranteed by the Geosynthetics Manufacturer.

8. Quality control certificates, signed by a responsible party employed by the Geosynthetics Manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. At a minimum, results shall be given for:

   a. Density (ASTM D1505)
   b. Carbon black content (ASTM D1603)
   c. Carbon black dispersion (ASTM D3015)
   d. Thickness (ASTM D751)
   e. Tensile properties (ASTM D638)
   f. Puncture resistance (ASTM D4833)
   g. Index friction (GRI GS-7)

   These quality control tests shall be performed in accordance with the test methods for every 50,000 ft^2 (5,000 m^2) of material.

9. Results of environmental stress crack resistance tests (GRI GM-5b). At a minimum, tests shall be performed once every resin lot.

The Geosynthetics Manufacturer shall identify all rolls of geomembranes with the following:

1. Geosynthetics Manufacturer's name

2. Product identification

3. Thickness

4. Roll number

5. Roll dimensions

The CQA Engineer shall review these documents and shall report any discrepancies with the above requirements to the Project Manager. The CQA Engineer shall verify that:

1. Property values certified by the Geosynthetics Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Geosynthetics Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Rolls are appropriately labeled.

5. Certified minimum properties meet the project specifications.

6. Project specifications and a copy of the CQAP are provided by the Project Manager to the Installer.

11.4 Conformance Testing

11.4.1 Sampling Procedures

Upon delivery of the rolls of the geomembrane, the CQA Consultant shall obtain samples for conformance testing. The geomembrane rolls to be sampled shall be selected by the CQA Consultant. Samples shall be taken across the entire width of the roll judged by the CQA Consultant not to be damaged. Unless otherwise specified, samples shall be 3 ft (1 m) long by the roll width. The CQA Consultant shall mark the machine direction on the samples with an arrow.

A lot shall be defined as a group of consecutively numbered rolls from the same manufacturing line. Alternatively, a lot may be designated by the CQA Engineer based on a review of all roll information including quality control documentation and manufacturing records.

Samples shall be taken at a rate of one per lot and not less than one per 100,000 ft^2 (10,000 m^2) of geomembrane. These samples shall be forwarded to the Geosynthetic QAL for conformance testing for the noted items presented in the following Section.

11.4.2 Conformance Tests

The following conformance tests shall be conducted:

1. Density (ASTM D1505)
2. Carbon black content (ASTM D1603)
3. Carbon black dispersion (ASTM D3015)
4. Thickness (ASTM D751)
5. Tensile properties (ASTM D638)

11.4.3 Test Results

All conformance test results shall be reviewed and accepted or rejected by the CQA Engineer prior to the deployment of the geomembrane. The CQA Engineer shall examine all results from laboratory conformance testing and shall report any nonconformance to the Project Manager. The CQA Engineer shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications.

If the Geosynthetics Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Geosynthetics Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Geosynthetics Manufacturer present during the testing. Alternatively, the Geosynthetics Manufacturer may have the sample retested at two different Owner-approved Geosynthetic QALs. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Project Manager.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of the Project Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting the project specification. This procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line. To isolate the out-of- specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed

test shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

11.5 Subgrade Preparation

11.5.1 Surface Preparation

The Earthwork Contractor shall be responsible for preparing the underlying soil prior to geomembrane placement. The Project Manager shall coordinate the work of the Earthwork Contractor and the Installer so that the requirements of this CQAP are met.

Before the geomembrane installation begins, the CQA Consultant shall verify that:

1. A licensed land surveyor in the State of Ohio has verified all lines and grades.

2. A qualified and licensed Professional Engineer in the State of Ohio has verified that the underlying soil meets the criteria specified in the project specifications.

3. The underlying soil surface to be lined has been rolled, compacted, or hand-worked so as to be free of irregularities, protrusions, loose soil, and abrupt changes in grade.

4. The surface of the underlying soil and GCL does not contain stones which may be damaging to the geomembrane.

5. There is no area excessively softened by high water content.

6. There is no area where the underlying soil surface contains desiccation cracks which may damage the geomembrane.

The Installer shall certify in writing that the surface on which the geomembrane will be installed is acceptable. A certificate of acceptance shall be given by the Installer to the CQA Consultant prior to commencement of geomembrane deployment in the area under consideration. The Project Manager shall be given a copy of this certificate by the CQA Engineer.

After the underlying soil has been accepted by the Installer, it is the Installer's responsibility to indicate to the Project Manager any change in the underlying soil condition that may require repair work. The Project Manager may consult with the CQA Engineer regarding the need for repairs. If the CQA Engineer concurs with the Installer, the Project Manager shall ensure that the underlying soil is repaired.

At any time before or during the geomembrane installation, the CQA Engineer shall indicate to the Project Manager any locations which may not be adequately prepared for the geomembrane.

11.5.2 Anchor Trench

The CQA Consultant shall verify:

1. The anchor trench has been constructed according to the Remedial Design plans and specifications.

2. If the anchor trench is excavated in a clay material susceptible to desiccation, the amount of trench open at any time should be minimized. The CQA Engineer shall inform the Project Manager of any signs of significant desiccation associated with the anchor trench construction.

3. Rounded corners are provided in the trench so as to avoid sharp bends in the geomembrane.

4. Excessive amounts of loose soil are not allowed to underlie the geomembrane in the anchor trench.

5. The anchor trench is adequately drained to prevent ponding or softening of the adjacent soils while the trench is open.

6. The anchor trench is backfilled and compacted as outlined in the project specifications.

Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetic components. The CQA Consultant shall observe the backfilling operation and advise the Project Manager of any problems. Any problems shall be documented by the CQA Consultant in the daily report.

11.6 Geomembrane Deployment

11.6.1 Panel Nomenclature

A field panel is defined as a unit of geomembrane which is to be seamed in the field. A field panel is a roll or a portion of a roll cut in the field. The CQA Consultant shall confirm that each field panel is given an identification code (number or letter-number) consistent with the layout plan. This identification code shall be as simple and logical as possible and shall be agreed upon by the Project Manager, Installer and CQA Consultant.

In general, it is not appropriate to identify panels using roll numbers since roll numbers established in the manufacturing plant are usually cumbersome and are not related to location in the field. The CQA Consultant shall establish a table or chart showing correspondence between roll numbers and field panel identification codes. The field panel identification code shall be used for all quality assurance records.

11.6.2 Panel Deployment Procedure

The CQA Engineer shall review the panel deployment progress of the Installer and advise the Project Manager on its compliance with the approved panel layout drawing. The CQA Engineer shall also review the panel deployment for suitability to actual field conditions such as issues relating to wind, rain, compacted cohesive soil layer desiccation and other site-specific conditions. Once approved, only the Project Manager can authorize changes to the panel deployment procedure. The CQA Consultant shall verify that the condition of the underlying soil does not change detrimentally during installation.

The CQA Consultant shall verify that field panels are installed at the locations indicated on the Installer's layout plan, as approved by the Project Manager. The CQA Consultant shall record the identification code, location, and date of installation of each field panel.

11.6.3 Deployment Weather Conditions

Geomembrane deployment shall not be undertaken if weather conditions will preclude material seaming following deployment.

The normal required weather conditions for seaming are as follows:

1. Ambient temperature between 32°F (0°C) and 104°F (40°C).
2. Dry conditions (no precipitation or other excessive moisture).
3. No excessive winds.

The CQA Consultant shall verify that these weather conditions are fulfilled. Ambient temperature shall be measured by the CQA Consultant in the area in which the panels are to be placed.

The CQA Engineer shall inform the Project Manager of any weather-related problems which may not allow geomembrane placement to proceed. The Project Manager will determine if the installation is to be stopped or special procedures are to be used.

11.6.4 Method of Deployment

Before the geomembrane is handled on site, the CQA Consultant shall verify that handling equipment to be used on the site is adequate and does not pose risk of damage to the geomembrane. During handling, the CQA Consultant shall observe and verify that the Installer's personnel handle the geomembrane with care.

The CQA Consultant shall verify the following:

1. Equipment used does not damage the geomembrane by handling.

2. The prepared surface underlying the geomembrane is acceptable immediately prior to geomembrane placement.

3. Geosynthetic elements immediately underlying the geomembrane are clean and free of debris.

4. Personnel do not smoke or wear damaging shoes while working on the geomembrane, or engage in other activities which could damage the geomembrane.

5. The method used to unroll the panels does not cause excessive scratches or crimps in the geomembrane and does not damage the supporting soil.

6. The method used to place the panels minimizes wrinkles, especially differential wrinkles between adjacent panels.

7. Adequate temporary loading and/or anchoring (such as sand bags or tires), not likely to damage the geomembrane, is placed to prevent uplift by wind. In case of high winds, continuous loading is recommended along edges of panels to minimize risk of wind flow under the panels.

8. Direct contact with the geomembrane is minimized, and the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected. See Section 11.11 for geomembrane protection.

The CQA Engineer shall inform the Project Manager if the above conditions are not fulfilled.

11.6.5 Damage and Defects

Upon delivery to the site, the CQA Consultant shall conduct a surface observation of all rolls for defects and for damage. This examination shall be conducted without unrolling rolls unless defects or damages are found or suspected. The CQA Engineer shall advise the Project Manager, in writing, of any rolls or portions of rolls which should be rejected and removed from the site because they have severe flaws, and/or minor repairable flaws.

The CQA Consultant shall examine each panel, after placement and prior to seaming, for damage and/or defects. The CQA Engineer shall advise the Project Manager which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels, or portions of damaged panels, which have been rejected shall be marked and their removal from the work area recorded by the CQA Consultant. Repairs shall be made using procedures described in Section 11.10.

11.6.6 Writing on the Liner

To avoid confusion, the Installer and the CQA Consultant shall each use different colored markers that are readily visible for writing on the geomembrane. The markers used must be semi-permanent and compatible with the geomembrane. The Installer shall use a white marker to write on the geomembrane while the CQA Consultant shall use a yellow marker.

11.7 Field Seaming

11.7.1 Seam Layout

Before installation begins, the Installer shall provide the Project Manager and the CQA Consultant with a panel layout drawing. This drawing shall present all the proposed seams of the lining system at the facility. The CQA Engineer shall review the panel layout drawing and verify that it is consistent with accepted state-of-practice. No panels may be seamed until written approval of the panel layout drawing has been provided by the CQA Engineer. In addition, panels not specifically shown on the panel layout drawing may not be used without the CQA Engineer's prior approval.

In general, seams should be oriented parallel to the line of maximum slope; thus, oriented along and not across the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 5 ft (1.5 m) from the toe or crest of the slope, or areas of potential stress concentrations, unless otherwise authorized by the Project Manager.

A seam numbering system compatible with the panel numbering system shall be used by the CQA Consultant.

11.7.2 Accepted Seaming Methods

Approved processes for field seaming are fusion welding and extrusion welding. Proposed alternate processes shall be documented and submitted by the Installer to the CQA Consultant for approval. Only apparatus which have been specifically approved by make and model shall be used.

11.7.2.1 Fusion Process

The CQA Consultant shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances with the project specifications to the Project Manager.

The CQA Consultant shall also verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus agreed upon at the pre-construction meeting.

2. Equipment used for seaming is not likely to damage the geomembrane.

3. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.

4. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage such that no damage occurs to the geomembrane.

5. A movable protective layer is used as required by the Installer directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between the sheets and to prevent debris from collecting around the pressure rollers.

6. The geomembrane panels are aligned to have an overlap of 4 to 6 inches (100 mm to 150 mm) for fusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.

7. No solvent or adhesive is used.

8. The geomembrane is protected from damage in heavy traffic areas.

11.7.2.2 Extrusion Process

The CQA Consultant shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances with the project specifications to the Project Manager.

The CQA Consultant shall verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus agreed upon at the pre-construction meeting.

2. Equipment used for seaming is not likely to damage the geomembrane.

3. Prior to beginning a seam, the extruder is purged until all heat-degraded extrudate has been removed from the barrel.

4. Clean and dry welding rods or extrudate pellets are used.

5. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.

6. Grinding is completed no more than one hour prior to seaming.

7. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage such that no damage occurs.

8. The geomembrane is protected from damage in heavy traffic areas.

9. Exposed grinding marks adjacent to an extrusion weld shall be minimized. In no instance shall exposed grinding marks extend more than ¼ in (6 mm) from the finished seamed area.

10. The geomembrane panels are aligned to have a nominal overlap of 3 inches (75 mm) for extrusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.

11. No solvent or adhesive is used.

12. The procedure used to temporarily bond adjacent panels together does not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any temporary welding apparatus is controlled such that the geomembrane is not damaged.

11.7.3 Seam Preparation

The CQA Consultant shall verify that prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris or foreign material of any kind. If seam overlap grinding is required, the CQA Consultant must verify that the process is completed according to the Geosynthetics Manufacturer's instructions within one hour of the seaming operation, and in a way that does not damage the geomembrane. The CQA Consultant shall also verify that seams are aligned with the fewest possible number of wrinkles and "fishmouths".

11.7.4 Trial Seams

Trial seams shall be made on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming. Such trial seams shall be made at the beginning of each seaming period, and at least once every five hours, for each production seaming apparatus used that day. Trial seams shall be made under the same conditions as production seams.

The trial seam sample shall be at least 5 ft (1.6 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Seam overlap shall be as indicated in Section 11.7.2. Two specimens shall be cut from the sample with a 1 in (25 mm) wide die. The specimens shall be cut by the Installer at locations selected randomly along the trial seam sample by the CQA Consultant.

The specimens shall be tested in peel using a field tensiometer. The tensiometer shall be capable of maintaining a constant jaw separation rate of two inches per minute. They should not fail in the seam as described in Section 11.9.5. If a specimen fails, the entire trial seam operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be accepted

and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved. The CQA Consultant shall observe all trial seam procedures.

The remainder of the successful trial seam sample shall be retained in the Project Manager's archives for possible laboratory testing. Each sample shall be assigned a number and marked accordingly by the CQA Consultant, who shall also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description.

If agreed upon between the Project Manager and the CQA Engineer, and documented by the CQA Consultant in the daily report, the remaining portion of the trial seam sample can be subjected to destructive testing as indicated in Section 11.9.6. If a trial seam sample fails a test conducted by the Geosynthetic QAL, then a destructive seam test sample shall be taken from each of the seams completed by the seamer during the shift related to the subject trial seam. These samples shall be forwarded to the Geosynthetic QAL and, if they fail the tests, the procedure indicated in Section 11.9.7 shall apply. The conditions of this paragraph shall be considered satisfied for a given seam if a destructive seam test sample has already been taken.

11.7.5 General Seaming Procedures

During general seaming, the CQA Consultant shall verify the following:

1. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 in (150 mm) beyond the cut in all directions.

2. If seaming operations are carried out at night, adequate illumination shall be provided.

3. Seaming shall extend to the outside edge of panels placed in the anchor trench.

4. All cross seam tees should be extrusion welded to a minimum distance of 4 in (100 mm) on each side of the tee.

5. No field seaming shall take place without the Master Seamer being present.

6. A firm substrate may be required to be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support.

The CQA Consultant shall verify that the above seaming procedures or any other procedures agreed upon and indicated in this CQAP are followed, and shall inform the Project Manager of any nonconformance.

11.7.6 Seaming Weather Conditions

11.7.6.1 Cold Weather Conditions

To ensure a quality installation, if seaming is conducted when the ambient temperature is below 32°F (0°C), the following conditions shall be met:

1. Geomembrane surface temperatures shall be determined by the CQA Consultant at intervals of at least once per 100 feet (30 m) of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 32°F (0°C).

2. For fusion welding, preheating may be waived by the Project Manager based on a recommendation from the CQA Engineer, if the Installer demonstrates to the CQA Engineer's satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

3. If preheating is required, the CQA Consultant shall observe all areas of geomembrane that have been preheated by a hot air device prior to seaming, to ensure that they have not been overheated.

4. Care shall be taken to confirm that the surface temperatures are not lowered below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.

5. All preheating devices shall be approved prior to use by the CQA Consultant.

6. Additional destructive tests (as described in Section 11.9) shall be taken at an interval between 250 feet and 500 feet (75 to 150 m) of seam length, at the discretion of the CQA Engineer.

7. Sheet grinding may be performed before preheating, if applicable.

8. Trial seaming, as described in Section 11.7.4, shall be conducted under the same ambient temperature and preheating conditions as the production seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature drops by more than 10°F from the initial trial seam test conditions. Such new trial seams shall be conducted upon completion of seams in progress during temperature drop.

11.7.6.2 Warm Weather Conditions

At ambient temperatures above 104°F, no seaming of the geomembrane shall be permitted unless the Installer can demonstrate to the satisfaction of the Project Manager that geomembrane seam quality is not compromised. Trial seaming, as described in Section 11.7.4, shall be conducted under

the same ambient temperature conditions as the production seams. At the option of the CQA Consultant, additional destructive tests may be required for any suspect areas.

11.8 Nondestructive Seam Testing

11.8.1 Concept

The Installer shall nondestructively test all field seams over their full length using an air pressure test (for double fusion seams only), a vacuum test or other approved method. Air pressure testing and vacuum testing are described in Sections 11.8.2 and 11.8.3 respectively. The purpose of nondestructive tests is to check the continuity of seams. It does not provide quantitative information on seam strength. Nondestructive testing shall be carried out as the seaming work progresses, not at the completion of all field seaming.

For all seams, the CQA Consultant shall:

1. Observe nondestructive testing procedures.
2. Record location, data, test unit number, name of tester, and outcome of all testing.
3. Inform the Installer and Project Manager of any required repairs.

Any seams that cannot be nondestructively tested shall be cap-stripped with the same geomembrane. The cap-stripping operations shall be observed by the CQA Consultant for uniformity and completeness.

11.8.2 Air Pressure Testing

Air pressure testing is applicable to double fusion welding which produces a double seam with an enclosed space.

1. The equipment for air pressure testing shall consist of the following:

    a. An air pump (manual or motor driven), equipped with pressure gauge and capable of generating and sustaining a pressure between 25 and 30 psi (160 and 200 kPa) and mounted on a cushion to protect the geomembrane.
    b. A rubber hose with fittings and connections.
    c. A sharp hollow needle, or other pressure feed device, approved by Project Manager.

2. The following procedures shall be followed:

    a. Seal both ends of the seam to be tested.
    b. Insert needle or other approved pressure feed device into the air channel created by the fusion weld.
    c. Insert a protective cushion between the air pump and the geomembrane.

d. Pressurize the air channel to a pressure of approximately 30 psi (200K Pa). Close valve, allow 2 minutes for pressure to stabilize, and sustain pressure for at least 5 minutes.
e. If loss of pressure exceeds the maximum permissible pressure differential as outlined in the project specifications or does not stabilize, locate faulty area and repair in accordance with Section 11.10.3.
f. Cut opposite end of tested seam area once testing is completed to verify continuity of the air channel. If air does not escape, locate blockage and retest unpressurized area. Seam the cut end of the air channel.
g. Remove needle or other approved pressure feed device and seal the hole in the geomembrane.

11.8.3 Vacuum Testing

Vacuum testing is applicable to extrusion welding.

1. The equipment shall consist of the following:

   a. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a porthole or valve assembly, and a vacuum gauge.
   b. A pump assembly equipped with a pressure controller and pipe connections.
   c. A rubber pressure/vacuum hose with fittings and connections.
   d. A soapy solution. (CQA Consultant shall verify that the solution bubbles when air is passed through.)
   e. A bucket and wide paint brush, or other means of applying the soapy solution.

2. The following procedures shall be followed:

   a. Wet a strip of geomembrane approximately 12 in x 48 in (0.3 m x 1.2 m) with the soapy solution.
   b. Place the box over the wetted area.
   c. Close the bleed valve and open the vacuum valve.
   d. Verify that a leak-tight seal is created.
   e. Energize the vacuum pump and reduce the applied pressure to approximately 5 psi (10 in of Hg/35 kPa) gauge.
   f. For a minimum of 10 seconds, apply vacuum with the box placed and maintaining a seal, examine the geomembrane through the viewing window for the presence of soap bubbles.
   g. If no bubble appears after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in (75 mm) overlap, and repeat the process.
   h. All areas where soap bubbles appear shall be marked and repaired in accordance with Section 11.10.3.

11.8.4 Test Failure Procedures

The Installer shall complete any required repairs in accordance with Section 11.10. For repairs, the CQA Consultant shall:

1. Observe the repair and testing of the repair.
2. Mark on the geomembrane that the repair has been made.
3. Document the repair procedures and test results.

11.9 Destructive Seam Testing

11.9.1 Concept

The purpose of destructive tests is to evaluate seam strength. Destructive seam tests shall be performed at selected locations. Seam strength testing shall be done as the seaming work progresses, not at the completion of all field seaming.

11.9.2 Location and Frequency

The CQA Consultant shall select where seam samples will be cut out for laboratory testing. The frequency and locations shall be established as follows:

1. A minimum frequency of one test location per 500 ft (150 m) of seam length performed by each welding machine. This frequency is to be determined as an average taken over the entire geomembrane lined area.

2. Test locations shall be determined during seaming at the CQA Consultant's discretion. Special consideration shall be given to locations where the potential for imperfect welding, such as overheating, contamination, and offset welds exists.

The Installer shall not be informed in advance of the locations where the seam samples will be taken.

11.9.3 Sampling Procedures

Samples shall be cut by the Installer at locations chosen by the CQA Consultant as the seaming progresses so that laboratory test results are available before the geomembrane is covered by another material. The CQA Consultant shall:

1. Observe sample cutting.

2. Assign a number to each sample, and mark it accordingly.

3. Record sample location on layout drawing.

4. Record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

Repair all holes in the geomembrane resulting from destructive seam sampling in accordance with repair procedures described in Section 11.10.3 immediately following receipt of successful test results. Test the continuity of the new seams in the repaired area according to Section 11.8.3.

11.9.4 Sample Dimensions

At each sampling location, two types of samples shall be taken by the Installer. First, two specimens for field testing should be taken. Each of these samples shall be cut with a 1 in (25 mm) wide die, with the seam centered parallel to the width. The distance between these two samples shall be 42 in (1.1 m). If both samples pass the field test described in Section 11.9.5, a sample for laboratory testing shall be taken.

The sample for laboratory testing shall be located between the samples for field testing. The sample for laboratory testing shall be 12 in (0.3 m) wide by 42 in (1.1 m) long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

1. One 12 in wide x 18 in long (0.3 m x 0.5 m) portion for Geosynthetic QAL testing.

2. One 12 in wide x 12 in long (0.3 m x 0.3 m) portion to the Installer for optional laboratory testing.

3. One 12 in wide x 12 in long (0.3 m x 0.3 m) portion to the Project Manager for archive storage.

Final determination of the sample sizes shall be made at the pre-construction meeting.

11.9.5 Field Testing

The two 1 in (25 mm) wide specimens mentioned in Section 11.7.4 and Section 11.9.4 shall be tested in the field using a tensiometer for peel adhesion and shall not fail according to the criteria in the project specifications. The tensiometer shall be capable of maintaining a constant jaw separation rate of two inches per minute. If the test passes in accordance with this section, the sample qualifies for testing in the laboratory. If it fails, the seam should be repaired in accordance with Section 11.9.7. Final judgement regarding seam acceptability, based on the failure criteria provided in the project specifications, rests with the CQA Engineer.

The CQA Consultant shall witness all field tests and mark all samples and portions with their number. The CQA Consultant shall also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description, and attach a copy to each sample portion.

11.9.6 Laboratory Testing

Destructive test samples shall be packaged and shipped, if necessary, under the responsibility of the CQA Consultant in a manner which will not damage the test sample. The sample shall be shipped as soon as possible to expedite laboratory testing. The Project Manager will be responsible for storing the archive samples. Test samples shall be tested by the Geosynthetic QAL.

Testing shall include seam strength and peel adhesion (ASTM D4437). The minimum acceptable values to be obtained in these tests are provided in the project specifications (see Appendix II). At least 5 specimens from each sample shall be tested, each in both shear and peel. Specimens shall be selected alternately by test from the samples (i.e., peel, shear, peel, shear). A passing test shall meet the minimum acceptable values in at least 4 of the 5 specimens tested for each method.

The Geosynthetic QAL shall provide test results within 24 hours of receiving the samples. The CQA Engineer shall review laboratory test results as soon as they become available, and make appropriate recommendations to the Project Manager.

11.9.7 Destructive Test Failure

When a sample fails a destructive test, whether that test is conducted by the Geosynthetic QAL or by field tensiometer, the Installer has two options:

1. The Installer can repair the seam between any two passing destructive test locations; or

2. The Installer can trace the welding path to an intermediate location 10 ft (3 m) minimum from the point of the failed test in each direction and take a sample with a 1 in (25 mm) wide die for an additional field test at each location. If these samples pass, then full laboratory samples are taken. If these laboratory samples pass, then the seam is repaired between these locations. If any samples fail, then the process is repeated to establish the zone in which the seam should be repaired.

All acceptable repaired seams shall be bound by two locations from which samples passing laboratory destructive tests have been taken. Passing laboratory destructive tests of trial seam samples taken as indicated in Section 11.7.4 may be used as a boundary for the failing seam. In cases exceeding 150 ft (50 m) of repaired seam, a sample taken from the zone in which the seam has been repaired must pass destructive testing. Repairs shall be made in accordance with Section 11.10.

The CQA Consultant shall document all actions taken in conjunction with destructive test failures.

11.10 Defects and Repairs

11.10.1 Identification

All seams and non-seam areas of the geomembrane shall be examined by the CQA Consultant for identification of defects, holes, blisters, undispersed raw materials, large wrinkles and any sign of contamination by foreign matter. The geomembrane surface shall be cleaned by the Installer prior to examination if the CQA Consultant determines that the amount of dust or mud inhibits examination.

11.10.2 Evaluation

Each suspect location both in seam and non-seam areas shall be nondestructively tested using the methods described in Section 11.8. Each location which fails the nondestructive testing shall be marked by the CQA Consultant and repaired by the Installer. Work shall not proceed with any materials which will cover locations which have been repaired until successful nondestructive and/or laboratory tests are obtained.

When seaming of the geomembrane is completed, and prior to placing overlying materials, the CQA Consultant shall indicate any large wrinkles which should be cut and reseamed by the Installer. The number of wrinkles to be repaired should be kept to an absolute minimum. Therefore, wrinkles should be located during the coldest part of the installation period, while keeping in mind the forecasted weather to which the uncovered geomembrane may be exposed. Wrinkles are considered to be large when the geomembrane can be folded over on to itself which is generally a wrinkle that extends 12 in (0.3 m) from the subgrade. Seams produced while repairing wrinkles shall be nondestructively tested.

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. If possible, the final cover should be placed during the coolest weather. In addition, small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by the CQA Consultant to verify that wrinkle formation is minimized and that, in all cases, the geomembrane is not folded over on itself.

11.10.3 Repair Procedures

Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be agreed upon between the Installer, and CQA Engineer.

1. The repair procedures available include:

    a. Patching, used to repair holes, tears, undispersed raw materials, and contamination by foreign matter.

b. Spot welding used to repair pinholes, or other minor, localized flaws.
c. Capping, used to repair large lengths of failed seams.
d. Extrusion welding the flap, used to repair areas of inadequate fusion seams which have an exposed edge. Repairs of this type shall be approved by the CQA Consultant and shall not exceed 100 ft (30 m) in total length.
e. Removing bad seam and replacing with a strip of new material welded into place.

2. For any repair method, the following provisions shall be satisfied:

a. Surfaces of the geomembrane which are to be repaired using extrusion methods shall be ground no more than one hour prior to the repair.
b. All surfaces shall be clean and dry at the time of the repair.
c. All seaming equipment used in repairing procedures shall meet the requirements of this CQAP.
d. Patches or caps shall extend at least 6 in (150 mm) beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately 3 in (75 mm).

11.10.4 Repair Verification

The CQA Consultant shall observe all nondestructive testing of repairs and shall record the number of each repair, date and test outcome. Each repair shall be nondestructively tested using the methods described in Section 11.8 as appropriate. Repairs which pass the nondestructive test shall be taken as an indication of an adequate repair. Repairs more than 150 ft (50 m) long require destructive test sampling. Failed tests require that the repair shall be redone and retested until a passing test results.

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. The placement of cover materials shall be observed by the CQA Consultant to verify that wrinkle formation is minimized and that, in all cases, the geomembrane is not folded over on itself.

11.11 Geomembrane Protection

The quality assurance procedures indicated in this Section are intended only to assure that the installation of adjacent materials does not damage the geomembrane. The quality assurance of the adjacent materials themselves are covered in separate Sections of this CQAP.

11.11.1 Soils

A copy of the project specifications prepared by the Design Engineer for placement of soils shall be given to the CQA Engineer by the Project Manager. The CQA Engineer shall verify that these project specifications are consistent with geosynthetic state-of-practice such as:

1. Placement of soils on the geomembrane shall not proceed at an ambient temperature below 32°F (0°C) nor above 104°F (40°C) unless otherwise specified.

2. Placement of soil on the geomembrane should be done during the coolest part of the day to minimize the development of wrinkles in the geomembrane.

3. Equipment used for placing soil shall not be driven directly on the geomembrane.

4. A minimum cover thickness of 1 ft (0.3 m) of soil is required for a light dozer, ground pressure of 5 psi (35 kPa) or lighter, to travel over the geomembrane.

5. A minimum cover thickness of 3 ft (0.9 m) of soil is required for heavy construction equipment over 5 psi to travel over the geomembrane. This requirement may be waived if provisions are made to protect the geomembrane through an engineered design. Drivers shall proceed with caution when on the overlying soil and prevent spinning of tires or sharp turns.

The CQA Consultant shall measure soil thickness and verify that the required thickness is present. The CQA Consultant must also verify that final thickness is consistent with the design and verify that placement of the soil is done in such a manner that geomembrane damage is unlikely. The CQA Engineer shall inform the Project Manager if the above conditions are not fulfilled.

12.0 GEOCOMPOSITE GAS VENTING AND DRAINAGE LAYERS

12.1 Definition and Applicability

Geocomposites are geotextile and geonets used as a filter and drainage media in lining and capping systems. This section is applicable to venting drainage geocomposites made of polyester or polypropylene non-woven geotextiles and high density polyethylene (HDPE) geonet. The geotextiles may be bonded to both sides of the geonet for the drainage layer and the gas venting layer.

12.2 Manufacturing Plant Inspection

If desired, the Owner or appropriate representative may conduct an inspection of the geocomposite Geosynthetics Manufacturer's plant. In addition, the Project Manager, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary. If possible, the project-specific inspection shall be prior to or during the manufacturing of the geocomposite rolls for that particular project. The purpose of the plant inspection is to review the manufacturing process and quality control procedures.

A manufacturing plant inspection shall include:

1. Verification that the proper quality control documentation has been received by the Geosynthetics Manufacturer from the component Geosynthetics Manufacturers.

2. Verification that properties guaranteed by the Geosynthetics Manufacturer are met and meet all project specifications.

3. Verification that the measurement of properties by the Geosynthetics Manufacturer is properly documented and test methods used are acceptable.

4. Spot inspection of the rolls and verification that they are free of imperfections or contamination by foreign matter.

5. Review of packaging, handling, storage, and transportation procedures and verification that these procedures will not damage the geocomposite.

6. Verification that roll packages have a label indicating the name of the Geosynthetics Manufacturer, type of geocomposite, roll number, and roll dimensions.

12.3 Quality Control Documentation

Prior to the installation of any geocomposite, the geocomposite Geosynthetics Manufacturer or Installer shall provide the CQA Consultant with the following information:

1. The origin (supplier's name and production plant) and identification (brand name and number) of the geotextile and geonet used to fabricate the geocomposite.

2. Copies of dated quality control certificates issued by the geotextile and geonet supplier. These certificates shall contain the results of the quality control tests performed on the geocomposite.

3. A specification for the geocomposite which includes all properties published by the Geosynthetics Manufacturer measured using the appropriate test methods.

4. Written certification that minimum values given in the specification are guaranteed by the Geosynthetics Manufacturer.

5. Quality control certificates for the geocomposite, signed by a responsible party employed by the Geosynthetics Manufacturer. The quality control certificates shall include roll identification numbers, testing procedures and results of quality control tests. At a minimum, results shall be given for:

   a. Mass per unit area (ASTM D3776)
   b. Thickness (ASTM D1777)
   c. Geotextile-geonet adhesion (ASTM D413)

   Quality control tests shall be performed in accordance with the test methods for at least every 40,000 ft^2 (4,000 m^2) of geocomposite produced.

The Geosynthetics Manufacturer shall identify all rolls of geocomposite with the following:

1. Geosynthetics Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

The CQA Engineer shall review these documents and shall report any discrepancies with the above requirements to the CQA Consultant. The CQA Engineer shall verify that:

1. Property values certified by the Geosynthetics Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Geosynthetics Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Roll packages are appropriately labeled.

5. Certified minimum roll properties meet the project specifications.

6. Project specifications and this CQAP were submitted by the Project Manager to the Installer.

12.4 Conformance Testing

12.4.1 Sampling Procedures

Upon delivery of the rolls of geocomposite, the CQA Consultant shall obtain samples for conformance testing. The rolls to be sampled shall be selected by the CQA Consultant. Samples shall not be taken from any portion of a roll which has been damaged. Unless otherwise specified, samples shall be 3 ft (1 m) long by the roll width. The CQA Consultant shall mark the machine direction on the samples with an arrow. All lots of material and the particular test sample that represents each lot should be defined before the samples are taken.

A lot shall be defined as a group of consecutively numbered rolls from the same manufacturing line. Alternatively, a lot may be designated by the CQA Consultant based on a review of all roll information including quality control documentation and manufacturing records.

Unless otherwise specified, samples shall be taken at a rate of one per lot, not to be less than one per 100,000 ft^2 (10,000 m^2) of geocomposite. These samples shall then be forwarded to the Geosynthetic QAL for testing to ensure conformance with the project specifications.

12.4.2 Conformance Tests

At a minimum, the following conformance tests shall be performed on the geocomposite as a unit:

1. Mass per unit area (ASTM D3776)
2. Geotextile-geonet adhesion (ASTM D413)

12.4.3 Test Results

All conformance test results shall be reviewed and accepted or rejected by the CQA Engineer prior to the deployment of the geocomposite. The CQA Engineer shall examine all results from laboratory conformance testing and shall report any nonconformance to the Project Manager. The CQA Engineer shall check that all test results meet or exceed the property values listed in the project specifications.

If the Geosynthetics Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Geosynthetics Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Geosynthetics Manufacturer present during the testing. Alternatively, the Geosynthetics Manufacturer may have the sample retested at two different Owner-approved Geosynthetic QALs at the expense of the Geosynthetics Manufacturer. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the CQA Consultant.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of the Project Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out-of-specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

12.5 Geocomposite Deployment

During shipment and storage, the geocomposite shall be protected from ultraviolet light exposure, moisture, mud, dirt, dust, puncture, cutting, or any other damaging conditions. Geocomposite rolls shall be shipped and stored in relatively opaque and watertight wrappings. The roll wrappings shall be removed shortly before deployment.

The CQA Consultant shall verify that the geonet is free of dirt and dust prior to installation. The CQA Consultant shall identify any dirty rolls and report them to the Project Manager. If the geonet is judged to be dirty or dusty by the CQA Consultant, it shall be cleaned by the Installer prior to installation. Any washing operation shall be observed by the CQA Consultant and improper washing operations shall be reported to the Project Manager.

The CQA Consultant shall observe rolls upon delivery at the site and any deviation from the above requirements shall be reported to the Project Manager.

The Installer shall handle all geocomposite in such a manner as to ensure they are not damaged, and the following shall be complied with:

1. On slopes, the geocomposite shall be securely anchored and then rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite shall be positioned by hand after being unrolled to minimize wrinkles.

2. In the presence of wind, all geocomposites shall be weighted with sandbags or the equivalent. Sandbags shall be installed during deployment and shall remain until replaced with cover material.

3. Unless otherwise specified, single-sided geocomposite shall not be welded to the geomembrane.

4. Geocomposites shall be cut using a hook blade or other tool approved by the CQA Consultant. If in place, special care shall be taken to protect underlying geosynthetics from damage which could be caused by the cutting of the geocomposite. Care shall be taken not to leave the tools in the geocomposite.

5. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.

6. During placement of geocomposite, care shall be taken not to entrap in or beneath the geocomposite stones or dirt that could damage the underlying geomembrane, cause clogging of drains or filters, or hamper subsequent seaming. If dirt or excess dust is entrapped in the geonet of single-sided geocomposite, it should be washed clean prior to placement of the next material on top of it. In this regard, care shall be taken with the handling of sandbags, to prevent puncturing the sandbag.

7. A visual examination of the geotextile component of the geocomposite shall be carried out over the entire surface, after installation, to ensure that no potentially harmful foreign objects are present.

The CQA Consultant shall note any noncompliance and report it to the Project Manager.

12.6 Seaming Procedures

In general, no horizontal seams shall be allowed on sideslopes. Thus, seams shall be along, not across, the slope, except as part of a patch. If horizontal seams are required, they shall be offset from adjacent horizontal seams.

At a minimum, the following requirements shall be met:

1. Adjacent geocomposite shall be overlapped so that the geonet overlaps by at least 4 in (100 mm) and geotextiles overlap by at least 3 in (75 mm).

2. If two sided geocomposite or the geotextile is on bottom, seam geotextile together.

3. The geonet overlaps shall be tied with plastic fasteners. Tying devices shall be white or yellow for easy inspection. Metallic devices are not allowed.

4. Tying shall be every 5 ft (1.5 m) along the slope, every 6 in (150 mm) in the anchor trench, and every 12 in (150 mm) along end-to-end seams on the base of the landfill.

5. In the corners of the sideslopes where overlaps between perpendicular strips are required, an extra layer shall be unrolled along the slope, on top of the previously installed geocomposite, from top to bottom of the slope.

6. When more than one layer of geocomposite is installed, joints shall be staggered.

7. Once geonet is tied, the geotextile of the geocomposite shall be seamed. On slopes shallower than 10H:1V, geotextiles shall be sewn (preferred), or thermally bonded with the written approval of the CQA Consultant. The Installer shall pay particular attention to seams to ensure that no earth cover material could be inadvertently inserted beneath the geotextile.

8. Any sewing shall be done using polymeric thread with chemical and ultraviolet light resistance properties equal to or exceeding those of the geotextile. Sewing shall be done using machinery and stitch types specified in the project specifications or as approved in writing by the CQA Engineer.

The CQA Consultant shall note any noncompliance and report it to the Project Manager.

12.7 Defects and Repairs

12.7.1 Identification

If a defect is identified in the geocomposite, the CQA Consultant shall determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Consultant shall determine the extent of the deficient area by additional tests, observations, a review of records and other means that the CQA Engineer deems appropriate.

12.7.2 Notification

After determining the extent and nature of the defect, the CQA Consultant shall promptly notify the Installer and Project Manager. A work deficiency meeting shall be held as required between the Installer, CQA Engineer, Design Engineer, Project Manager and any other necessary parties to assess the problem, review alternative solutions, and implement an action plan.

12.7.3 Repair Procedures

The final decision as to the appropriate repair shall be agreed upon between the Project Manager, Installer, Design Engineer, and CQA Engineer. Prior to acceptance of the geocomposite, the Installer shall locate and repair all damaged areas as directed by the CQA Consultant. Care shall be taken to remove any soil or other material which may have penetrated the torn geotextile. The CQA Consultant shall observe any repair and report any noncompliance with the requirements in writing to the Project Manager.

If in the CQA Consultant's judgement, the defect is determined to be small, typically smaller than 3 by 3 feet (1 m by 1 m), the geocomposite shall be repaired as follows:

1. If the geonet is judged to be undamaged but the geotextile is damaged, a patch of geotextile shall be placed over the damaged area. The geotextile patch shall be thermally bonded in place with a minimum of 12 inch (0.3 m) overlap in all directions.

2. If the geonet is judged to be damaged, the damaged geonet shall be removed. A section of geonet shall be cut to replace the removed section. The geonet shall overlap the removed section by 6 inches in all directions and be tied to the existing geonet using white plastic fasteners placed at least every 6 inches (150 mm). A geotextile patch shall be placed over the repaired geonet section. The geotextile patch shall be thermally bonded in place with a minimum of 12 inch (0.3 m) overlap in all directions.

If in the CQA Consultant's judgement, the defect is determined to be large, typically larger than 3 by 3 feet (1 m by 1 m), the geocomposite shall be replaced.

The CQA Consultant shall observe any repair and report any noncompliance with the above requirements in writing to the Project Manager.

12.8 Geocomposite Protection

For single-sided geocomposites, soils should never be placed in direct contact with the geonet. All soil materials located on top of the geocomposite shall be deployed in such a manner as to ensure:

1. The geocomposite and underlying lining materials are not damaged.
2. Minimal slippage of the geocomposite on underlying layers occurs.
3. No excess tensile stresses occur in the geocomposite.

Any noncompliance with these guidelines or the project specifications shall be noted by the CQA Consultant and reported to the Project Manager.

13.0 PASSIVE GAS VENTS AND GAS PROBES

Passive gas vents include:

- Perforated PVC pipe set in a gravel-filled trench. The trench placed in the top of the waste is approximately 1 foot deep, 2 feet wide and 6 feet long, and interfaces with the geocomposite gas venting layer of the final cover.
- Geomembrane pipe boot to provide a seal for the geomembrane primary barrier around the pipe.
- Turbine gas vent cap.

Gas probes include:

- Perforated PVC pipe set in a gravel filled borehole that extends approximately 20 feet below ground surface.
- Bentonite surface seal.
- Protective outer steel casing.

13.1 Observation and Quality Control

Observation and quality control of the passive gas vents include:

- Visual and photographic records of the excavation into the subbase and waste, if encountered, and disposal of the waste.
- Visual and photographic records of the installation of the PVC vent pipe including pipe perforations and gravel backfill.
- Visual and photographic records of placing the geocomposite gas venting layer around the vent pipe and over the gravel backfill.
- Visual and photographic records of the placement of the final cover around the vent pipe including installation and welding of the geomembrane pipe boot.
- Visual and photographic record of the completed vent.

Observation and quality control of the gas probes include:

- Visual and photographic record of the drilling and gas probe pipe installation.
- Visual and photographic record of the bentonite surface seal.
- Visual record of the protective steel casing pipe installation.

13.2 Confirmation

Confirmation of gas vent and probe construction shall be made by:

- Survey locations of the vents and probes.
- Visual observation and photographic record of the construction effort.
- Visual observation of the relocation of excavated waste.
- Classification of aggregate materials.

14.0 EXCAVATION FOR THE GROUNDWATER INTERCEPTION TRENCH

The excavation for the interception trench and cut-off wall will be performed using the slurry trench method of construction.

14.1 Description and Applicability

The intent of the groundwater interception trench is to intercept and collect the flow of ground water as it moves through the stratigraphy from the landfill and buried lagoon toward the East Fork of Mill Creek. The grades identified on the drawings indicate the required depth for the interception trench bottom. Ground water will flow, by gravity, through the interception alignment to a sump located at the "low" end of each interception trench. For this reason, the slope identified for the bottom of the trench must be adhered to.

14.2 Quality Control Documentation

Prior to the construction of the groundwater interception system, the interception trench, cut-off wall, and force main must be staked in the field to provide the locational verification required to address constructability. This will allow for minor adjustments in the alignments to avoid obstacles or account for any unforeseen field conditions. Field survey stakes shall be placed at fifty (50) foot intervals.

14.3 Construction Observations

As the trench is excavated, survey measurements shall be taken to the bottom of the excavation. These depth measurements shall be taken at twenty-five (25) foot intervals. All measurements shall be compared to remedial design drawing elevations and the grade/slope from the last point calculated. Elevations shall also be recorded at the top of the trench, adjacent to the trench, so that depth can be calculated. A profile of the trench top and bottom will be required at the completion of the project.

Where rock in encountered as part of the excavation for the interception system, the top of rock elevation will be taken at twenty-five (25) foot intervals in addition to the information identified above.

At the ends of the trenches, the QAC will verify that the trench has reached full depth at the design location for the starting point and ending point of the trench. Additional measurements will also be taken to ensure that the sump is constructed to at least the minimum dimensions shown on the remedial design drawings.

15.0 GEOTEXTILE

A geotextile wrap is provided for the granular material in the interceptor trench.

15.1 Description and Applicability

The geotextile lines the sides of the interceptor trench to filter out fines that could flow into the trench and foul the granular drainage material. The geotextile is continuous down the side of the trench, across the bottom and up the opposite side. The two ends of the geotextile are to be overlapped at the top of the trench. The geotextile sheets shall also be overlapped along the length of the trench to assure complete coverage of the soil trench interface.

15.2 Conformance Testing

The manufacturer will be required to provide certification that the material meets the design specifications. The QAE will review the certifications and compare them with the required specifications for the material. Deviations will be recorded and the Project Manager informed.

The QAC will also perform transmissivity testing on the geotextile to verify that water will pass thru the geotextile and satisfy the design criteria stated in the specifications. Additionally, the gradient ratio or long term soil fabric filtration test will be performed to verify that the geotextile will not be clogged by the soil particles. These tests will be run at the frequency of two tests per manufacturer's lot.

15.3 Construction Observation

The QAC will provide full time observation of the installation of the geotextile. Additionally, the QAC will verify overlaps, observe the geotextile installation to identify procedures or processes that may cause the geotextile to become folded or otherwise not cover the soil trench interface. The QAC will also observe the tension on the geotextile during the placement of granular material, to determine the potential for tearing the geotextile. Lastly, the QAC will verify the geotextile in the sump locations does not contain any seams in the geotextile.

16.0 GRANULAR DRAINAGE MATERIAL

16.1 Description and Applicability

The granular drainage material has been sized and specified for the collection trench such that design flows are maintained for the ground water through the trench, and so the material will not react with the leachate. For this reason it is important that the material installed meet the specification requirements. The granular drainage material will be installed inside of the geotextile wrap, within the trench.

16.2 Conformance Testing

One test shall be performed per source to verify the carbon content and a test performed to verify the gradation of the material. These tests shall be performed prior to the material being delivered to the site. A verification of the gradation will be performed on the material delivered to the site to ensure that the material previously tested is delivered to the site.

The QAC personnel will be responsible for verifying that the material conforms with the specifications.

16.3 Construction Observation

The QAC will observe material delivered to the site and identify any variation in the material. If variations are observed, additional tests may be performed at the discretion of the Project Manager.

The QAC will observe the granular material as it is placed to ensure that the material is not fouled by other materials in handling. Additionally, the QAC will observe the material as it is placed into the trench and identify any procedures or processes that could harm the Geotextile. The top elevation of the granular material will be recorded at twenty-five (25) foot intervals.

17.0 EXTRACTION AND INSPECTION WELLS AND PIEZOMETERS

The extraction and inspection wells will be installed within the interceptor trench. The piezometers will be located on either side of the trench.

17.1 Description and Applicability

The location of the extraction wells has been established to coincide with the low point of each interceptor trench. It is imperative that the well extend into the sump and within six (6) inches of the bottom of the sump. Additionally, a pump will be placed in the well and will need to reach the bottom of the well. For this reason, the wells must be installed at the correct location and the well must be installed vertically with minimal lateral displacement.

17.2 Conformance Testing

The materials delivered to the site will be inspected for damage and for the manufacturer and product specification stamp. These markings will be checked against the remedial design specifications before the material will be approved by the QAC.

17.3 Construction Observation

The QAC personnel will observe the installation of the extraction and inspection wells. The QAC will observe the installer to ensure that the contractor places granular material on all sides of the well during the backfilling operation. Additionally, the depth of the well being installed will be recorded. After installation, the height of the well above grade will be recorded. The depth of the well will be calculated based on the length of casing and screen installed. This depth will be compared to the surveyed depth. Variations will be brought to the Project Managers attention.

18.0 BIO-POLYMER SLURRY

The Bio-Polymer slurry will be used for construction of the interceptor trench.

18.1 Description and Applicability

The Bio-Polymer Slurry will be required to maintain the stability of the side walls of the interception trench during the trench excavation process. The Slurry will allow for the placement of the geotextile, the granular material and the wells. After installation of the interceptor trench, the slurry will be degraded or broken by slurry modifiers. This will allow the trench to achieve the design permeability and the soils adjacent to the trench assume their original hydraulic conductivity.

18.2 Conformance Testing

The contractor shall submit physical and chemical characteristics and properties of the Bio-Polymer to be used. Additionally, the contractor shall submit test data to document these properties for both the Bio-Polymer Slurry and the degraded slurry. MSDS's shall be submitted to the QAC for the Bio-Polymer materials.

18.3 Construction Observation

The contractor will be required to perform the following tests at the identified frequencies:

Viscosity	4 per shift,
Density	4 per shift,
pH	4 per shift and
Filtrate Loss	1 per shift.

This data shall be provided to the QAC as it is obtained.

19.0 CUT-OFF WALL EXCAVATION

The cut-off wall will be constructed using a soil-bentonite slurry.

19.1 Description and Applicability

The cut-off wall will run along an alignment that parallels the stream alignment. The wall will extend down to and be embedded in the bedrock along its length. The purpose of the wall is to prevent the flow of ground water from the site, toward the East Fork of Mill Creek, and from the creek back toward the interceptor trench.

19.2 Conformance Testing

The manufacturer of the bentonite and any additives shall provide manufacturer certificates of compliance for these materials to the QAC. The materials delivered to the site will be verified by comparing the shipping ticket with the manufacturer's certification.

Additionally, the contractor will be required to submit slurry mix designs and trial mix reports using soils from the site. This data will be reviewed for compliance with the specifications prior to the initiation of construction.

19.3 Construction Observation

The QAC will observe the preparation of the slurry at the site, and verify that it complies with the trial mix procedures. In addition, the QAC will perform the tests identified in the following table at the frequencies specified.

20.0 INTERCEPTION SYSTEM FORCE MAIN

The force main will convey groundwater collected in the interceptor trench to the sanitary sewer.

20.1 Description and Applicability

The force main is a 2-in HDPE pipe designed to carry groundwater, under pressure, from the interceptor trench to the existing sanitary sewer.

The length of force main which extends from north of the trench to the sanitary sewer tie-in (outside of the interceptor trench/cut-off wall) will be encased within a 4-in PVC secondary containment pipe, as indicated on the drawings of Section 2.0 of the Design report.

20.2 Conformance Testing

Pressure tests shall be conducted in the presence of the QAC to verify the integrity of the constructed force main. Equipment shall be provided to supply water, pressure (including a regulator set to avoid overpressuring pipe), and to monitor pressure and temperature. The section of pipe to be tested shall be plugged, filled with water (vented at high points to purge air pockets while filling), and pressurized to at least 150 percent of design operating pressure (but not less than 50 psi).

The applied pressure will be allowed to stabilize, and temperature and pressure will be monitored for a period of not less than 1-hr. At the end of the test period, the end of the tested segment opposite the pressure gauge will be vented and the gauge monitored to assure continuity of the tested segment.

A pressure loss of not more than 1 percent of the applied pressure during the test period will be considered acceptable.

In the area where a containment pipe is required, the containment pipe will also be pressure tested.

20.3 Construction Observation

The QAC will observe and document the following:

1. Date of test.
2. Description and identification of piping system tested.
3. Type of test performed.
4. Test fluid.
5. Test pressure.
6. Type and location of leaks detected.
7. Corrective action taken to repair leaks.
8. Results of retesting.

Tables

Tables

TABLES

TABLE 1

CONSTRUCTION DOCUMENTATION SOILS TESTS AND FREQUENCY
SKINNER LANDFILL

Test Type	Test Method	Test Frequency
Compacted Cohesive Soil Layer (Pre-construction):		
o Percent fines	ASTM D1140	1/1,000 cy
o Percent gravel	ASTM D422	1/1,000 cy
o Liquid & plastic limits	ASTM D4318	1/1,000 cy
o Permeability	ASTM 5084	1/10,000 cy
o Moisture content	ASTM D2216	1/1,000 cy
o Moisture-density relationship (Standard Proctor)	ASTM D689	1/10,000 cy
Compacted Cohesive Soil Layer (During Construction):		
o Field density and moisture content (nuclear meter and sand cone method)	ASTM D2922 ASTM D1556	5 tests/acre/lift 1 at start of project, 1 at end of project
o Natural Moisture Content	ASTM D2216	1/5,000 cy
o Survey - grade and thickness		100 ft grid
General earthfill (subbase only):		
o Field density and moisture content	ASTM D2922	2 tests/acre/lift
o Moisture-density relationship (Standard Proctor)	ASTM D689	1/material type
o Grain-size distribution (sieve and hydrometer)	ASTM D1140, D422	3/material type
o Atterberg Limits	ASTM D4318	3/material type
Topsoil (post-construction):		
o pH, nitrogen, phosphorous, and potassium		1 per 10 acres
o USDA soil classification		Visual
o Survey - grade and thickness		100 ft grid

TABLE 2

SAMPLE QUANTITIES, CONTAINERS, PRESERVATIVES, AND PACKAGING REQUIREMENTS
SKINNER LANDFILL
GEOTECHNICAL TESTING

Analysis	Container	Preservation	Holding Time	Volume of Samples	Shipping	Normal Packaging
Moisture-Density Relationship/Moisture Content	Sealed Plastic Bag or Bucket	None	None	10 to 15 lbs	Regular mail	
Atterberg Limits	5 gal plastic bucket	None	None	Fill bucket	Regular mail	
Grain-size distribution	5 gal plastic bucket	None	None	Fill bucket	Regular mail	
Permeability	5 gal plastic bucket	None	None	Fill bucket	Regular mail	
Gradation determination	5 gal plastic bucket	None	None	Fill bucket	Regular mail	
pH, Nitrogen, Phosphorous, and Potassium	2 8-oz glass jars	None	None	Fill jars	Regular mail	Vermiculite

TABLE 3

MATERIALS QUALITY CONTROL PROGRAM
SOIL/BENTONITE
SLURRY TRENCH CUT-OFF WALL

MATERIALS				
SUBJECT	STANDARD	TYPE OF TEST	MINIMUM FREQUENCY	SPECIFIED VALUES
Water	--	- pH - Total Hardness	Per water source or as changes occur	As required to properly hydrate bentonite with approved additives
Additives	--	Manufacturer certificate of compliance	One per truckload	As approved by Engineer
Bentonite	API Std 13A	Manufacturer certificate of compliance	One per truckload	Premium grade sodium cation montmorillonite
Backfill soils	--	Selected soils approved by the Engineer	One per source	Consistent with Design Mix
Prepared for placement into the trench	API Std 13B	- Unit Weight - Viscosity - Filtrate	2 set per shift or per batch (pond) One per truckload	Unit weight $\geq$ 1.03 gm/cc V $\geq$ 15 centipose or 40 sec-Marsh @ 68° Loss $\leq$ 30 cc in 30 min @ 100 psi
SLURRY				
In Trench	API Std 13B 1	- Unit Weight	2 per shift at point of trenching	Unit weight = 1.03-1.50 gm/cc
BACKFILL MIX				
At Trench	ASTM C 138 ASTM C 143 ASTM D 422 EM-1110-2-1906	- Unit Weight - Slump - Gradation - Permeability	2 per shift 1 per _____ sf	15 pcf $\geq$ slurry density Slump 2 to 6 inches Consistent with Design Mix K $\leq 10^{-7}$ cm/sec

The results of all field testing done will be recorded on field report tables and retained for the final documentation report.

TABLE 4

BIO-POLYMER SLURRY
CONSTRUCTION DOCUMENTATION TESTS AND FREQUENCY
SKINNER LANDFILL

Test Type	Test Frequency
Bio-Polymer Slurry:	
o Density	4 tests/shift
o Viscosity	4 tests/shift
o pH	4 tests/shift
o Filtrate Loss	1 test/shift

APPENDIX I

SAMPLE CQA FORMS

RUST ENVIRONMENT & INFRASTRUCTURE

Daily Summary of Site Activities

Site: _____ Project No.: _____

Date: _____ Time Work Began: _____ Time Work Ended: _____

Staff:	Type	No.	Organization	Hours

Equipment:	Present	Utilized (Y/N)

Work Completed: _____

Comments: _____

Future Plans: _____

Prepared By: _____

Page _____ of _____

RUST ENVIRONMENT & INFRASTRUCTURE

Construction Photo Log

Sheet ____ of ____

Project: _____ Project No.: _____

	Date Taken	Picture No.	Description
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			

Notes: _____

RUST ENVIRONMENT & INFRASTRUCTURE

Field Density Test Report
(Nuclear Density Test)

Date: _____ Project: _____ Page ____ of ____

Daily Report No.: _____ Project No.: _____

Technician: _____ Computer Entry: _____ Computer Backcheck: _____

Test Number	Retest Ref. No.	Location and Description	North Coordinate	East Coordinate	Elevation (Ft.)	Soil Description	Probe Depth (Inches)	Wet Density (Pcf)	Dry Density (Pcf)	Moisture (Pcf)	Moisture (%)	Proctor (Pcf)	% Com-paction

Comments: _____

RUST ENVIRONMENT & INFRASTRUCTURE

Geosynthetic Materials Inventory Checklist

T11.828

Project Name: _____ Date: _____

Client: _____ Material Type: _____

Project No.: _____ Manufacturer: _____

Lot Number	Roll Number	Dimensions	Condition

Totals:

Notes: _____

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RUST ENVIRONMENT & INFRASTRUCTURE

Certificate Of Acceptance Of Soil Subgrade By Installer

Page _____ of _____

Installer _____

Authorized Representative _____

Location _____

Project _____

Owner _____

I the Undersigned, duly authorized representative of _____

do hereby accept the Soil Subgrade surface and shall be responsible for its integrity and suitability, in accordance with these specifications from this date to completion of the installation.

_____

Name Signature Title

_____

Date

Certification Accepted By – RUST Environment & Infrastructure Inc.

_____

Name Signature Title

_____

Date

_____

Geomembrane Panels Placed

RUST ENVIRONMENT & INFRASTRUCTURE

Panel Placement Information

Client: _____ Page ____ of ____

Date: _____ Project: _____ Computer Entry: _____

Daily Report No.: _____ Project No.: _____ Computer Backcheck: _____

Time	Panel Identification			Batch/Roll Number	Deployed Panel Length	Station		Observer	Comments/Damage
	Layer	Number	Location			Beg.	End		
				Total Length					

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RUST ENVIRONMENT & INFRASTRUCTURE

Trial Weld Information

Client: _____ Page ____ of ____

Date: _____ Project: _____ Computer Entry: _____

Daily Report No.: _____ Project No.: _____ Computer Backcheck: _____

Time	AMB Temp	Sample ID	Seamer ID	Machine ID	Extrusion Welds		Fusion Welds		Peel PPI			Shear PPI	Observer	Comments
					Barrel Temp	Preheat Temp	Wedge Temp	Wedge Speed						

RUST ENVIRONMENT & INFRASTRUCTURE

Panel Seaming Information

Page ____ of ____

Client: _____

Date: _____ Project: _____ Computer Entry: _____

Daily Report No.: _____ Project No.: _____ Computer Backcheck: _____

Start Time	Seam ID	Seam Location	Seamer ID	Machine ID	Station		Seam Length	Observer	Comments
					Beg.	End			

Total: _____

Client: _____ Page ____ of ____

Date: _____ Project: _____ Computer Entry: _____

Daily Report No.: _____ Project No.: _____ Computer Backcheck: _____

Seam Number ID	Seam Location	Station		Test Crew	Air Testing					Vacuum Test P/F	Observer	Comments
					Time		Pressure					
		Beg.	End		Beg.	End	Beg.	End	P/F			

RUST ENVIRONMENT & INFRASTRUCTURE

Destructive Seam Sample Log

Client: _____ Page ____ of ____

Date: _____ Project: _____ Computer Entry: _____

Daily Report No.: _____ Project No.: _____ Computer Backcheck: _____

Sample Number	Date Sampled	Seam ID	Location	Seamer ID	Machine ID	Field Test Peel	Field Test (PPI)	Lab P/F	Sample Reason / Comments

Client: _____ Page ____ of ____

Date: _____ Project: _____ Computer Entry: _____

Daily Report No.: _____ Project No.: _____ Computer Backcheck: _____

Date Repaired	Repair Number	Seam ID	Panel(s)	Location	Description of Damage	Type/Size of Repair	Repair Crew	Date Tested	Tested By	Observer	Comments

RUST ENVIRONMENT & INFRASTRUCTURE

Daily Field Report Geosynthetics Summary

Project No.: _____ Report No. _____

Page _____ of _____

Date: _____

I. INSTALLED QUANTITIES

Material	SF Today	SF Total

II. FUSION SEAMING

Mouse	LF Today	LF Total

III. EXTRUSION SEAMING

Tech.	Gun	LF Today	LF Total

IV. DESTRUCTIVE SAMPLES MARKED

DS	Seam	Station

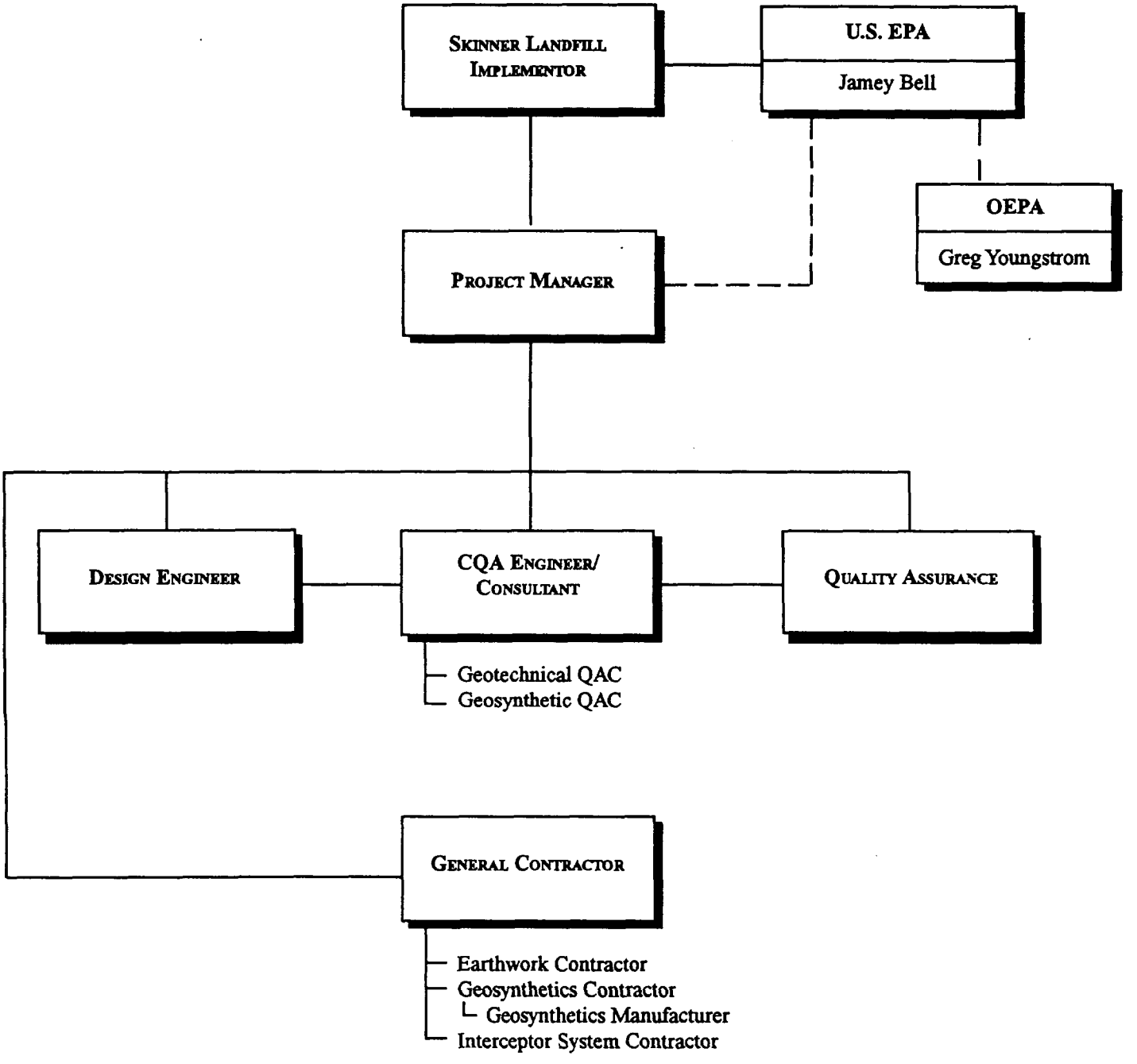
V. COMMENTS

Signature: _____

White Copy - Library File Yellow Copy - Owner Pink Copy - Employee's Field File

Appendix II

LINES OF COMMUNICATION



Appendix III
RESOLUTION MEETING AGENDA
EXAMPLE

1. Introductions

    A. Assign Minute Taker
    B. Identify Parties
        1. Project Manager
        2. Design Engineer
        3. CQA Engineer/RPO
        4. Interception System QAC
        5. Owner representative
        6. Others

2. Tour Project Site

3. Review Documents

    A. Project Plans
        1. Design Drawings
        2. Support Plans
    B. Project Specifications
    C. Construction Quality Assurance Manuals
    D. Permit Documents

4. Construction Quality Assurance Plan

5. Discuss Contract Administration and Construction Issues

6. Define Lines of Communication

7. Define Project Deliverables

8. Determine Schedule

Appendix IV
PRE-CONSTRUCTION MEETING AGENDA
EXAMPLE

1. Introductions

   A. Assign Minute Taker
   B. Identify Parties
      1. Project Manager
      2. Design Engineer
      3. Surveyor
      4. Earthwork Contractor
      5. Geosynthetic Installation Contractor
      6. Interception System Contractor
      7. Interception System Trench QAC
      8. Engineer/RPO
      9. Owner representative
      10. U.S. EPA Representative
      11. OEPA Representative
      12. Driller
      13. Subcontractors
      14. Others

2. Tour Project Site

3. Review Documents

   A. Project Drawings
   B. Project Specifications
   C. Geosynthetic Panel Layout
   D. Construction Quality Assurance Plans
   E. Health and Safety Plan
   F. SPCC Plan
   G. Air Monitoring Plan
   H. Contingency Plan

4. Define Lines of Communication

   A. Lines of Communication
   B. Reporting Methods
   C. Distribution Methods
   D. Progress Meetings
   E. Procedures for Approving Design Clarifications and Changes During Installation

Appendix IV (Continued)
PRE-CONSTRUCTION MEETING AGENDA
EXAMPLE

F. Procedures for Approving Earthwork, Geosynthetics, Other Materials and Groundwater Interception System
G. Procedures for Resolution of Construction Problems

5. Review Site Requirements

   A. Safety Rules
   B. Site Rules
   C. Work Schedule
   D. Storage of Materials
   E. Available Facilities

6. Discuss Construction Issues

   A. Scope of Work
   B. Review Design
      1. Project Drawings
      2. Specifications
      3. Geosynthetic Panel Layout
   C. Construction Procedures
      1. Proposed Construction Sequencing
      2. Location of Soil Stockpile Areas
      3. Location of Geosynthetic Storage Area
      4. Location of Interception System Material Storage Area
      5. Equipment
   D. Construction Schedule
   E. Procedures for Preparing and Approving Change Orders
   F. Health and Safety Plan
   G. Progress Reports

7. Select Testing Equipment, Review Sampling and Testing Procedures

8. Review Construction Quality Assurance Plan

   A. Soils
   B. Geosynthetics
   C. Drainage Systems

Appendix IV (Continued)
PRE-CONSTRUCTION MEETING AGENDA
EXAMPLE

D. Wells and Piezometers
E. Groundwater Interception System

9. Establish Project Deliverables

A. Responsibilities
   1. Owner
   2. Design Engineer
   3. Project Manager
   4. Geosynthetics Installation Contractor
   5. Earthwork Contractor
   6. Interception System Contractor
   7. CQA Engineer and RPO
   8. Interception System QAC
   9. Surveying Services
B. Distribution of Deliverables
C. Approval Procedures
D. Minutes of Meetings from the Project Manager (purpose, distribution)

Appendix V
FINAL CONSTRUCTION COMPLETION REPORT
GENERAL OUTLINE

1. Introduction

    A. Purpose
    B. Scope
    C. Unit Description
    D. Project Parties

2. Project CQAP

    A. Scope
    B. Design Changes
    C. Project-Specific Addenda
    D. Permit Conditions
    E. Regulations (ARAR's)

3. Work Performed

    A. Weather Constraints
    B. Pre-construction Testing
    C. Conformance Testing
    D. Visual Monitoring
    E. Photo Documentation
    F. Construction Testing
    G. Repairs

4. Discussion of Construction Problems and Resolutions including Design changes.

5. Summary and Conclusions

6. Project Certification Statement

7. Appendices

    A. Key Project Personnel including:
        1. Owner
        2. Design Engineer Personnel
        3. CQA Consultant Personnel
        4. Earthwork Contractor Personnel

Appendix V (Continued)
FINAL CONSTRUCTION COMPLETION REPORT
GENERAL OUTLINE

5. Geosynthetic Installation Contractor Personnel
6. Groundwater Interception Personnel
7. Driller Personnel
8. Surveyor
9. U.S. EPA Personnel
10. OEPA Personnel

B. Construction Quality Assurance Plan (CQAP) with Project-Specific Addenda
C. Design Change Forms
D. Earthwork Testing Records
E. Conformance Testing Records
F. Geosynthetics Manufacturer Quality Control Records
G. Quality Assurance Reports
H. Subgrade Acceptance Certificates
I. Panel Placement and Seaming Records
J. Trial Weld Records
K. Non-Destructive Seam Testing Records
L. Destructive Seam Testing Records
M. Repairs
N. Record Drawings
O. Photo Records
P. Boring Logs
Q. Well Construction Drawings
R. Pump Control Settings

SUPPORT PLAN J

SKINNER LANDFILL SUPERFUND SITE
OPERATION & MAINTENANCE PLAN
WEST CHESTER, BUTLER COUNTY, OHIO

Rust Environment & Infrastructure of Ohio Inc.
PROJECT NO. 72680

May 20, 1996

LIST OF ACRONYMS

AMP	Air Monitoring Plan
AOC	Administrative Order on Consent
BOD	Biochemical Oxygen Demand
CLP	Contract Laboratory Program
COD	Chemical Oxygen Demand
Conrail	Consolidated Railroad Corporation
CQAP	Construction Quality Assurance Plan
CRL	Central Regional Laboratory
DNAPLs	Dense Non-Aqueous Phase Liquids
DQOs	Data Quality Objectives
FML	Flexible Membrane Liner (Low Density Polyethylene)
FS	Feasibility Study
FSP	Field Sampling Plan
ft	Feet
GWMP	Groundwater Monitoring Plan
HASP	Health and Safety Plan
ID	Inner Diameter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSL	Mean Sea Level
NCP	National Contingency Plan
NEI	NEI Laboratories, Inc.
OEPA	Ohio Environmental Protection Agency
PCB	Polychlorinated Biphenyls
PAHs	Polynuclear Aromatic Hydrocarbons
PMP	Performance Monitoring Plan
PPE	Personal Protective Equipment
PRP	Potentially Responsible Party
QA	Quality Assurance
QAPP	Quality Assurance Project Plan (Laboratory)
QAPjP	Quality Assurance Project Plan
QC	Quality Control
RA	Remedial Action
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Manager
Rust E&I	Rust Environment & Infrastructure of Ohio Inc.
SU	Standard Units
SOP	Standard Operating Procedure
SOW	Statement of Work
SVE	Soil Vapor Extraction

LIST OF ACRONYMS - CONT.

SVOCs	Semi-Volatile Organic Compounds
SWMP	Surface Water Monitoring Plan
TAL	Target Analyte List
TCL	Target Compound List
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
U.S. EPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds

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1.0 INTRODUCTION

This Operation and Maintenance Plan (O&M Plan) was prepared for Skinner Landfill, West Chester, Ohio in accordance with the Ohio Administrative Code, Solid Waste Management Rule: 3745-27-14: Post-Closure Care. This Plan presents guidelines for the post-construction O&M care of the Skinner Landfill Site. The Plan details control measures, contingency actions, and environmental monitoring to care for the site following implementation of the Remedial Design Components.

The post-construction O&M care period begins upon issuance of final approval from the United States Environmental Protection Agency (U.S. EPA) and Ohio Environmental Protection Agency (OEPA) that the Remedial Action components are complete and operational. The following sections describe the operation and maintenance as well as monitoring activities that will be conducted as part of post-closure care

1.1 Regulatory Compliance

Ohio Administrative Code, Rule 3745-27-14 outlines several compliance requirements. Generally post-closure compliance consists of the following:

- Continue operation and maintenance of the surface water management system, any explosive gas extraction, control and/or monitoring system, and the groundwater interception and monitoring system.

- Maintain the integrity and effectiveness of the cap system, including making repairs as necessary.

- Perform quarterly inspections during each year of the post-construction O&M care period and submit a written summary and a schedule of any actions to be taken to maintain the facility, as required above, to the U.S. EPA and OEPA district office (Dayton) no later than fifteen (15) days after the inspection.

- Fulfill all monitoring and reporting requirements in accordance with OAC Rule 3745-27-10 for groundwater, and OAC Rule 3745-27-12 for explosive gas.

1.2 Contact During Post-Construction Operations & Maintenance Period

Emergency Contact

Fire Department	
Police Department	
Citizen Group	[TO BE DETERMINED]
OEPA	
U.S. EPA, Region V	

Electrical Contractor
Pump Supplier
O&M Firm
Health Department

2.0 LANDFILL COVER

The landfill cover consists of approximately 10.5 acres. The landfill cover serves as a closure for the landfill and buried lagoon. The primary components of the cover are (starting from the waste): subgrade, geocomposite gas vent layer, 18-inches of low permeable soil, geosynthetic clay layer, 40-mil geomembrane, geocomposite drainage layer, soil cover, and vegetation.

2.1 Operation & Maintenance Tasks

This plan provides for inspection and repair of the physical features of the site after closure. The maintenance program includes the following: inspections, final cover repair, vegetation repairs, and security measures.

2.1.1 Inspections

Perform quarterly site inspections to identify areas of refuse subsidence, areas of final cover soil erosion, sediment buildup in the drainage control system, areas of poor vegetation, animal intrusion, and miscellaneous items in need of repair. Prepare a written report following each inspection and file the report with U.S. EPA.

2.1.2 Final Cover Repairs

Repair final cover areas that have experienced differential settlement (identified by signs of ponded water) and erosion. Repairs shall include the regrading of the area to restore the area to positive surface drainage grades.

2.1.3 Vegetation Repairs

Areas repaired on the final cover will require re-establishment of vegetative cover. In addition to maintaining and establishing a good vegetative growth, annual mowing of the final cover surface should occur during the post-construction period. Vegetation repair will include placement of fertilizer, seed and mulch as described in Section 4.0.

2.1.4 Security Measures

Site access is controlled by perimeter fencing located inside the Skinner property. The site entrances are secured with gates and locks. Quarterly inspections shall include identification of fencing that requires repair or replacement. Make repairs as soon as possible after discovery.

2.2 Contingency Plans

There are seven occurrences that would cause the need for a corrective measure to be taken. These occurrences include: leachate breakouts, gas migration, fires, explosions, spills, erosion, landfill settlement, and vectors.

2.2.1 Leachate Breakouts

Should a leachate breakout occur, implement the following action plan.

Upon discovery of the leachate breakout, identify and inspect the location. If the breakout is through the final cover, remove the overlying vegetative growth layers, geocomposite layer, geomembrane, and GCL to expose the compacted clay capping layer. Scarify and recompact the clay material to seal the breakout. Carefully remove sufficient quantity of each material to allow reconstruction to occur. Perform compaction and permeability tests on the recompaction effort to confirm that the compacted clay capping layer was returned to its 1×10^{-7} cm/s hydraulic conductivity condition. Restore final cover by deploying the GCL, geomembrane, and geocomposite material; spreading the vegetative cover layer materials and landscaping the final grade surface. Use new geosynthetic materials for the restoration. Tie the replaced materials cleanly into the undisturbed materials, i.e., geocomposite to overlap in-place undisturbed geocomposite to get a homogenous layer as initially installed. Record the breakout and repair actions in the Quarterly Report.

2.2.2 Explosive Gas Migration

Upon detection of an explosive gas concentration which equals or exceeds the explosive gas threshold limit (EGTL) in the gas monitoring probes, implement the following contingency actions. The EGTL is:

- 50% of the lower explosive limit (LEL) at the facility boundary; or
- 25% of the LEL in on-site structures.
- The LEL is 5% methane by volume.

1. Gas monitoring personnel shall verify explosive gas concentrations by immediate retesting.

2. Upon verification of a reading at or above the EGTL, notify the Implementor and the Project Manager (PM).

3. The PM will increase monitoring frequency in the monitoring gas probes. The Implementor and the PM will determine if additional monitoring such as punch bar probes is warranted or if corrective measures can be implemented. Additional increases above the EGTL or 90% of the LEL at the site boundary will indicate an emergency level of gas in the probes.

4. Once the Implementor and the PM determine that an emergency level of gas is present in the probes, the PM will immediately notify the appropriate local public safety authorities. These will include but may not be limited to: the local Health Department, Division of Fire, Division of Police, U.S. EPA and the OEPA Southwest District Office (See Section 1.2). See correspondence in Appendix I for identification of authorities pertinent to this site.

5 The Implementor and the PM will determine whether the frequency of monitoring should be increased and/or whether the monitoring system should be modified to improve detection. Barhole probing in the area surrounding the permanent probe location or the original barhole station will be conducted, when directed by the PM, in an effort to determine the extent of shallow surface migration.

2.2.2.1 Building/Structure Locations

Upon detection of explosive gas concentrations which equals or exceeds the EGTL within a building near the landfill implement the following contingency actions:

1. Verify by retesting.
2. Notify the Implementor.
3. The PM may then expand monitoring procedures for gases within the buildings and/or develop contingency procedures which may include, but are not limited to any one or a combination of the following:

- Installation of permanent gas monitoring probes supplemented with barhole monitoring for combustible gas in the subject area.
- Installation of a continuous combustible gas monitor within the structure.
- Increase monitoring frequency.
- Develop and post evacuation procedures.
- Adapt a new monitoring procedures.

2.2.3 Fires

A fire at the landfill could be present at the surface, such as a grass fire, or within the landfill with the deposited waste burning. Upon detection of a fire, immediately notify the Town of West Chester Fire Department, Implementor, PM, U.S. EPA and OEPA. The fire department shall determine the method to extinguish the fire. In most cases, for fires within the landfill, the burning waste must be removed, separated from the rest of the landfill, and smothered. Water supply should be available to put out any burning equipment. Vapor-suppressing foam and soil are possible materials to smother a fire.

2.2.4 Explosions

In the event of an explosion, all site personnel will immediately evacuate the site to a safe distance. Notify the U.S. EPA, OEPA, Health Department, and the local fire and police departments (See Section 1.2), and summon qualified personnel to determine the nature of the explosion.

2.2.5 Spills

To prevent spillage during refueling for construction equipment in repair activities, the procedure should occur over a spill containment area. The area will be an area with a perimeter dike/berm of sufficient height to contain potential spills. Use earthen material to absorb the spilled product.

If a spill occurs, it must be reported to the U.S. EPA, OEPA and local authorities. Records of the incident should remain on file and be summarized in the annual report.

2.2.6 Erosion and Differential Settlement

Perform corrective maintenance if inspections reveal excessive erosion, surface displacements, irregularities, ponding of surface waste, desiccation, or vegetative overgrowth or damage. Eroded areas will require removal of the affected loose soil followed by replacement and regrading to provide a uniform grade. Subsided, settled, or areas with ponding requiring repair shall be investigated by qualified personnel to determine the cause of the displacement. Place suitable soil on the affected areas and regrade as required. If investigations reveal that a malfunction of the cover has caused the displacement (e.g., drainage layer failure), repair or replace the defective items and regrade the site. Reseed, fertilize and mulch any areas lacking vegetation and areas repaired as needed to maintain adequate cover.

Erosion may occur in and around surface water control structures which consist of the benches, rock-lined letdowns, drainage swales, culverts, and sedimentation control mechanisms. Perform corrective measures if inspections reveal erosion, displacement of rip-rap, or clogging of parts of the system. Repairs may include regrading, repair, replacement of rip-rap, or revegetation. Use temporary erosion control mechanisms (e.g., erosion matting, ditch checks, silt fencing, etc.) in these disturbed areas until the vegetation is re-established.

2.2.7 Vectors

Conduct inspections quarterly to identify possible signs of animal burrowing. If evidence of burrowing animals is detected, implement response actions. These response actions could include trapping of the animals and relocating them to new locations, spraying the area with repellant solutions that would chase the animals away, and or installing mechanical devices, such as a thumper that pounds the ground which irritates the animals and chases them away. Repair the final grade surface to its original condition.

2.3 Construction Procedures For Site Maintenance

The construction procedures addressed in this section are presented to direct cap maintenance and repair personnel. The possible work elements for cap maintenance include: subbase grade shaping, final cover construction, surface water drainage control construction, and gas vent installation.

2.3.1 Subbase Grade

Some repairs to the cap may involve excavating beyond the final cover system. In this case, backfilled materials (covered refuse and general earthfill) must be compacted to a suitable density to restore the subbase grade. The top of the material must conform with bottom of liner elevations and confirmed by a licensed surveyor in the State of Ohio. The location, procedure, and survey information shall be documented and submitted with quarterly or annual report.

2.3.2 Final Cover

The final cover consists of a geocomposite gas venting layer, an 18-inch compacted cohesive soil secondary capping layer, geosynthetic clay liner (GCL), 40-mil textured geomembrane, geocomposite drainage layer, and a 30-inch vegetative cover containing at least 6 inches of topsoil. Upon detection of an eroded slope, or final cover area in need of repair, document its location and determine the extent of the repair. An eroded slope problem usually can be remedied by removing a portion of the 30-inch-thick vegetative cover via backhoe to the bottom of the erosion rill. Replace the soil using low ground pressure construction equipment and light compaction. Reseed the area according to specifications as discussed in Section 4.6.

If the repair requires that the cohesive soil secondary capping material be removed, care shall be taken to segregate the material for re-use. If it is necessary to utilize additional cohesive soil, it shall be taken from an approved stockpile, or qualified and tested in accordance with the CQAP.

If a leachate breakout is detected, it is likely that a section of the entire final cover system will need to be removed. Perform the following steps to remove the final cover system:

- Mark off area to be repaired in the field with stakes or flags. The area should be substantially larger than the actual working area for ease of repair construction.

- Using heavy equipment, remove the topsoil layer and stockpile separately.

- Remove the entire 36-inch-thick vegetative cover. The 12-inches of material atop the geocomposite shall be removed by hand labor or the bucket of the trackhoe. (Be careful not to disturb geosynthetics). No heavy equipment shall operate on the geosynthetics with less than 12-inches of cover.

- Laborers shall cut the geosynthetic layers one at a time. Begin cutting a minimum of 12-inches within the geosynthetic exposed area to allow for overlap of repair materials.

- Remove compacted clay capping layer material using a trackhoe bucket. The trackhoe shall be able to sit on a portion of the landfill which is not under repair and be able to extend the bucket arm to remove the soil. All soil components removed from the final cover shall be stockpiled separately (i.e., topsoil, vegetative cover and compacted clay capping layer).

- When the gas venting layer is exposed, laborers shall cut the area in question and the PM representative shall document the appearance of the top of the subgrade.

After excavation of the repair area, and after the subgrade is properly compacted, deploy the geocomposite, used as a gas venting layer, over the finished subgrade and tie to already in-place geocomposite with plastic fasteners. Inspect the top of the finished subgrade for larger stones (greater than 3 inches in any dimension) which may cause damage to the geocomposite. Place a loose 4-inch lift of clay soil for the first lift and compact using a small sheepsfoot compactor to minimize damage on the underlying geocomposite. If the area is too small for large compaction equipment, use a jumping jack or similar equipment. Place the remaining lifts on the wet side of optimum moisture content in maximum 8 inch loose lifts and compact with a sheepsfoot compactor (or jumping jack in smaller areas) in order to achieve a hydraulic conductivity of 1×10^{-7} cm/s or less to provide a low permeability layer. Seal the top of the compacted clay capping layer using a rubber tire compactor, vibratory steel roller, or jumping jack in small repair areas.

Place patches of GCL and geomembrane over the repaired area. Patches of GCL and geomembrane shall extend a minimum of six inches beyond the repair area. Overlap the GCL over the in-place GCL and extrusion weld the geomembrane to in-place membrane. Extrusion seams will adhere to the manufacturer's specifications. Perform seam testing as the seams are completed. Testing shall be in conformance with the CQAP.

Tie the second geocomposite layer, used as a drainage layer, to the in-place geocomposite as described earlier over the geomembrane. Do not travel on the geocomposite with any type of vehicle until a 12 inch thickness of vegetative cover is spread over the geocomposite. Spread the remaining vegetative cover material over the geocomposite using a low ground pressure tracked dozer. Then spread the 6 inch topsoil layer, and grade the final surface to prepare for seeding.

Prior to seeding, prepare the topsoil by loosening it to a depth of 2 inches and level. Remove all stone 4 inch or greater in diameter and debris from the topsoil surface. Apply seed, fertilizer and mulch. Seed will consist of tall Fescue K-31 (80 lbs/ac) combined with "quick-cover" perennial ryegrass (80 lbs/ac). Fertilize shall be 1000 lb/acre of 12-12-12 mixture.

Mulch can consist of straw or suitable similar material. Place mulch to a loose depth of ½ inch to 1-1/2 inch by hand and anchor it with a Krimper or straight discs with serrated edges. Place mulch within 24 hours of seeding. Seed, fertilizer and mulch may be applied in one application.

2.3.3 Surface Water Drainage Control

Maintenance of surface water drainage control will consist of the following:

- Quarterly inspections of diversion swales, letdowns, and sediment control devices.
- Periodic cleaning of sediment control devices by removing the silt which is deposited.
- If rip-rap lined channels are damaged, the PM shall assess the situation and determine the repair method. If the rip-rap is damaged, periodically consult a design engineer for a permanent solution.
- Inspect for erosion of grassed channels, and repair by regrading and consult a design engineer to determine if rip-rap is necessary, when erosion occurs frequently.

2.3.4 Gas Venting Installation

It may be necessary to install additional gas vents after completion of closure construction. In order to install a gas vent, remove the 30-inch-thick vegetative cover as discussed in Section 3.2. When the vegetative cover material is cleared from the geosynthetics, place a foot of sand in the repair area. A drilling rig with an 8-inch-diameter auger drill will sit on the adjacent undisturbed final cover and drill in the sand covered area. Drill an 8-inch-diameter borehole through the geosynthetics and extend the hole 20 feet past the bottom of the cap system. Insert a 4-inch-diameter PVC Schedule 80 pipe into the borehole. The pipe shall have 3/8-inch-diameter perforations from the bottom of the pipe up to the gas venting layer. Fill the annulus with 3/4-inch to 1-1/2-inch-diameter clean stone to the top of the gas venting layer. Place a layer of filter fabric in the annulus to separate the clean stone from bentonite pellets. Place the bentonite pellets in the annulus to the top of the compacted clay layer.

Install a geomembrane pipe boot around the 4-inch-diameter PVC pipe. (The boot shall be installed by qualified geosynthetic installers). Weld the boot to the geomembrane and secure the boot around the PVC pipe with silicone caulk and a stainless steel clamp. Install drainage layer geocomposite, then backfill with the vegetative cover soil around the PVC pipe as described in Section 3.2. The PVC pipe shall extend 8 feet above the surface of the final cover system. Install a galvanized metal wind turbine at the top of the pipe.

2.3.5 Final Cover Repair Testing

A third party shall perform the laboratory tests required for repair construction. This will confirm that the borrow materials for the final cover repairs meet the project specifications. Refer to Table 1 for tests and frequencies.

2.3.6 QA/QC Plan for Repair Construction

An on-site construction quality assurance (CQA) consultant shall confirm that the repair construction activities comply with the project specifications. The CQA Consultant is an independent consultant that is responsible for observing and documenting activities related to the quality assurance of the project for the repair of the facility components. The facility components include: foundation (subbase), and final cover system.

The CQA Consultant is responsible for issuing a record of construction report under the seal of a professional engineer registered in the State of Ohio. The CQA Consultant shall be experienced in quality assurance activities for the assigned task. Field representatives shall have specific experience in the installation of items for which they are responsible. Operators of the nuclear moisture/density meter shall be certified in its operation and use. The PM may choose to request the presence of an OEPA or U.S. EPA representative during all repair construction.

The CQA Consultant shall observe and document the activities of the contractor in sufficient detail and with sufficient continuity to provide a high level of confidence that the work complies with the design drawings and documents. In addition, the CQA Consultant shall perform and repeat tests, as necessary, to provide a high degree of certainty that the physical/mechanical characteristics of each item covered under this plan meet or exceed project specifications.

The CQA Consultant shall issue a report of repair activities. This report shall include, at a minimum, visual observations and test results.

The CQA Consultant is required to inform the PM and contractor, in a timely manner, of any difference of the CQA Consultant's interpretation of the plans and documents from the contractor's interpretation as soon as they come to the CQA Consultant's attention.

Testing of soil materials during repair construction shall consist of density, and moisture content to confirm that the repair construction of the final cover meet the moisture/density values established by the Proctor tests. Compliance with the required 1×10^{-7} cm/s hydraulic conductivity for final cover will be based on attaining the moisture-density values determined during test pad construction. This testing will satisfy the frequencies and methods identified in Table 1.

Penetrations resulting from the density testing shall be repaired by filling the hole with bentonite clay and hand tamping.

Testing during repair construction of the geomembrane layer shall consist of continuous nondestructive seam testing, destructive seam testing every 500 ft of weld, and field seam trial welds every 4 hours. Specific details on these test procedures/methods and frequencies are discussed in the Construction Quality Assurance Plan.

Verify final cover system grades through surveying. Surveying shall be completed by or under the direction of a licensed surveyor registered in the State of Ohio.

If, through the field testing process, it is found that the project specifications are not met, the CQA Consultant shall immediately determine the extent and nature of the deficiency. Schedule appropriate retests after reworking, repairing or replacing the deficient area(s). If, after repeated attempts to correct a deficiency, a project specification can not be met, the CQA Consultant shall inform the PM. The CQA Consultant and the PM then shall determine what modifications need to be made in materials, design, or construction technique in order to meet project standards. Perform retests to confirm that any deficiency is corrected before additional work in that area occurs.

If repair construction difficulties arise, a contingency plan to respond to this situation would begin with a meeting to discuss the situation. This meeting would involve the PM, the CQA Consultant and the construction contractor. The purpose of the meeting is to define the problem and resolve it such that repair work can continue.

2.3.7 Records of Construction

As part of repairs to the final cover system, prepare reports to record the quality control and quality assurance efforts used during repair construction to verify substantial compliance with the design. Reports shall consist of the following:

1. Description of repair construction activities.

2. Recorded survey data which at a minimum shall include, base grade elevations, final cover elevations at top of compacted clay layer and top of vegetative cover unless U.S. EPA or OEPA representatives agree to approve repair work in the field.

3. Results from material testing of the soils, geocomposite, geomembrane layer, and GCL.

4. Drawings and photographs that depict site construction activities and recorded conditions.

5. A description of any deviation from the design documents, as approved by U.S. EPA and OEPA.

Submit copies of repair documentation to the U.S. EPA , Southwest District Office of the OEPA in the quarterly reports and annual O&M report.

2.4 Technical Specifications For Site Maintenance

This section presents the specifications of the materials to close and maintain the facility. The specifications presented below are minimum standards and shall be updated as technology and regulatory requirements change. The specifications are written in accordance with U.S. EPA

document U.S. EPA/625/4-91/025 entitled "Design and Construction of RCRA/CERCLA Final Covers."

2.4.1 Compacted Clay Capping Layer

The compacted clay capping layer shall conform to the following and any requirements of the test pad report:

1. Material: Clay soil with a Unified Soil Classification System designation of CL-ML, CL, or CH.

2. Permeability: 1×10^{-7} cm/s or less.

3. Clod Size: Maximum of 3 inch or half of the lift thickness, whichever is less.

4. Compaction moisture content: At optimum or wet of optimum moisture content, based on the standard Proctor curve used for degree of compaction determination.

5. Degree of compaction: At least 95% of the standard Proctor maximum dry density.

6. Construction lift thickness: 8 inch or less, loose.

7. Thickness: Minimum of 18 inches.

8. Testing: Conducted in accordance with U.S. EPA/625/4-91/25 "Design and Construction of RCRA/CERCLA Final Covers."

2.4.2 Geosynthetic Clay Layer (GCL)

The GCL used for repair of the final cover system shall conform to the following:

1. Material: New, first quality, bentonite layer sandwiched between a non-woven and woven geotextile.

2. Subgrade preparation: Remove all angular soil particles, such as angular gravel, larger than ½ inch in any dimension, as well as grade stakes or hubs. Do not place GCL on a frozen subgrade or in area which has become softened by precipitation, i.e., unconfined compressive strength less than 2,000 psf.

3. GCL shall have values as outlined in Table 2.

2.4.3 Geomembrane Layer

The geomembrane used for repair of the final cover system shall conform to the following:

1. Material: New, first-quality, 40-mil low density polyethylene resin.

2. Textured on both sides of the sheet.

3. Physical properties of resin used for extrusion welding shall be the same as those of resin used in manufacture of geomembrane.

4. Geomembrane shall have values as outlined in Table 3.

2.4.4 Geocomposite (Geonet with Geotextile)

1. The geocomposite for the gas venting layer shall consist of the geonet and geotextile on both sides.

2. The geocomposite for the drainage layer shall consist of the geonet and geotextile on both sides.

3. Geonet shall be HDPE.

4. Geotextile shall be 6-oz. non-woven polyester heat bonded to geonet.

2.4.5 Vegetative Soil Cover Material

1. Material: Soil shall have sufficient fertility to support vegetation and protect geocomposite and geomembrane from damage due to root penetration and frost. It shall be free of debris and rock over 4 inches in diameter.

2. Placement of vegetative soil cover materials:

    a. Place soil layer material on geocomposite within 30 days of completing conformance testing of geomembrane.

    b. Push soil layer material out over geocomposite ahead of equipment in two 12-inch thick lifts.

    c. Place soil layer material on slopes beginning at the low end of the affected area and proceed upslope.

d. Equipment used to install soil layer material over geocomposite shall have a maximum contact pressure of 5 psi on soil layer material.

3. Thickness: Minimum of 24 inches.

4. Compaction: Soil cover shall be placed with a minimum of compactive effort in order to promote growth of vegetation.

2.4.6 Topsoil

The topsoil for repair of the final cover system shall conform to the following:

1. Material: Humus - bearing soil that is capable of supporting vegetative growth and is free of debris and rocks over 4-inch in diameter.

2. Thickness: Minimum of 6 inches.

2.4.7 Vegetation

The vegetation process for repair of the final cover system shall conform to the following:

1. Seeding: tall fescue (80 lbs/acre) combined with "quick cover" perennial rye grass (80 lbs/acre).

2. Fertilizer: 12-12-12 mixture (1000 lbs/acre).

3. Mulch: straw (120 bales/acre).

2.4.8 Gas Vent/Probe Materials

The following materials shall be utilized to repair the gas venting system:

1. Perforated 4-inch-diameter Schedule 80 PVC pipe. Perforations shall be drilled at 3/8-inch-diameter, 4 spaced 90° apart around pipe and 4 to 6 inches vertically apart. Rotate perforations 45° continuously.

2. Solid 4-inch-diameter Schedule 80 PVC pipe.

3. Manufactured geomembrane boot to fit around 4-inch-diameter pipe (NSC or approved other).

4. Stainless steel clamp bolted around boot and PVC pipe. (Romac Industries Style SSI Stainless - Steel Pipe Repair Clamp or approved other).

5. Stone material - 3/4-inch-diameter to 1-1/2-inch-diameter clean crushed stone (AASHTO No. 4 stone or equal).

6. Powdered bentonite (Volclay brand or approved equal).

7. Galvanized metal wind turbine with fitting for 4-inch-diameter pipe.

3.0 GROUNDWATER INTERCEPTION SYSTEM

The groundwater extraction system consists of approximately 770 lineal feet of interceptor trench in three sections and 985 lineal feet of cut-off wall. Located at the low point of the three sections of the interceptor trenches are three extraction wells. Each of the three extraction wells has a submersible pump in it. The pump discharge is tied to a force main that carries the groundwater from the wells to a discharge point into an existing sanitary sewer and local POTW. The pumps have three level controls, one for "pump on", one for "pump off" and one for high level "alarm". If a pump on signal is continuous for a predetermined amount of time, an alarm condition will occur. Each pump is connected to a run timer that accumulates run time.

All of the pumps will operate independently. They are connected to a main control panel which is located at the west end of the groundwater interception system. The panel contains run indicator lights for the pumps as well as pump on/off switches. Additionally, the panel includes an telephone auto dialer that will call a minimum of four predetermined numbers in the event of an alarm situation. The auto dialer will have prerecorded messages indicating the alarm condition and location. The system is designed to be run electronically, without the need for operator interface.

3.1 Operation & Maintenance Tasks

The pumps, valves, settings for the pump control and alarm, flow measurement device and continuous sampler are the primary components requiring maintenance. During the first six months of operation, perform the operation and maintenance tasks related to the Groundwater Interception system on a monthly basis. After the first six months, perform the O&M activities on a quarterly basis.

The following sections describe the activities and equipment to maintain and monitor during the post-closure care period at the site.

3.1.1 Valves

For the valves, the only maintenance item requiring regular attention will be the operation of the valve. Rotate the valves through the complete range of operation twice during each scheduled O&M activity. Record any problems with the operation of the valve and evaluate for further action.

3.1.2 Pumps

During scheduled O&M activities, check each of the control levels for pump on, pump off and alarm to determine if any adjustments are required. Record the run time for the pumps as well as the control levels. If run times are different than design values, evaluate the requirement for an adjustment to the levels. Consult the PM regarding these adjustments. Pull the pumps at each O&M activity to inspect them for any material build up on the pump casing. Remove any material build up on the pump.

Put the entire system through an operation cycle, if possible. This may not be possible due to low water levels.

3.1.3 Flow Measurement Device

Take readings at the in line magnetic flow meter and record in the inspection log. Compare recorded flows with the calculated flow values from the pump timers. Investigate significant variations in the values. These variations could mean meter malfunctions or a possible forcemain leak. Report the variations and actions taken in the quarterly and annual reports.

3.1.4 Continuous Sampler

The samples will be collected from the continuous sampler. Additionally, the sample quantities will be compared with anticipated sample quantities based on the flow volume. Variations will be investigated and remedied. Report the variations and actions taken in the quarterly and annual reports.

3.1.5 Extraction Wells

The extraction wells are located at the low points of the collector trenches. Pumps will be placed in the wells to remove liquid from the trench and pump the liquid through the forcemain.

3.2. Contingency Plans

There are three potential operational problems: a high groundwater level in the trench, a low groundwater level in the trench, and flow measurement deviating from calculated flow based on the run time indicator. In addition, a discussion of corrective actions for the case of failure in the groundwater interception system is included.

The O&M manual that is provided after construction will be the best source of information for troubleshooting the system. The design engineer is the next best source of information.

3.2.1 High Level of Groundwater in Interceptor Trench

A high level of groundwater in the trench will in most cases indicate a pump failure. An alarm is sent to the control panel where system will activate the auto dialer and make a phone call to a preestablished number. The system continues to run through a list of numbers until it receives the required acknowledgment.

The person who responds to the alarm will take the spare pump that will be locked in the sampler vault to the extraction well where the alarm condition occurred. The first step will be to attempt to operate the current pump manually. If this causes the pump to operate, there is an apparent problem with the electronics. The pump will be left on to attempt to trigger the low level alarm. If an alarm

can be triggered, then the problem resides with the pump on control. If no alarm is set off when the level goes below the low level control, there is a problem with the electronics at the well.

If the level controls both function properly, then switch the pumps out and operate the system on manual to see if the system responds. If the system responds, then send the pump for repair; if not, a repair person will be called to check the entire operation at the well location.

3.2.2 Low Level of Groundwater in Interceptor Trench

For a low level alarm, exercise a procedure similar to the high level alarm.

3.2.3 Flow Measurement Deviations

If variations occur between the measured flow and the calculated flow, perform the following activities to identify the problem.

1. Take readings from pump timers.

2. Shut off pumps 2 and 3 and operate pump 1 manually for a predetermined time. Prior to and after the shut down of pump 1, take readings at the flow measurement device and compare to that from pump run timer.

3. If the measurements agree, proceed to shut off pumps 1 and 3 and operate pump 2 as described in step 1.

4. Repeat step 2 with pump 3 running and pumps 1 and 2 off.

5. If at any time the numbers (flows) do not agree, inspect piping at the extraction well location.

6. If no apparent problems are identified, check the level controls for proper settings. If they are not at the correct levels they should be adjusted and the test rerun.

7. If they are at the correct level, pull the pump and inspect it for blockage or build-up.

8. If no blockage is identified, reinstall the spare pump and rerun the test.

9. If agreement is not reached, there is an apparent problem with the forcemain. Contact the design engineer.

3.2.4 Failure in Groundwater Interception System

Failure will be indicated if the performance monitoring wells (identified in the LTPP) indicate contamination beyond the groundwater interception system location. In the event that this occurs, the levels within the trenches will be adjusted to minimize the level of groundwater allowed to stand in the trench.

Piezometers will be installed (as part of the LTPP) on each side of the trench, in the area of concern, starting at the upper reaches of the trench to test the effectiveness of the trench system. Based on the information gathered and analyzed by the PM, corrective action will be determined, if necessary.

The bulk of the site has a redundant system for protection (the cut-off wall behind the collection trench). The exception to this is the trench at the east end of the site. Being a single system, this appears to be the most vulnerable. However, by the nature of its shallow depth, and the space available to construct it, it also has the highest probability of being installed as designed. When this information is included with the information from the GWDI regarding the locations where contaminated groundwater was found, the perceived vulnerability of the system diminishes.

The resources most able to address failures will be the people most familiar with the site. These people would be the site hydrogeologist and design engineer.

3.2.5 Corrective Action Implementation Schedule

No corrective action will be taken until two consecutive performance monitoring events indicate a failure. At that point, a response plan will be developed. If a third exceedence is determined, the corrective, investigative plan will be implemented. Based on the data gathered from the response plan, future steps will be developed.

Anticipating the worst possible failure, the result would be to notify the community of potential contamination of the East Fork of Mill Creek. With the concentrations identified in the analytical data to date, this is a highly unlikely occurrence.

3.3 Monitoring And Laboratory Testing Procedures For Interceptor Trench Maintenance

Sampling of the effluent from the groundwater interception system will be required as part of discharge permit conditions from BCDES. The frequency and analytical parameters have not been defined at this time.

3.3.1 Monitoring Tasks

Sample the effluent to the sanitary sewer in accordance with BCDES requirements. Based on the capacity of the sampler and the flow rate from the extraction wells, the time frame for sample collection will be determined.

3.3.2 Data Collection, Laboratory Tests and their Interpretation

Samples from the groundwater interception system will be collected at the frequency identified in the BCDES discharge permit. Laboratory analysis will be performed in accordance with the permit to discharge to the Butler County Sanitary Sewer. The analysis will be reported in conformance with the permit.

3.3.3 Quality Assurance

The quality assurance is anticipated to be the BCDES personnel taking their own samples and comparing their analyticals with the analyticals reported.

3.3.4 Monitoring Frequency Schedule

Monitoring of the effluent from the collection trench will be performed as required by BCDES. Monitoring results will be reported to BCDES and filed on site. The post construction monitoring of the groundwater will be performed in accordance with the LTPP.

3.3.5 Verification Sampling Procedures

No verification samples will be required as BCDES will be taking verification samples for analysis at varying frequencies.

3.4 Technical Documentation For Interceptor Trench Maintenance

3.4.1 Daily Operating Logs

These are not applicable as there will not be an operator on-site daily.

3.4.2 Laboratory Records

Laboratory records will be required by the BCDES. These records will be reported to U.S. EPA at the same frequency required by the BCDES.

3.4.3 Operating Cost Records

Costs will consist of electric used, phone hook up and any routine monitoring and emergency response costs. Electric and phone costs will be kept on file. Reports will be turned into the U.S. EPA for all monitoring and alarm response situations.

4.0 RECORDKEEPING AND REPORTING

4.1 Personnel and Maintenance Records

Visitors to the site, or in the case of contractors, the fore-person will be required to fill out a site visit report. These reports will be kept on record with the PM and a quarterly summary report provided to U.S. EPA along with the routine quarterly report.

4.2 Monthly/Annual Reports to U.S. EPA and OEPA

The reporting frequency will be predominantly dictated by the frequency of effluent analysis reporting. Due to the low level of activity at the site, it is proposed that reporting be made quarterly, with an annual summary report.

Tables

TABLES

TABLE 1

SOIL TESTS AND FREQUENCIES
SKINNER LANDFILL

PRE-CONSTRUCTION	
Test Type [2]	Test Frequency
Compacted Clay Capping Layer:	
o Moisture-density relationship (standard or modified proctors)	1/10,000 cy
o Atterberg Limits	1/1,500 cy
o Grain-size distribution (sieve and hydrometer)	1/1,500 cy
o Recompacted Permeability (hydraulic conductivity)	1/10,000 cy
General earthfill:	
o Moisture-density relationship (standard or modified proctors)	1/material type
o Grain-size distribution (sieve and hydrometer)	3/material type
o Atterberg Limits	3/material type
o UU Triaxial	1/material type
o CU Triaxial	1/material type

DURING CONSTRUCTION		
Soil Type	Test[2]	Frequency
Compacted Clay Capping	Density/Moisture Content	5 tests/acre/lift[1]
General Earthfill	Density/Moisture Content	2 tests/acre/lift[1]

(1) Number of tests to be prorated based on area. In no case will there be no density/moisture testing unless repair is less than 50 square feet.

(2) Testing procedure shall use the current ASTM method at time of the repair.

TABLE 2
GCL SPECIFICATIONS

PROPERTY	QUALIFIER	UNITS	BENTOFIX NS
Physical			
- Mass Per Unit Area	typical	lb/ft^2 (g/m^2)	1.10 (5390)
- Thickness	typical	in (mm)	0.24 (6.0)
Mechanical			
- Grab Tensile[1]	typical	lb (N)	120 (530)
- Puncture	typical	lb (N)	130 (590)
- Friction Angle[2]	minimum	degrees	25
- Peel Strength	minimum	lb (N)	15
Hydraulic			
- Water Permeability[3]	maximum	cm/s	3×10^{-9}
COMPONENTS			
COMPONENT	STANDARD	UNITS	BENTOFIX NS
Carrier/Geotextile			woven
- Mass Per Unit Area	minimum	oz/yd^2 (g/m^2)	3.25 (110)
Cover Geotextile			nonwoven
- Mass Per Unit Area	minimum	oz/yd^2 (g/m^2)	6.0 (200)
Sodium Bentonite			
- Mass Per Unit Area	minimum	lb/ft^2 (g/m^2)	1.0 (4900)
- Montmorillonite	minimum	%	90
Content	minimum	%	70
- Moisture Content	maximum	%	10
- Swell Index	minimum	ml	25
- Water Absorption	minimum	%	600
- Fluid Loss	minimum	ml	18
-Confined Swell	minimum	%	350

TABLE 3

TEXTURED GEOMEMBRANE SPECIFICATIONS

Property	Qualifier	Unit	Specified Value
Thickness	minimum nominal	mils mils	36 40
Density	minimum	g/cu cm	0.90
Melt Flow Index	maximum	g/10 min.	1.1
Tensile Strength at Break	minimum	lb/in. width	45
Elongation at Break	minimum	%	300
Tear Resistance	minimum	lb	12
Puncture Resistance	minimum	lb	30
Carbon Black Content	range	%	2-3
Dimensional Stability (each direction)	maximum change	%	3
Friction Angle with GCL	minimum	degrees	
Friction Angle with Geocomposite	minimum	degrees	
Shear Strength (1) (at yield point)	minimum	lb/in. width	36 and FTB(2)
Peel Adhesion	minimum	lb/in. width	36 and FTB(2, 3)

Footnotes:

(1) Also called "Bonded Seam Strength".

(2) FTB = Film Tear Bond.

(3) For machine-welded seams, no more than 10% of seam width shall separate at any point. For hand-welded seams, no more than 1/8 in. separation shall occur from edge of sheet at any point.