

April 18, 2007

Wayne Price
New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505

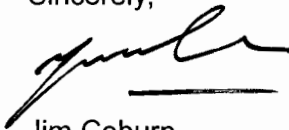
**RE: Sampling and Analysis Plans for the Benson-Montin-Greer Highway 537
Receiving Station Pipeline Spill, and Llaves Pipeline Spills, Rio Arriba
County, New Mexico**

Dear Mr. Price:

Enclosed please find an investigative Sampling and Analysis Plans (SAP) prepared by Animas Environmental Services, LLC (AES) on behalf of Benson Montin Greer Drilling Corporation (BMG) for the BMG Highway 537 pipeline spill and Llaves pipeline spills, which occurred in March 2007 and February 2007, respectively.

If you have any questions regarding the SAP please do not hesitate to contact me, Ross Kennemer or Elizabeth McNally at (505) 564-2281.

Sincerely,



Jim Coburn
Project Manager

Attachments: Sampling and Analysis Plan Highway 537 Truck Receiving Station Llaves
Oil Pipeline Spill, Los Ojitos Canyon, Rio Arriba County, New Mexico
Sampling and Analysis Plan February 2006 and February 2007 Llaves
Pipeline Spills, Llaves, Rio Arriba County, New Mexico

Cc: (Without Enclosures)

Brandon Powell
New Mexico Oil Conservation Division
1000 Rio Brazos Rd.
Aztec, NM 87410

Mike Dimond
Benson Montin Greer Drilling Corporation
4900 College Blvd.
Farmington, NM 87401





Animas Environmental Services, LLC

624 E. Comanche . Farmington, NM 87401 . TEL 505-564-2281 . FAX 505-324-2022 . www.animasenvironmental.com

April 10, 2007

Dixon Sandoval
Jicarilla Apache Nation Environmental Protection Office
P.O. Box 507
Dulce, NM 87528

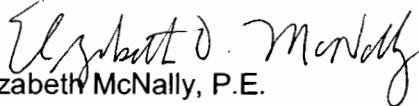
RE: Sampling and Analysis Plan for the Benson Montin Greer Drilling Corporation's Highway 537 March 2007 Pipeline Spill

Dear Mr. Sandoval:

Enclosed please find an investigative Sampling and Analysis Plan (SAP) prepared by Animas Environmental Services, LLC (AES) on behalf of Benson Montin Greer Drilling Corporation (BMG) for the BMG Highway 537 pipeline spill, which occurred in March 2007.

If you have any questions regarding the SAP, please do not hesitate to contact me, Ross Kennemer or Jim Coburn at (505) 564-2281.

Sincerely,


Elizabeth McNally, P.E.

Enclosures: Sampling and Analysis Plan (5 copies)

Cc: (with enclosures)

Jhana Enders, Region 6 On-Scene Coordinator (2 copies)
Superfund Division
USEPA (65F-PE)
1445 Ross Ave.
Dallas, TX 75202

Brandon Powell
New Mexico Oil Conservation Division
1000 Rio Brazos Rd.
Aztec, NM 87410



Mike Dimond (2 copies)
Benson Montin Greer Drilling Corporation
4900 College Blvd.
Farmington, NM 87401

Tony Schmitz, Private Land Owner

Files:2007/BMG/Highway 537/Sampling and Analysis Plan Cov Let 041007



Animas Environmental Services, LLC

624 E. Comanche . Farmington, NM 87401 . TEL 505-564-2281 . FAX 505-324-2022 . www.animasenvironmental.com

SAMPLING AND ANALYSIS PLAN

Benson Montin Greer
Highway 537 Truck Receiving Station Llaves Oil Pipeline Spill
Los Ojitos Canyon, Rio Arriba County, New Mexico

April 5, 2007

Prepared for:
Dixon Sandoval
Jicarilla Apache Nation
Environmental Protection Office
P.O. Box 507
Dulce, NM 87528

Jhana Enders
U.S. EPA On-Scene Coordinator
U.S. EPA Region 6 (65F-PE)
1445 Ross Ave.
Dallas, TX 75202

Prepared on behalf of:
Benson-Montin-Greer Drilling Corporation
4900 College Blvd.
Farmington, NM 87402



Contents

1.0	Introduction	1
2.0	Site Information	1
2.1	Site Location.....	1
2.2	Spill History	1
3.0	Regional and Local Geology and Hydrogeology	2
3.1	Geology.....	2
3.2	Hydrogeology	2
4.0	Proposed Scope of Work.....	3
4.1	Access Agreements.....	3
4.2	Archaeological Clearances	3
4.3	U.S. Army Corps of Engineers Permit.....	3
4.4	Utilities Notification	3
4.5	Health and Safety Plan.....	3
4.6	Installation of Soil Borings	4
4.6.1	Soil Borings	4
4.7	Soil Sampling and Analyses	4
4.7.1	Soil Sample Collection.....	4
4.7.2	Field Screening.....	5
4.7.3	Laboratory Analyses - Soil.....	5
4.8	Groundwater Monitor Well Installation	6
4.8.1	Groundwater Monitor Well Installation and Construction.....	6
4.8.2	Groundwater Monitor Well Development.....	6
4.8.3	Groundwater Monitor Well Monitoring and Sampling	7
4.8.4	Professional Survey.....	7
4.8.5	Laboratory Analyses - Groundwater.....	7
4.9	Equipment Decontamination.....	8
4.10	Investigation Derived Waste	9
4.10.1	Investigation Derived Waste - Soil	9
4.10.2	Investigation Derived Waste - Groundwater.....	9
4.10.3	Investigation Derived Waste – Equipment Decontamination Water.....	9
4.11	Quality Assurance/Quality Control and Chain of Custody Procedures	9
4.11.1	Quality Control Samples	9
4.11.2	Sample Quality Assurance Elements	10
4.11.3	Chain of Custody Record	10
4.11.4	Custody Seal	10
5.0	Deliverables.....	11
6.0	Post-Removal Controls.....	11
7.0	Implementation Schedule	12
8.0	Certification	13
9.0	References.....	14

Figures

Figure 1. Oil Spill Location and Proposed Soil Boring/Monitoring Wells

Appendices

Appendix A. HASP for Site Assessment

Appendix B. Sample Soil Boring Log and Water Sample Collection Form

Appendix C. Standard Operating Procedures

1.0 Introduction

Pursuant to a verbal request from the U.S. Environmental Protection Agency (USEPA) Superfund Division, Animas Environmental Services, LLC (AES), on behalf of Benson Montin Greer Drilling Corporation (BMG), submits this Sampling and Analysis Plan (SAP) for BMG's Highway 537 Truck Receiving Station Llaves Pipeline oil spill, which was discovered on March 7, 2007.

2.0 Site Information

2.1 Site Location

The Llaves Pipeline is a 4-inch diameter pipeline that carries crude oil and is located in the southeast portion of the San Juan Basin, Rio Arriba County, New Mexico. Surface ownership in the area where the spill occurred includes Jicarilla Apache Nation Lands and private land owned by the Schmitz Ranch. The pipeline transects several small, unnamed tributaries (in the area where the spills occurred) that drain to the Los Ojitos Arroyo and eventually to Largo Canyon.

The spill began on the Schmitz Ranch within the SW ¼ NW ¼ of Section 18, T25N, R3W (latitude and longitude recorded as N36° 23' 59.781" and W107° 11' 26.450") and flowed into the Los Ojitos Arroyo and then downstream to a livestock pond located on Jicarilla Apache Nation Land within the SE ¼ SE ¼ of Section 13, T25N, R4W (latitude and longitude recorded as N36° 23' 40.417" and W107° 11' 53.337"), Rio Arriba County, New Mexico. The location of the spill and flow route are shown on Figure 1.

2.2 Spill History

On March 7, 2007, Schmitz Ranch personnel observed oil leaking into the Los Ojitos Canyon Arroyo. BMG management were immediately contacted and dispatched BMG personnel to investigate. BMG personnel discovered that a small corrosion hole in the Llaves Pipeline, which runs parallel to the south side of Highway 537, was the source of the leaking oil, and the pipeline was removed from service. BMG is not able to determine the exact date that the leak began, but oil production inventory records indicate that approximately 500 barrels of oil had leaked.

On March 7, 2007, BMG reported the spill to the New Mexico Oil Conservation Division (NMOCD), and on March 8, 2007, BMG reported the spill to the USEPA and the Jicarilla Apache Nation Environmental Protection Office (JEPO).

On March 9, 2007, BMG subcontractors began removing free-oil that had pooled in low areas and also oil floating on surface water within the arroyo and livestock pond. Since March 9, 2007, spill cleanup efforts have continued five to six days per week. On March 31, 2007, with USEPA and NMOCD approval, BMG subcontractors burned as much free-oil within the arroyo as possible. Vacuum removal of residual free-oil that was not burned will continue. Also, as of April 4, 2007, approximately 8,000 cubic yards of oil contaminated soils

have been excavated and transported off-site to the Schmitz Ranch Landfarm, a NMOCD permitted facility. Additionally, subcontracted environmental cleanup crews directed by JEPO have removed free-oil from the portion of the arroyo on tribal lands by vacuuming and burning.

3.0 Regional and Local Geology and Hydrogeology

3.1 Geology

Rio Arriba County, New Mexico, is located along the southeastern margin of the San Juan Basin portion of the Colorado Plateau physiographic province. The San Juan Basin is a large, structural depression encompassing approximately 22,000 square miles and contains deep Tertiary fill resting on rocks of Late Cretaceous age. The lithography consists primarily of the Mesa Verde Formation, composed primarily of sandstones. The topography is broad and mostly flat, surrounded by mountains and deep canyons. Major rivers carved deep canyons and mesas, and physical erosion from wind and water chipped and polished the exposed rocks in the canyons.

The regional geology of the Los Ojitos Canyon area is predominately Late Cretaceous coastal plains and shoreline and marine units that were deposited along the western margin of the interior seaway. The shallow inland sea transgressed and regressed over a period of 250 million years, depositing the Dakota Sandstone and Mancos Shale units. The Dakota Sandstone records the alternating rise (shale) and fall (sandstones) of sea level as the shoreline moved back and forth across the area about 98 to 100 million years ago. The long-term rise in sea level deposited rocks of the Mancos Group, which from oldest to youngest, include the Graneros Shale, Greenhorn Limestone, and Carlile Shale. Gradually the sea level dropped again, and the shoreline retreated to the northeast, as deposition of the Mesaverde Group began. The Mesaverde Group consists of alternating sandstones, siltstones, and coal deposited by rivers flowing into the shallow sea.

3.2 Hydrogeology

The Llaves pipeline transects several unnamed washes that lead to the Los Ojitos Canyon Arroyo, which drains southwest to Largo Canyon and ultimately to the San Juan River.

Locally, shallow groundwater is encountered within the valleys and canyons at depths less than 50 feet and is typically associated with arroyos, which can be incised as much as 20 feet below the valley floor. Within the area where the pipeline spill occurred, groundwater arroyo cuts range from 5 to 10 feet, and groundwater was encountered at about 46 feet below the ground surface (bgs) at the point of the spill and 5 to 10 feet below the arroyo base, along most of the spill route.

4.0 Proposed Scope of Work

Site investigation activities will be initiated in order to delineate the full extent of petroleum hydrocarbon impacted surface and subsurface soils and groundwater. The investigation procedures are designed to be protective of both surface water and groundwater and are based upon protocols outlined in the USEPA documents, *Expedited Site Assessment Tools for Underground Storage Tank Sites*, March, 1997, and *Site Characterization for Subsurface Remediation*, November, 1991.

4.1 Access Agreements

Prior to initiating the field work, AES will obtain a written property access agreement from the Schmitz Ranch and the Jicarilla Apache Nation.

4.2 Archaeological Clearances

A cultural resources clearance survey is in the process of being completed by the Jicarilla Apache Archaeologist for the portion of the spill located on Jicarilla Apache lands. Prior to initiating site work, AES will ensure that the cultural resources clearance is complete and will comply with any protective measures outlined by the Archaeologist.

In the event that any evidence of human remains or burials is encountered, all work will be ceased immediately, and the appropriate authorities will be contacted. Under Federal and Tribal law, mitigative action will be required before any site investigation activities can be continued.

4.3 U.S. Army Corps of Engineers Permit

Prior to initiating the site investigation, AES will consult with the U.S. Army Corps of Engineers (USACE) to obtain, if necessary, a Nation Wide 404 permit.

4.4 Utilities Notification

AES will utilize the New Mexico One-Call system to identify and mark all underground utilities at the site before the start of any proposed field activities which could impact buried utilities. Any local utilities not participating in the New Mexico One-Call system will be contacted separately by AES for utility locations.

4.5 Health and Safety Plan

AES has a Health and Safety Program in place to ensure the health and safety of all AES employees. The Health and Safety Program defines safety practices and procedures to be instituted in all AES work places, as applicable. The program meets the requirements promulgated by the Occupational Safety and Health Act (OSHA). All AES personnel are appropriately trained in accordance with OSHA 40 CFR 1910.120.

A comprehensive site-specific Health and Safety Plan (HASP) addressing the site investigation and associated sampling will be prepared prior to the start of the field work. An example of the plan that will be utilized for the project is included in Appendix A.

All employees and subcontractors will be required to read and sign the HASP to acknowledge their understanding of the information contained within them. The HASP will be implemented and enforced on site by the assigned Site Safety and Health Officer. Daily tailgate meetings will be held and documented during field activities and will address specific health and safety concerns or issues.

4.6 Installation of Soil Borings

AES proposes to install 10 soil borings along the route of the spill in order to define the lateral and vertical extent of near surface and subsurface soil contamination. Four soil borings (PMW-1 through PMW-4) will be advanced with a hollow stem auger rig, and the remaining borings (PMW-5 through PMW-10) will be installed with a direct push rig. The locations of the soil borings are presented on Figure 1.

4.6.1 Soil Borings

Soil borings PMW-1 through PMW-4 will be advanced with a CME-75 drill rig equipped with hollow stem augers (4.25-inch inside diameter and 7.25-inch outside diameter). Hollow stem auger drilling will be provided by Envirotech, Inc., Farmington, New Mexico, or by Earth Worx Environmental Services, LLC (Earth Worx), Los Lunas, New Mexico. Soil borings PMW-5 through PMW-10 will be advanced with a DT 6620 track-mounted direct push rig, manufactured by Geoprobe[®], and equipped with 2-inch outer diameter (OD) core barrel. Direct push drilling will be provided by Earth Worx.

4.7 Soil Sampling and Analyses

4.7.1 Soil Sample Collection

Borings to be located outside of the arroyo (PMW-1 through PMW-4), near the spill release point, will be advanced to approximately 55 feet below ground surface (bgs), where it is anticipated that groundwater will be encountered at approximately 45 feet bgs. Borings located within the arroyo (PMW-5 through PMW-10) will be advanced to groundwater or about 10 to 15 feet below the arroyo base. Proposed boring locations are included on Figure 1.

Each boring will be logged for lithology and sampled continuously for field screening of volatile organic compounds (VOCs) with a photo-ionization detector (PID) organic vapor meter (OVM). Additionally, a minimum of three soil samples will be collected from each boring for laboratory analysis; one sample from the surface; one from the depth at which the highest vapor reading was recorded, and one sample from the capillary fringe just above groundwater.

For each soil boring, a Soil Boring Log will be completed. These logs will record sample identification, depth collected, and method of collection, as well as observations of soil moisture, color, density, grain size, plasticity, contaminant presence, and overall stratigraphy. An example of the log which will be used is included in Appendix B.

Soil samples will be collected from continuously driven core-barrel samplers during advancement of the soil borings. Discrete samples will be collected based on PID-OVM screening measurements from the core barrel sampler and transferred to appropriately labeled sample containers. Soil sample collection will be completed in strict accordance

with the USEPA Environmental Response Team's Standard Operating Procedures (SOPs), which are included in Appendix C.

4.7.2 Field Screening

Samples will be collected at approximate 4-foot intervals from each soil sampling location and field screened for volatile organic vapors utilizing a PID-OVM calibrated with isobutylene gas to obtain preliminary data regarding potential petroleum hydrocarbon-impacted soil.

Once collected, the soil sample to be field screened will be immediately placed in a clean 16 ounce glass jar, filled approximately half full, and sealed with a threaded ring lid and a sheet of aluminum foil. The sample jar will then be placed in a warm water bath where it will be warmed to approximately 80°F. Approximately ten minutes will be allowed for the soil to be heated and for any VOCs in the soil to accumulate in the head space of the jar. During the initial stages of headspace development, the sample will be gently shaken for one minute to promote vapor development and disaggregate the sample. Volatile gases will then be measured by piercing the aluminum foil with the sample probe of the PID-OVM. The highest (peak) measurement will be recorded. PID-OVM readings will be recorded onto the Soil Boring Logs. All field screening will be completed in strict accordance with the USEPA Environmental Response Team's SOP, which is included in Appendix C.

The action level for PID-OVM readings will be considered to be any reading that is above a non-detectable concentration. The extent of soil contamination will continue to be defined in either vertical and/or horizontal direction until non-detectable field screening concentrations are reached. A minimum of three confirmation laboratory samples will be collected; one from surface soils, one from the interval with the highest PID-OVM reading, and one from the capillary fringe just above groundwater.

4.7.3 Laboratory Analyses - Soil

Analytical samples collected from soil borings will be submitted to an EPA-approved laboratory, Pinnacle Laboratories, Albuquerque, New Mexico, or one of its subcontractors for analysis of the following parameters:

Table 1. Soil Analytical Parameters

<i>Soil Boring</i>	<i>Parameter</i>	<i>Analytical Method</i>	<i>Analyzing Laboratory</i>
All Soil Borings (SB-1 – SB-10)	BTEX	EPA Method 8021	Pinnacle Laboratories, 2709-D Pan Am Freeway NE Albuquerque, NM (505) 344-3777
All Soil Borings (SB-1 – SB-10)	Total Petroleum Hydrocarbons (TPH) (C ₆ -C ₃₆)	EPA Method 8015 Modified	Pinnacle Laboratories, 2709-D Pan Am Freeway NE Albuquerque, NM (505) 344-3777

As described above, three discrete soil samples from each boring will be submitted for laboratory analyses. Additional soil samples will be collected and submitted for laboratory

analyses if warranted by field observation. Therefore, based on 10 proposed soil borings, a minimum 30 soil samples will be submitted for laboratory analyses.

Once collected, sample containers will be packed with ice in insulated coolers and shipped via FedEx or UPS to the analyzing laboratory. Typical laboratory regular turn around time is 12 to 15 business days.

For all laboratory samples, quality assurance and quality control (QA/QC) procedures, sample preservation, apparatus required, and analyses performed will be in accordance with USEPA Document EPA-600, "Methods for Chemical Analysis for Water and Wastes" dated July 1982; and USEPA document SW-846, 3rd Edition, "Test Methods for Evaluating Solid Waste: Physical Chemical Methods", dated November, 1986.

4.8 Groundwater Monitor Well Installation

4.8.1 Groundwater Monitor Well Installation and Construction

Groundwater monitoring wells will be installed within each of the 10 soil borings. Monitoring well construction for PMW-1 through PMW-4 will consist of 2-inch diameter wells constructed from Schedule 40 PVC casing and screen, with a screened interval of 15 feet. The sand pack will extend to one foot above the top of the screened interval, and a bentonite plug will be installed above the sand pack. The remaining well annulus will be filled with concrete grout with approximately five percent bentonite up to within a foot of ground surface. Wells will be completed above grade within a 4-inch diameter locking steel casing to prevent damage to the wells. A well completion diagram for the 2-inch diameter wells is included on Figure 1.

Monitor wells PMW-5 through PMW-10 will consist of 1.4-inch outside diameter (OD) [0.75-inch inside diameter (ID)] Schedule 40 PVC screen and 1.0-inch blank riser casing. The screened interval will extend 10 feet across the water table for these shallow wells installed within the arroyo. The wells will be constructed of a 1.4-inch OD (0.75-inch ID) pre-packed screen (0.010-inch slot). The screen is factory packed with 20/40 Colorado silica sand. A bentonite seal will be placed above the sand pack, and concrete grout with approximately five percent bentonite will be poured from the top of the bentonite plug up to within a foot of ground surface. An above grade locking steel protective casing, enclosed with a shroud or concrete, will be installed on the well to prevent unauthorized access and damage from runoff and debris within the wash. Proposed monitoring well construction schematics for the shallow wells (PMW-5 through PMW-10) are included on Figure 1. Monitoring wells will be installed in strict accordance with the USEPA Environmental Response Team's SOP, which is included in Appendix C.

4.8.2 Groundwater Monitor Well Development

Following monitor well installation and completion, each well will be developed by a combination of surging and bailing techniques. It is estimated that approximately 2 gallons of water will be generated during development of the 1-inch diameter shallow groundwater monitor wells (PMW-5 through PMW-10), and about 15 gallons of water will be produced during development of the deeper 2-inch diameter wells (PMW-1 through PMW-4). Groundwater purged from the wells will be contained in labeled and sealed 55-gallon drums. Development water will remain on-site in a secure location until proper disposal. Monitoring

wells will be developed in strict accordance with the USEPA Environmental Response Team's SOP, which is included in Appendix C.

4.8.3 Groundwater Monitor Well Monitoring and Sampling

Upon completion and development, the monitor wells will be allowed to sit undisturbed for a minimum of one week. The groundwater monitor wells will then be gauged to determine water table elevation and direction of groundwater flow. The wells will then be purged of a minimum of three well volumes, and a groundwater sample will be collected from each well.

Groundwater samples will be collected from each well with a new disposable bailer equipped with a low-flow release valve. Purging data, including pH, temperature, conductivity, oxidation-reduction potential, and dissolved oxygen, will be measured with a YSI water quality meter and documented on a Water Sample Collection Form along with purged water volume. All sampling and purging equipment will be thoroughly decontaminated between uses. An example of the Water Sample Collection Form which will be used is included in Appendix B.

Duplicate groundwater samples will be collected from each monitoring well and held in the event that further laboratory analyses are required. All sample collection data, including sample collection depth, will be documented on a Water Sample Collection Form. A Chain of Custody Record will be completed in the field as samples are being collected. Samples will be stored in a chilled, insulated cooler at 4°C until delivered to the analyzing laboratory.

Groundwater monitoring, well installation, well development, and sampling will be completed in strict accordance with the USEPA Environmental Response Team's SOPs, which are included in Appendix C.

4.8.4 Professional Survey

The location and elevation of the top of each well casing will be surveyed to the nearest 0.01 foot with reference to mean sea level by a licensed surveyor in order to accurately determine the local groundwater depth and flow direction beneath the site. Each well will be tied to an existing USGS benchmark. AES will arrange with a New Mexico Licensed Professional Surveyor to complete the survey upon completion of the monitoring well installation.

4.8.5 Laboratory Analyses - Groundwater

All groundwater analytical samples collected from the monitoring wells will be submitted to an EPA-approved laboratory, Pinnacle Laboratories, Albuquerque, New Mexico, or one of its subcontractors for analysis of the following parameters:

Table 2. Groundwater Analytical Parameters

<i>Water Sample Location</i>	<i>Parameter</i>	<i>Analytical Method</i>	<i>Analyzing Laboratory</i>
All Monitoring Wells (MW-1 – MW-10)	BTEX	EPA Method 8021	Pinnacle Laboratories, 2709-D Pan Am Freeway NE Albuquerque, NM (505) 344-3777
All Monitoring Wells (MW-1 – MW-10)	Total Petroleum Hydrocarbons (TPH) (C6-C36)	EPA Method 8015 Modified	Pinnacle Laboratories, 2709-D Pan Am Freeway NE Albuquerque, NM (505) 344-3777

A travel blank and field blank will be analyzed BTEX per EPA Method 8021. Once collected, sample containers will be packed with ice in insulated coolers and shipped via FedEx or UPS to the laboratory. Typical laboratory regular turn around time is 12 to 15 days.

For all laboratory samples, QA/QC procedures, sample preservation, apparatus required, and analyses performed will be per USEPA Document EPA-600, "Methods for Chemical Analysis for Water and Wastes" dated July 1982; and USEPA document SW-846, 3rd Edition, "Test Methods for Evaluating Solid Waste: Physical Chemical Methods", dated November 1986, as amended by Update One, July 1992.

4.9 Equipment Decontamination

In order to prevent cross-contamination between sampling locations, strict decontamination procedures will be employed during the investigation. All direct push equipment will be decontaminated after completing each soil boring, and sampling equipment (i.e. hand auger, spoon sampler, and other hand tools) will be decontaminated following each use at an individual depth or location.

All decontamination of equipment will be completed within 110-gallon plastic tubs, which will contain the effluent. At least two tubs will be used, one designated for direct push core barrels and the other for small sampling equipment. On an as-needed basis, effluent from the tubs will be transferred by small pump or bucket into 55-gallon DOT approved drums, which will then be marked with identification labels and sealed. Decontamination procedures that will be employed are outlined below.

For small equipment such as direct push core barrels, hand augers, hand tools, and spoon samplers:

1. Physical removal of gross contamination and all debris with brushes
2. High pressure wash with non-phosphate detergent
3. Hand wash with non-phosphate detergent and water using brush
4. Rinse with water
5. Second Rinse with water

6. Air dry

All decontamination procedures will be completed in strict accordance with the USEPA Environmental Response Team's SOPs, which are included in Appendix C.

4.10 Investigation Derived Waste

4.10.1 Investigation Derived Waste - Soil

Contaminated soils will be managed in accordance with applicable State, Federal and Tribal regulations. All contaminated drill cuttings will be placed within 55-gallon DOT approved drums, which will then be marked with identification and sealed. These soils will then be disposed of at the Schmitz Ranch Landfarm, an NMOCD approved facility. Disposal manifest will be included within the assessment report.

4.10.2 Investigation Derived Waste - Groundwater

Contaminated water will be managed in accordance with applicable Federal and Tribal regulations. Groundwater obtained from monitoring well development and pre-sample purging will be stored on-site within 55-gallon DOT approved drums, which will then be marked with identification and sealed. This water will then be disposed of at an evaporation pond at the Schmitz Ranch Landfarm. Disposal manifest will be included within the assessment report.

4.10.3 Investigation Derived Waste – Equipment Decontamination Water

All decontamination and rinse water will be managed in accordance with applicable Federal and Tribal regulations. This water will be stored on-site within 55-gallon DOT approved drums, which will then be marked with identification and sealed. Equipment decontamination water will then be disposed of at an evaporation pond at the Schmitz Ranch Landfarm. Disposal manifest will be included within the assessment report.

4.11 Quality Assurance/Quality Control and Chain of Custody Procedures

4.11.1 Quality Control Samples

Field quality control samples will be collected in order to assess variability of the media being sampled and to detect contamination and sampling error in the field. Field QC samples will include field duplicates, trip blanks and if applicable, equipment rinsate blanks.

- One field duplicate sample will be collected for every ten field samples collected for laboratory analysis in order to check for reproducibility of laboratory and field procedures.
- One trip blank sample will be utilized per sampling event to check for contamination of volatile organic samples during handling and shipment from the field to the analyzing laboratory.
- One equipment rinsate blank will be collected per sampling event to check field decontamination procedures if sampling equipment is decontaminated and reused in the field.

Laboratory QC samples will be analyzed by the laboratory and will consist of matrix spike and matrix spike duplicates for organic samples in order to identify, measure and control the sources of error that may be introduced from the time of sample bottle preparation through analysis.

4.11.2 Sample Quality Assurance Elements

Sample quality assurance elements will include the following:

1. Sample documentation (location, date and time collected, batch, etc.)
2. Complete chain of custody records
3. Initial and periodic calibration of field equipment
4. Determination and documentation of applicable detection limits
5. Analyte(s) identification
6. Analyte(s) quantification

4.11.3 Chain of Custody Record

A Chain of Custody Record will be maintained from the time of sample collection until final deposition. Every transfer of custody will be noted and signed for and a copy of the record will be kept by each individual who has signed it. The Chain of Custody Record will include the following information:

1. Sample identification
2. Sample location
3. Sample collection date
4. Sample information, i.e., matrix, number of bottles collected, etc.
5. Names and signatures of samplers
6. Signatures of all individuals who have had custody of the samples

When samples are not under direct control of the individual currently responsible for them, they will be stored in a locked container which has been sealed with a Custody Seal.

4.11.4 Custody Seal

Custody seals demonstrate that a sample container has not been opened or tampered with. The individual who has custody of the samples will sign and date the seal and affix it to the container in such a manner that it cannot be opened without breaking the seal.

5.0 Deliverables

Within 60 days of the completing the SAP, a Site Assessment Report (SAR) summarizing the SAP activities will be submitted to the USEPA, JEPO and the Schmitz Ranch. The SAR will include the following:

1. A summary of all work conducted in the implementation of the SAP;
2. Maps of all sampling locations, including soil and groundwater contamination plumes;
3. All laboratory data and quality assurance and quality control information; and
4. Recommendations of further sampling which needs to be conducted as a result of the sampling pursuant to the SAP.
5. Recommendations for further remediation measures

6.0 Post-Removal Controls

Measures for post-removal controls will be determined once the extent of horizontal and vertical contamination has been defined, and the contaminated soils and/or groundwater have been mitigated. Post-removal control measures will fall in accordance with 40 CFR 300.415 and OSWER Directive 9360.2-02 and will be presented in the Work Plan accompanying the SAR. Control measures may potentially include:

1. Fences, warning signs, or other security or site control precautions where humans or animals have access to the release;
2. Drainage controls;
3. Stabilization of berms, dikes, or impoundments;
4. Excavation, consolidation, or removal of highly contaminated soils from drainage or other areas, where such actions will reduce the spread of, or direct contact with the contamination

7.0 Implementation Schedule

AES proposes the following timeline to implement SAP activities, once written USEPA and USFS approval has been received. This schedule assumes that no inclement weather occurs which could result in a delay in implementing field activities.

Task	Days from SAP Approval
1. Army Corps consultation. Schedule direct push rig for soil borings and monitor well installation; provide notification to USEPA, Jicarilla Apache Tribe, and Schmitz Ranch of scheduled site activities	10
2. Complete installation of soil borings and groundwater monitor wells; collect and submit soil and groundwater samples for laboratory analysis	30
3. Receive laboratory analytical reports for soil and groundwater samples	45
4. Prepare and submit Site Assessment Report (SAR)	90

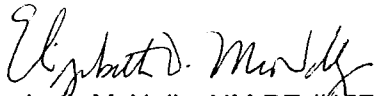
8.0 Certification

AES has prepared this Sampling and Analysis Plan on behalf of Benson Montin Greer Drilling Corporation to complete an environmental site assessment associated with the Highway 537 Truck Receiving Station Llaves Oil Pipeline spill, which occurred in March 2007.

Respectfully submitted,



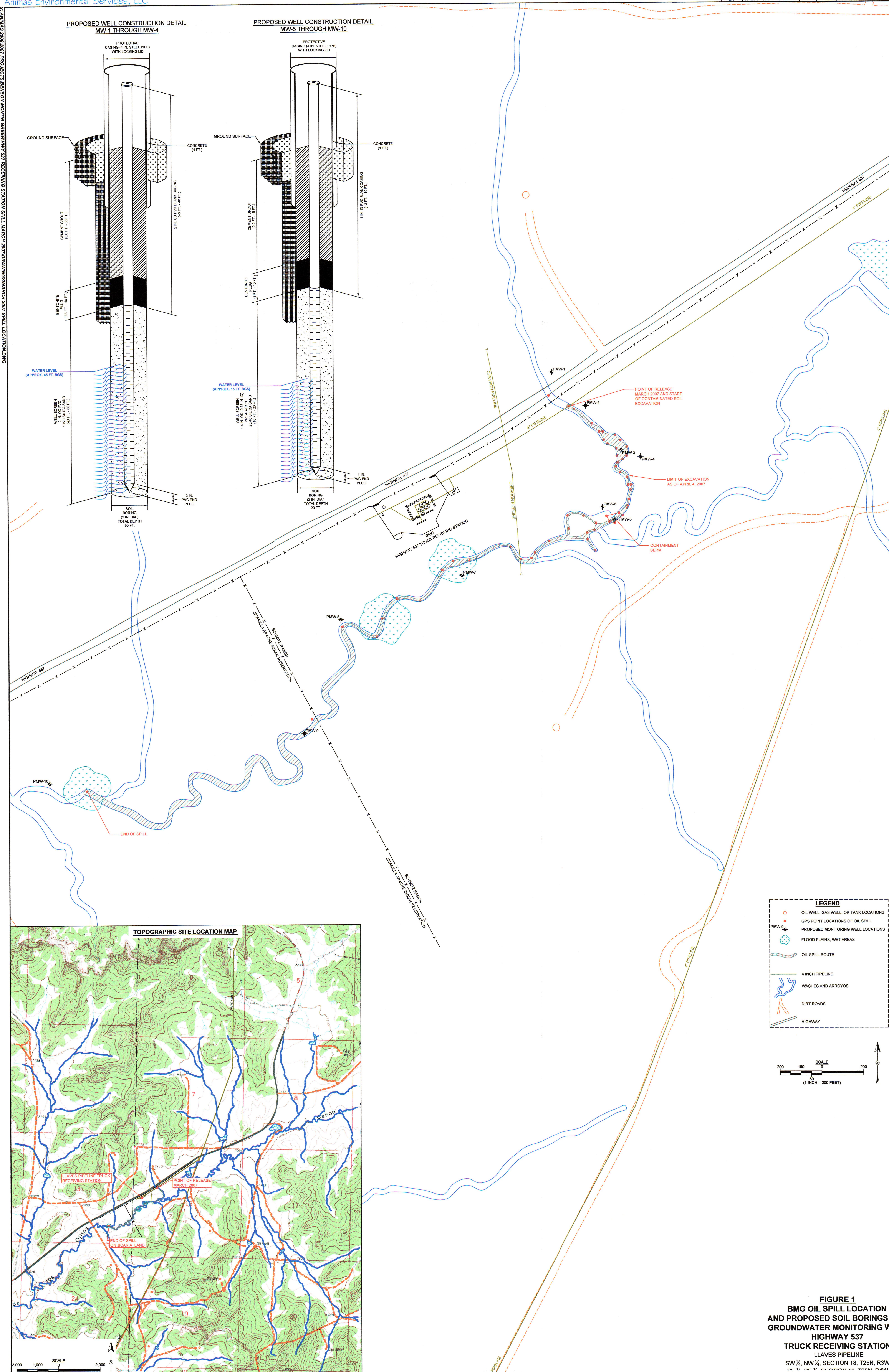
Ross Kennemer
Project Manager



Elizabeth McNally, NM PE #05799
Environmental Engineer

9.0 References

- U.S. Environmental Protection Agency (USEPA). 1982. *Methods for Chemical Analysis for Water and Wastes*. Document EPA-600, July, 1982.
- USEPA. 1992. SW-846, 3rd Edition, *Test Methods for Evaluating Solid Waste: Physical Chemical Methods*, dated November, 1986, and as amended by Update One, July, 1992.
- USEPA. 1991. *Site Characterization for Subsurface Remediation*, EPA 625/4-91-026, November, 1991.
- USEPA. 1997. *Expedited Site Assessment Tools for Underground Storage Tank Sites*. OSWER 5403G and EPA 510B-97-001, March, 1997.
- USEPA. 2001. Contract Laboratory Program (CLP) Guidance for Field Samplers. OSWER 9240.0-35, EPA 540-R-00-003. June, 2001.





Animas Environmental Services, LLC

624 E. Comanche . Farmington, NM 87401 . TEL 505-564-2281 . FAX 505-324-2022 . www.animasenvironmental.com

Site Health and Safety Plan For Site Assessment and Groundwater Monitoring and Sampling Activities

Site Name:

**Benson Montin Greer
March 2007 Highway 537 Pipeline Spill
Rio Arriba County, New Mexico**

Date:

April 6, 2007

Prepared By:

**Ross Kennemer
Health and Safety Officer**

**Animas Environmental Services, LLC.
(505) 564-2281**



Table of Contents

1.0	INTRODUCTION	1
1.1	Purpose	1
1.2	Visitors	2
2.0	KEY PERSONNEL/IDENTIFICATION OF HEALTH AND SAFETY	3
2.1	Key Personnel	3
2.2	Site Specific Health and Safety Personnel	3
2.3	Organizational Responsibility	3
3.0	TASK/OPERATION SAFETY AND HEALTH RISK ANALYSIS	4
3.1	Historical Overview of Site	4
3.1.1	<i>Spill History</i>	4
3.2	Task by Task Risk Analysis	4
3.3	PERSONAL PROTECTIVE EQUIPMENT TO BE USED	6
3.4	Reassessment of Protection Program	7
3.5	Specific Contaminants To Be Monitored At The Site	7
3.5.1	<i>Volatile Organics (Hydrocarbons)</i>	7
4.0	PERSONNEL TRAINING REQUIREMENTS	8
4.1	Pre-Assignment and Annual Refresher Training	8
4.2	Site Supervisors Training	8
5.0	DAILY TAILGATE SAFETY MEETINGS	9
6.0	SITE CONTROL MEASURES	9
6.1	Buddy System	9
6.2	Site Communications Plan	9
6.2.1	<i>Hand Signals</i>	9
6.3	Work Zone Definition	10
6.4	Emergency Alarm Procedures	10
6.4.1	<i>Standing Orders For Exclusion (Work) Zone</i>	10
6.5	Nearest Medical Assistance	10
7.0	EMERGENCY RESPONSE/CONTINGENCY PLAN	11
7.1	Evacuation Routes/Procedures	11
7.2	Emergency Contact/Notification System	12
7.3	Emergency Medical Treatment Procedures	12
7.4	Fire or Explosion	12
7.5	Spill or Leaks	13
7.6	Emergency Equipment/Facilities	13
8.0	CONFINED SPACE ENTRY PROCEDURES	13
9.0	SPILL CONTAINMENT PROGRAM	13
10.0	HAZARD COMMUNICATION	14
10.1	Container Labeling	14
10.2	Material Safety Data Sheets (MSDSs)	14
10.3	Employee Training and Information	14

Figures

1. Site Plan With Work Areas
2. Route to Nearest Medical Facility

Appendices

- Appendix A. MSDSs for Contaminants of Concern
Appendix B. Daily Tailgate Safety Meeting Record

1.0 INTRODUCTION

This site specific Health and Safety Plan has been developed for use during the assessment of Benson Montin Greer Drilling Corporation (BMG) Highway 537 oil spill, which occurred in March 2007. The spill started in the SW¼ NW¼ of Section 18, T25N, R3W and ended in the SE¼ SE¼ of Section 13, T25N, R4W, Rio Arriba County, New Mexico. Latitude and Longitude are N36° 23' 40.417" and W107° 11' 53.337".

The assessment includes the installation of 10 soil borings that will be completed as groundwater monitoring wells, as well as the collection of soil and groundwater samples (**see Figure 1 – Site Plan and Work Areas for the locations of the soil borings/monitoring wells**).

This plan has been prepared utilizing the *U.S. Environmental Protection Agency (USEPA), Office of Solid Waste and Emergency Response Health and Safety Planner Version 3.0/4.0*. During development of this plan consideration was given to current safety standards as defined by EPA/OSHA/NIOSH, health effects and standards for known contaminants, and procedures designed to account for the potential for exposure to unknown substances. Specifically, the following reference sources have been consulted:

1. OSHA 29 CFR 1910.120 and EPA 40 CFR 311
2. U.S. EPA, OERR ERT Standard Operating Safety Guides
3. NIOSH/OSHA/USCG/EPA Occ. Health and Safety Guidelines
4. (ACGIH) Threshold Limit Values

This section of the Site Health and Safety Plan (HASP) document defines general applicability and general responsibilities with respect to compliance with Health and Safety program that will be in effect during this project, which will include, but not limited to the following tasks:

1. Installation of soil borings/monitoring wells using a Hollow Stem Auger Drill Rig (CME-75) and Direct Push Drill Rig (Track-Mounted).
2. Collection of soil and groundwater samples that are contaminated with crude oil.

1.1 Purpose

The purpose of this Site Specific Health and Safety Plan is to define the requirements and designate protocols to be followed during completion of this project. Applicability and compliance with this plan extends to all government employees, contractors, subcontractors, and visitors.

Prior to entering the work areas, all personnel, government employees, contractors and subcontractors, shall be informed by the Site Safety and Health Officer (Ross Kennemer, Animas Environmental Services, LLC) of the site conditions, emergency response procedures, and any potential fire, explosion, health, or safety hazards that might be present. This HASP summarizes those hazards in Table 3.1 and 3.2.

This plan must be reviewed and an agreement to comply with the requirements must be signed by all personnel prior to entering the work area.

1.2 Visitors

All visitors, government employees, contractors and subcontractors entering the work area, which for the purposes of the plan is defined as **within 50 feet in any direction from the drilling rig or well installation as identified on Figure 1 – Site Plan and Work Areas**, will be required to fully comply with and demonstrate with appropriate documentation, without exception, the following:

1. **Site Health and Safety Officer (Site Supervisor)** – OSHA 40 hour HAZWOPER Course; current 8 hour HAZWOPER Refresher; current 8 hour Supervisor Training; and valid certificate for completion of First Aid Basics and Adult CPR.
2. **Direct Investigation (Contractors, Subcontractors, and Consultants)** – OSHA 40 hour HAZWOPER Course and current 8 hour HAZWOPER Refresher.
3. **Indirect Investigation Visitors (All Visitors and Government Employees)** – OSHA 24 hour HAZWOPER Occasional Site Worker Course and current 8 hour HAZWOPER Refresher.
4. **All Contractors, Subcontractors, Consultants, Visitors and Government Employees -**
Provide own personal protective equipment to include hard hat, safety glasses, steel-toed boots.
5. **All Contractors, Subcontractors, Consultants, Visitors and Government Employees -**
Read and verify, by signature, compliance with the provisions of this HASP

In the event that a contractor, subcontractor, consultant, visitor or government employee does not adhere to the provisions of the HASP, that individual will be requested to leave the Work Area.

2.0 KEY PERSONNEL/IDENTIFICATION OF HEALTH AND SAFETY

2.1 Key Personnel

The following personnel and organizations are critical to the planned activities at the site. The organizational structure will be reviewed and updated periodically by the site supervisor.

Ross Kennemer, Health and Safety Officer/Project Manager, Animas Environmental Services, LLC
Elizabeth McNally, PE (Environmental Engineer), Animas Environmental Services, LLC
Jim Coburn, Environmental Engineer, Animas Environmental Services, LLC

2.2 Site Specific Health and Safety Personnel

The Site Health and Safety Officer (HSO) will maintain total responsibility for ensuring that the provisions of this HASP are adequate and implemented in the field. Changing field conditions may require decisions to be made concerning adequate protection programs. Therefore, it is vital that personnel assigned as HSO be experienced and meet the additional training requirements specified by OSHA in 29 CFR 1910.120 (see Section 4.2 of this HASP). The HSO is also responsible for conducting site inspections on a regular basis in order to ensure the effectiveness of this plan.

The HSO at the site is: Ross Kennemer, AES Project Manager

Designated alternates include: Jim Coburn, AES Environmental Engineer

2.3 Organizational Responsibility

Animas Environmental Services, LLC (AES) is responsible for providing technical, regulatory, and safety assistance for all site activities.

3.0 TASK/OPERATION SAFETY AND HEALTH RISK ANALYSIS

3.1 *Historical Overview of Site*

This HASP defines the known or potential hazards and the methods to protect personnel from those hazards as identified in previous site work or background information.

3.1.1 Spill History

On March 7, 2007, Schmitz Ranch personnel observed oil leaking into the Los Ojitos Canyon Arroyo. BMG management were immediately contacted and dispatched BMG personnel to investigate. BMG personnel discovered that a small corrosion hole in the Llaves Pipeline, which runs parallel to the south side of Highway 537, was the source of the leaking oil, and the pipeline was removed from service. BMG is not able to determine the exact date that the leak began, but oil production inventory records indicate that approximately 500 barrels of oil had leaked.

On March 7, 2007, BMG reported the spill to the New Mexico Oil Conservation Division (NMOCD), and on March 8, 2007, BMG reported the spill to the USEPA and the Jicarilla Apache Nation Environmental Protection Office (JEPO).

On March 9, 2007, BMG subcontractors began removing free-oil that had pooled in low areas and also oil floating on surface water within the arroyo and livestock pond. Since March 9, 2007, spill cleanup efforts have continued five to six days per week. On March 31, 2007, with USEPA and NMOCD approval, BMG subcontractors burned as much free-oil within the arroyo as possible. Vacuum removal of residual free-oil that was not burned will continue. Also, as of April 4, 2007, approximately 8,000 cubic yards of oil contaminated soils have been excavated and transported off-site to the Schmitz Ranch Landfarm, a NMOCD permitted facility. Additionally, subcontracted environmental cleanup crews directed by JEPO have removed free-oil from the portion of the arroyo on tribal lands by vacuuming and burning.

Based on historical soil sampling analytical results for the February 2006 spill, the following compounds have been identified as Compounds of Concern (COCs) for this project:

1. Benzene
2. Toluene
3. Ethylbenzene
4. Xylenes
5. Total Petroleum Hydrocarbons (TPH)

3.2 *Task by Task Risk Analysis*

The following sections summarize an evaluation of hazards based upon the knowledge of site history as presented in Section 3.1, and anticipated risks posed by the specific operation. This list in by no means all inclusive and other unforeseen hazards may exist.

Table 1. General Chemical Hazards for all Project Tasks

SUBSTANCES INVOLVED	CONTAMINANT CONCENTRATION	INHALATION RISK	INGESTION RISK	ABSORPTION RISK
Crude Oil	Moderate	Low	Low	Low
Gasoline	NA	NA	NA	NA
Diesel	NA	NA	NA	NA
Used Oil	NA	NA	NA	NA
Grease	NA	NA	NA	NA
Solvent/Cleaners pH Approximate Range 3.5 to 11 (Irritating Liquids)	NA	NA	NA	NA
Organic Solvents	NA	NA	NA	NA
Off-Spec paint (liquid/Solid)	NA	NA	NA	NA
Tar	NA	NA	NA	NA
Polychlorinated Biphenyl (PCB)	NA	NA	NA	NA
Acids	NA	NA	NA	NA
Bases	NA	NA	NA	NA
Pesticides and Herbicides	NA	NA	NA	NA
Anti-Freeze (Glycol)	NA	NA	NA	NA

Legend:

IDLH – Immediately Dangerous to Life and Health

NA – Not Applicable

**CONSULT ATTACHED MATERIAL SAFETY DATA SHEETS (MSDS) FOR
ADDITIONAL CHEMICAL INFORMATION**

Table 2. Potential Health and Safety Hazards for all Project Tasks

PHYSICAL HAZARDS	TASK: SITE WALK THROUGH	TASK: SOIL SAMPLING	TASK: WELL INSTALLATION	TASK: GROUND WATER SAMPLING	TASK HAZARD PROTECTION METHODS
Chemical Inhalation Hazard	Low	Low	Low	NA	Wear Respirator With Organic Vapor Cartridges, if needed
Chemical Ingestion Hazard	Low	Low	Low	NA	NA
Chemical Absorption Hazard	Low	Low	Low	NA	Wear Chemical Resistant Gloves While Handling Samples
Heavy Equipment and Moving Parts	Low	High	High	Low	Avoid rotating parts
Noise	Low	Moderate	Moderate	Low	Use Ear Protection, if needed
Equipment Exhaust Vapors	Low	Moderate	Moderate	Low	Stay Away from Drilling Rig
Traffic	Low	Low	Low	Low	Wear Safety Vest and be Aware of Traffic
Heat/Cold Stress	Low	Low	Low	Low	Wear Appropriate Field Clothing
Wildlife – bites and stings	Low	Low	Low	Low	Avoid Wildlife
Head Injury	Low	High	High	Low	Wear Hard Hat
Eye Injury	Low	High	High	Low	Wear Safety Glasses With Side Shields
Hand Injury	Low	High	High	Low	Wear Appropriate Gloves and Watch Where You put Your Hands
Foot Injury	Low	High	High	Low	Wear Steel Toed Boots

3.3 PERSONAL PROTECTIVE EQUIPMENT TO BE USED

Field work to be completed during the field investigation will require **Level D Protection**.

Level D Personnel Protective Equipment

1. Coveralls (if needed)
2. Gloves
3. Boots/shoes, leather or chemical-resistant, steel toe and shank
4. Safety glasses
5. Hard hat

3.4 Reassessment of Protection Program

The Level of Protection provided by PPE selection shall be upgraded or downgraded based upon a change in site conditions or findings of investigations.

When a significant change occurs, the hazards should be reassessed. Some indicators of the need for reassessment are:

1. Commencement of a new work phase, such as the start of drum sampling or work that begins on a different portion of the site.
2. Change in job tasks during a work phase.
3. Change of season/weather.
4. When temperature extremes or individual medical considerations limit the effectiveness of PPE.
5. Contaminants other than those previously identified are encountered.
6. Change in ambient levels of contaminants.
7. Change in work scope which affects the degree of contact with contaminants.
8. Commencement of a new work phase, such as the start of drum sampling or work that begins on a different portion of the site.
9. Change in job tasks during a work phase.
10. Change of season/weather.
11. When temperature extremes or individual medical considerations limit the effectiveness of PPE.
12. Contaminants other than those previously identified are encountered.
13. Change in ambient levels of contaminants.
14. Change in work scope which affects the degree of contact with contaminants.

3.5 Specific Contaminants To Be Monitored At The Site

The following provides a summary of the contaminants to be monitored for and frequency/schedule of monitoring. The air sampling checklist will serve as a site monitoring plan.

3.5.1 Volatile Organics (Hydrocarbons)

Air Monitoring Instruments

PID-OVM

Frequency : Regularly, during well installation

Locations : Within 5 feet of the bore hole

Action Levels

Organic gases and vapors:

Action Level: 50 ppm ambient

Action: Stop drilling and reassess PPE.

Reporting Format

Field data sheets

4.0 PERSONNEL TRAINING REQUIREMENTS

Consistent with OSHA's 29 CFR 1910.120 regulation covering Hazardous Waste Operations and Emergency Response, all **site personnel, including visitors**, are required to be trained in accordance with the standard. At a minimum all personnel are required to be trained to recognize the hazards on-site, the provisions of this HASP, and the responsible personnel. All visitors, government employees, contractors and subcontractors entering the work area, which for the purposes of the plan is defined as **within 50 feet in any direction of the drilling rig as "Work AREA" as identified on Figure 1 – Site Plan and Work Areas**, will be required to fully comply with and demonstrate with appropriate documentation, without exception, the following:

1. **Site Health and Safety Officer (Site Supervisor)** – OSHA 40 hour HAZWOPER Course; current 8 hour HAZWOPER Refresher; current 8 hour Supervisor Training; and valid certificate for completion of First Aid Basics and Adult CPR.
2. **Direct Investigation (Contractors, Subcontractors, and Consultants)** – OSHA 40 hour HAZWOPER Course and current 8 hour HAZWOPER Refresher.
3. **Indirect Investigation Visitors (All Visitors and Government Employees)** – OSHA 24 hour HAZWOPER Occasional Site Worker Course and current 8 hour HAZWOPER Refresher.

In the event that a contractor, subcontractor, consultant, visitor or government employee does not adhere to the provisions of the HASP, that individual will be requested to leave the Exclusion Area.

4.1 *Pre-Assignment and Annual Refresher Training*

Prior to arrival on site, visitors, government employees, contractors and subcontractors and each employer will be responsible for certifying that his/her employees or representatives meet the requirements of pre-assignment training, consistent with OSHA 29 CFR 1910.120 paragraph (e)(3). The employer should be able to provide a document certifying that each general site worker has received 40 hours of instruction off the site, and 24 hours of training for any workers who are on site only occasionally for a specific task. If an individual employee has work experience and/or training that is equivalent to that provided in the initial training, an employer may waive the 40-hour training so long as that equivalent experience is documented or certified. All personnel must also receive 8 hours of refresher training annually.

4.2 *Site Supervisors Training*

Consistent with OSHA 29 CFR 1910.120 paragraph (e)(8), individuals designated as site supervisors require an additional 8 hours of training. The following individuals are identified as site supervisors:

Ross Kennemer, AES Project Manager

5.0 DAILY TAILGATE SAFETY MEETINGS

At a minimum, prior to beginning work each day, a daily tailgate safety meeting will be held. All contractors, subcontractors, consultants, visitors, and government employees are expected to attend and actively participate in these safety meetings. The following items are examples that might be discussed by the site supervisor or other personnel:

1. Air Monitoring
2. Chemical hazards
3. Emergency response plan
4. Engineering controls and work practices
5. Personnel protective equipment
6. Physical hazards
7. Respiratory protection
8. Site Control
9. Symptoms of overexposure to hazards
10. Tool Safety
11. Training requirements

6.0 SITE CONTROL MEASURES

The following section defines measures and procedures for maintaining site control. Site control is an essential component in the implementation of the site health and safety program.

6.1 *Buddy System*

During all Level D activities or when some conditions present a risk to personnel, the implementation of a buddy system is mandatory. A buddy system requires at least two people who work as a team; each looking out for each other.

6.2 *Site Communications Plan*

Successful communications between field teams and contact with personnel in the support zone is essential. The following communications systems will be available during activities at the Site.

6.2.1 Hand Signals

Signal	Definition
Hands clutching throat	Out of air/cannot breath
Hands on top of head	Need assistance
Thumbs up	OK/I am all right/I understand
Thumbs down	No/negative
Arms waving upright	Send backup support
Grip partners wrist	Exit area immediately

6.3 Work Zone Definition

The two general work zones established at the Site are the Exclusion Zone and the Support Zone. Figure 1 provides a site map with the work zones designated on it.

The Exclusion Zone is defined as the area where contamination is either known or likely to be present, or because of activity, will provide a potential to cause harm to personnel. Entry into the Exclusion Zone requires the use of, at minimum, Level D personnel protective equipment.

The Support Zone is situated in clean areas where the chance to encounter hazardous materials or conditions is minimal. Personal protective equipment is therefore not required.

6.4 Emergency Alarm Procedures

Evacuation Routes and Procedures will be deployed in the event of an emergency. Communication signals will also be used according to Section 6.2.1.

Table 3. Personnel Requirements

Task	Control Measures	Comments
Site Walk Through	Line of Sight	
Groundwater Monitoring and Sampling	Line of Sight	

6.4.1 Standing Orders For Exclusion (Work) Zone

- No smoking, eating, or drinking in this zone.
- No horse play.
- No matches or lighters in this zone.
- Check-in on entrance to this zone.
- Check-out on exit from this zone.
- Implement the communications system.
- Line of sight must be in position.

**Wear the appropriate level of protection as defined in the Safety Plan.
Level D is anticipated for all site activities**

6.5 Nearest Medical Assistance

The route to the nearest hospital should be verified by the HSO, and should be familiar to all site personnel. The following individuals on site have current certification in CPR and/or first aid:

1. Ross Kennemer, AES Project Coordinator **Cellular Phone: (505) 486-1776**
2. Jim Coburn, AES Environmental Engineer (Alternate) **Cellular Phone: (505) 486-2859**

Nearest medical assistance is located at:

1. San Juan Regional Medical Center – 130 miles north of the site located at: 801 West Maple Street, Farmington, NM. Call 911, or (505) 325-5011 (see Figure 2 for route). Note - Air Ambulance is available with the following coordinates: Latitude and Longitude are N36° 29' 44.726" and W106° 50' 14.072".

7.0 EMERGENCY RESPONSE/CONTINGENCY PLAN

7.1 *Evacuation Routes/Procedures*

In the event of an emergency which necessitates an evacuation of the site, the following alarm procedures will be implemented:

1. Evacuation alarm notification should be made using three short blasts on the air horn or car horn.
2. All personnel should evacuate to a predetermined location upwind of any activities. The location will be determined each day prior to beginning activities.
3. Insure that a predetermined location is identified off-site in case of an emergency, so that all personnel can be accounted for.
4. Personnel will be expected to proceed to the closest exit with your buddy, and mobilize to the safe distance area associated with the evacuation route. Personnel will remain at that area until the re-entry alarm is sounded or an authorized individual provides further instructions.

Table 4. Emergency Recognition/Control Measures

HAZARD	PREVENTION/CONTROL	LOCATION
Fire/Explosion	Fire Extinguisher	Site Supervisor Vehicle

7.2 Emergency Contact/Notification System

The following list provides names and telephone numbers for emergency contact personnel. In the event of a medical emergency, personnel will take direction from the HSO and notify the appropriate emergency organization. In the event of a fire or spill, the site supervisor will notify the appropriate local, state, and federal agencies.

Organization	Telephone
Ambulance	911
Police	911
Fire	911
State Police	911
Hospital 1	911
Poison Control Center	1 800 432 6866
National Response Center	800-424-8802
Center for Disease Control	404-488-4100
Chemtrec	800-424-9555

7.3 Emergency Medical Treatment Procedures

Any person who becomes ill or injured in the exclusion zone must be decontaminated to the maximum extent possible. If the injury or illness is minor, full decontamination should be completed and first aid administered prior to transport. If the patient's condition is serious, at least partial decontamination should be completed (i.e., complete disrobing of the victim and redressing in clean coveralls or wrapping in a blanket.) First aid should be administered while awaiting an ambulance or paramedics. All injuries and illnesses must immediately be reported to the project manager. Any person being transported to a clinic or hospital for treatment should take with them information on the chemical(s) they have been exposed to at the site. This information is included in the MSDS Sheets

7.4 Fire or Explosion

In the event of a fire or explosion, the local fire department should be summoned immediately. Upon their arrival, the project manager or designated alternate will advise the fire commander of the location, nature, and identification of the hazardous materials on site. If it is safe to do so, site personnel may:

1. Use fire fighting equipment available on site to control or extinguish the fire; and,
2. Remove or isolate flammable or other hazardous materials which may contribute to the fire.

7.5 Spill or Leaks

In the event of a spill or a leak, site personnel will:

1. Inform their supervisor immediately;
2. Locate the source of the spillage and stop the flow if it can be done safely; and,
3. Begin containment and recovery of the spilled materials

7.6 Emergency Equipment/Facilities

The following emergency equipment is located in the Site Supervisor's vehicle:

- First aid kit
- Fire extinguisher
- Site telephone
- Mobile telephone
- Spill kits
- Eye wash

8.0 CONFINED SPACE ENTRY PROCEDURES

NO CONFINED SPACE ENTRY ACTIVITIES are planned as part of site activities. A confined space provides the potential for unusually high concentrations of contaminants, explosive atmospheres, limited visibility, and restricted movement. This section will establish requirements for safe entry into, continued work in, and safe exit from confined spaces. Additional information regarding confined space entry can be found in 29 CFR 1926.21, 29 CFR 1910 and NIOSH 80-106.

9.0 SPILL CONTAINMENT PROGRAM

The procedures defined in this section comprise the spill containment program in place for activities at the Site.

1. All drums and containers used during the clean-up shall meet the appropriate DOT, OSHA, and EPA regulators for the waste that they will contain.
2. Drums and containers shall be inspected and their integrity assured prior to being moved. Drums or containers that cannot be inspected before being moved because of storage conditions shall be positioned in an accessible location and inspected prior to further handling.
3. Operations on site will be organized so as to minimize the amount of drum or container movement.
4. Employees involved in the drum or container operations shall be warned of the hazards associated with the containers.
5. Where spills, leaks, or ruptures may occur, adequate quantities of spill containment equipment (absorbent, pillows, etc.) will be stationed in the immediate area. The spill containment program must be sufficient to contain and isolate the entire volume of hazardous substances being transferred.
6. Drums or containers that cannot be moved without failure, shall be emptied into a sound container.

7. Fire extinguishing equipment meeting 29 CFR part 1910 Subpart 1 shall be on hand and ready for use to control fires.

10.0 HAZARD COMMUNICATION

In order to comply with 29 CFR 1910.1200, Hazard Communication, the following written Hazard Communication Program has been established. All employees will be briefed on this program, and have a written copy for review.

10.1 Container Labeling

All containers received on site will be inspected to ensure the following: (1) all containers will be clearly labeled as to the contents; (2) the appropriate hazard warnings will be noted; and (3) the name and address of the manufacturer will be listed.

All secondary containers will be labeled with either an extra copy of the original manufacturer's label or with generic labels which have a block for identify and blocks for the hazard warning.

10.2 Material Safety Data Sheets (MSDSs)

Copies of MSDSs for all chemicals of concern known or suspected on site are provided in Appendix A. MSDSs should be reviewed by all employees and visitors.

10.3 Employee Training and Information

Prior to starting work, each employee will attend a health and safety orientation and will receive information and training on the following:

1. An overview of the requirements contained in the Hazard Communication Standard, 29 CFR 1910.1200;
2. Chemicals present in their workplace operations;
3. Location and availability of a written hazard program;
4. Physical and health effects of the hazardous chemicals;
5. Methods and observation techniques used to determine the presence or release of hazardous chemicals;
6. How to lessen or prevent exposure to these hazardous chemicals through usage of control/work practices and personal protective equipment;
7. Emergency procedures to follow if they are exposed to these chemicals;
8. How to read labels and review MSDSs to obtain appropriate hazard information;
9. Location of MSDS file and location of hazardous chemical list.

DRAWN BY	NCW	CHECKED BY APPROVED BY	EM	04-10-07	REVISIONS	
					BY: Nathan	DATE: 04-10-07

Animas Environmental Services, LLC

FIGURE 1 **GENERAL SITE PLAN WITH** **WORK ZONES** **BMG HIGHWAY 537 TRUCK** **RECEIVING STATION**

LLAVES PIPELINE

SW ¼, NW ¼, SECTION 18, T25N, R3W
SE ¼, SE ¼, SECTION 13, T25N, R4W
RIO ARRIBA COUNTY, NEW MEXICO

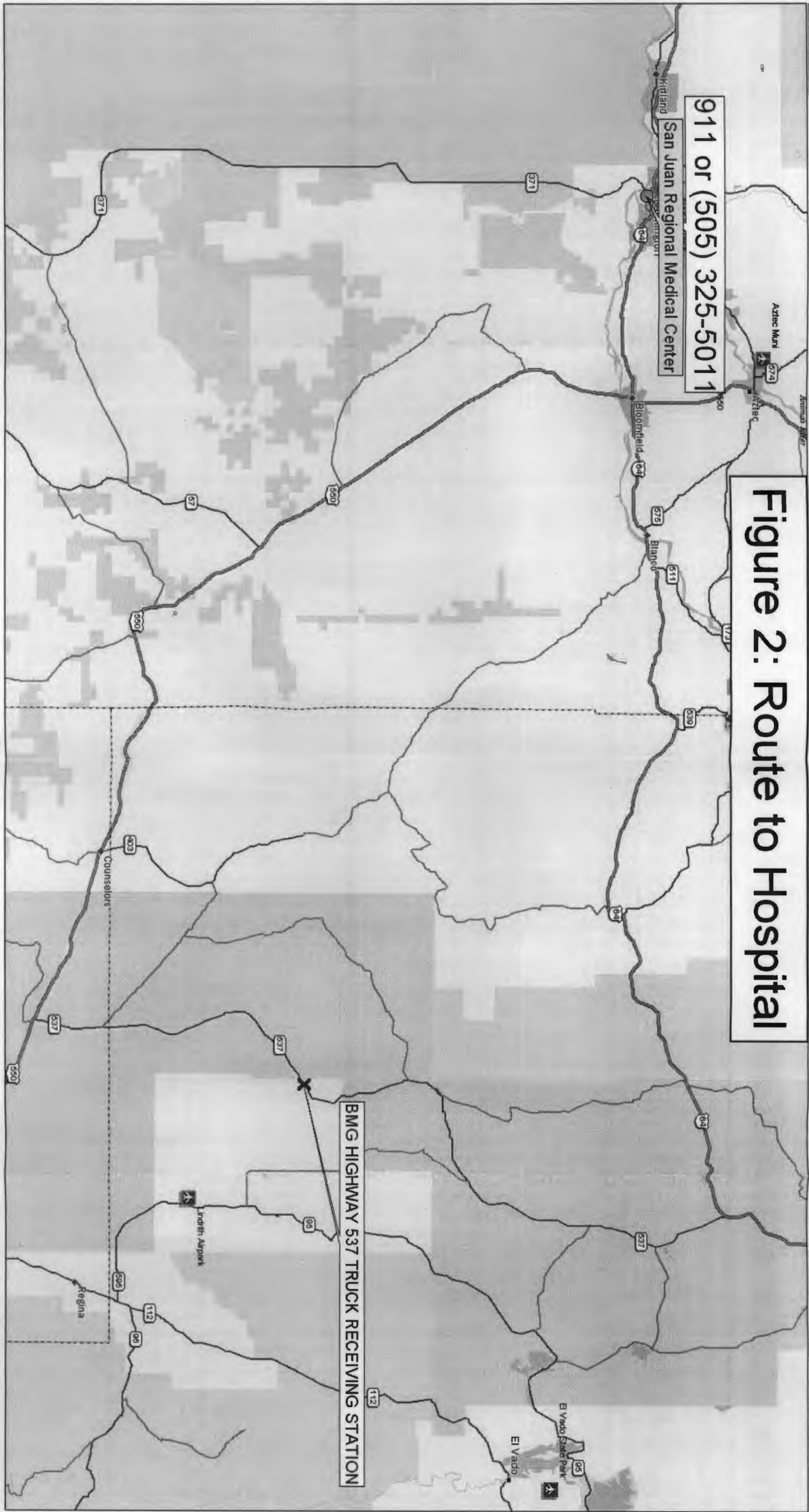
S:\ANIMAS 2000\2007 PROJECTS\BENSON MONTIN GREER\HWY 537 RECEIVING STATION SPILL MARCH 2007\ASPI\FIGURE 1 GENERAL SITE PLAN WITH WORK ZONES.DWG



LEGEND

- OIL WELL, GAS WELL, OR TANK LOCATIONS
- GPS POINT LOCATIONS OF OIL SPILL
- PROPOSED MONITORING WELL LOCATIONS
- WORK ZONES
- FLOOD PLAINS, WET AREAS
- OIL SPILL ROUTE
- 4 INCH PIPELINE
- WASHES AND ARROYOS
- DIRT ROADS
- HIGHWAY

Figure 2: Route to Hospital



911 or (505) 325-5011

San Juan Regional Medical Center

BMG HIGHWAY 537 TRUCK RECEIVING STATION

Data use subject to license.
© 2006 Delorme. Street Atlas USA® 2007.
www.delorme.com

0 2 4 6 8 10
miles
Data Zoom 8-7



MATERIAL SAFETY DATA SHEET

Crude Oil (sweet)

MSDS No. 6607

EMERGENCY OVERVIEW

CAUTION!

**FLAMMABLE LIQUID - SLIGHT TO MODERATE IRRITANT - EFFECTS
CENTRAL NERVOUS SYSTEM - HARMFUL OR FATAL IF SWALLOWED**

High fire hazard. Keep away from heat, spark, open flame, and other ignition sources.

If ingested, do NOT induce vomiting, as this may cause chemical pneumonia (fluid in the lungs). Contact may cause eye, skin and mucous membrane irritation. Avoid prolonged breathing of vapors or mists. Inhalation may cause irritation, anesthetic effects (dizziness, nausea, headache, intoxication), and respiratory system effects.

Long-term exposure may cause effects to specific organs, such as to the liver, kidneys, blood, nervous system, and skin. Contains benzene, which can cause blood disease, including anemia and leukemia.



NFPA 704 (Section 16)

1. CHEMICAL PRODUCT AND COMPANY INFORMATION

Hess Corporation
1 Hess Plaza
Woodbridge, NJ 07095-0961

EMERGENCY TELEPHONE NUMBER:
COMPANY CONTACT (business hours):
MSDS Internet Website:

CHEMTREC (800) 424-9300
Corporate EHS 732-750-6000
www.hess.com

SYNONYMS: Crude Petroleum; Sour Crude
See Section 16 for abbreviations and acronyms.

2. COMPOSITION and CHEMICAL INFORMATION ON INGREDIENTS

INGREDIENT NAME (CAS No.)	CONCENTRATION PERCENT BY WEIGHT
Petroleum Oil (8002-05-9)	100
Benzene (71-43-2)	Variable AP 0.1 to 1.0

A natural product derived from various oil production field primarily consisting of a complex combination of paraffinic and aromatic hydrocarbons and small amounts of nitrogen and sulfur compounds.

3. HAZARDS IDENTIFICATION

EYES

Contact with eyes may cause moderate to severe irritation.

SKIN

Practically non-toxic if absorbed following acute (single) exposure. May cause skin irritation with prolonged or repeated contact. Liquid may be absorbed through the skin in toxic amounts if large areas of skin are exposed repeatedly. Rare, precancerous warts on the forearms, backs of hands and scrotum have been reported from prolonged or repeated skin contact.

INGESTION



MATERIAL SAFETY DATA SHEET

Crude Oil (sweet)

MSDS No. 6607

The major health threat of ingestion occurs from the danger of aspiration (breathing) of liquid drops into the lungs, particularly from vomiting. Aspiration may result in chemical pneumonia (fluid in the lungs), severe lung damage, respiratory failure and even death.

Ingestion may cause gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous system (brain) effects similar to alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest, and death may occur.

INHALATION

Excessive exposure may cause irritations to the nose, throat, lungs and respiratory tract. Central nervous system (brain) effects may include headache, dizziness, loss of balance and coordination, unconsciousness, coma, respiratory failure, and death.

CHRONIC and CARCINOGENICITY

Similar products produced skin cancer and systemic toxicity in laboratory animals following repeated applications. This product contains polynuclear aromatic hydrocarbons which have been shown to be carcinogenic in laboratory animals after repeated and prolonged skin contact. The significance of these results to human exposures has not been determined - see Section 11, Toxicological Information.

Contains benzene, a regulated human carcinogen. Benzene has the potential to cause anemia and other blood diseases, including leukemia, after repeated and prolonged exposure.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE

Irritation from skin exposure may aggravate existing open wounds, skin disorders, and dermatitis (rash). Pre-existing, chronic respiratory disease, liver or kidney dysfunction, or central nervous system disorders may be aggravated by exposure.

4. FIRST AID MEASURES

EYES

In case of contact with eyes, immediately flush with clean, low-pressure water for at least 15 min. Hold eyelids open to ensure adequate flushing. Seek medical attention.

SKIN

Remove contaminated clothing. Wash contaminated areas thoroughly with soap and water or waterless hand cleanser. Obtain medical attention if irritation or redness develops. Thermal burns require immediate medical attention depending on the severity and the area of the body burned.

INGESTION

DO NOT INDUCE VOMITING. Do not give liquids. Obtain immediate medical attention. If spontaneous vomiting occurs, lean victim forward to reduce the risk of aspiration. Monitor for breathing difficulties. Small amounts of material which enter the mouth should be rinsed out until the taste is dissipated.

INHALATION

Remove person to fresh air. If person is not breathing provide artificial respiration. If necessary, provide additional oxygen once breathing is restored if trained to do so. Seek medical attention immediately.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES:

FLASH POINT:	< 73 to > 200 °F (< 23 to > 93 °C)
AUTOIGNITION TEMPERATURE:	N/D
OSHA/NFPA FLAMMABILITY CLASS:	1B (flammable liquid)
LOWER EXPLOSIVE LIMIT (%):	N/D
UPPER EXPLOSIVE LIMIT (%):	N/D

FIRE AND EXPLOSION HAZARDS



MATERIAL SAFETY DATA SHEET

Crude Oil (sweet)

MSDS No. 6607

Flash point and explosive limits are highly dependent on the crude oil source. Treat as an OSHA/NFPA flammable liquid unless otherwise indicated. Vapors may be ignited rapidly when exposed to heat, spark, open flame or other source of ignition. When mixed with air and exposed to an ignition source, flammable vapors can burn in the open or explode in confined spaces. Being heavier than air, vapors may travel long distances to an ignition source and flash back. Runoff to sewer may cause fire or explosion hazard.

EXTINGUISHING MEDIA

SMALL FIRES: Any extinguisher suitable for Class B fires, dry chemical, CO₂, water spray, fire fighting foam, or Halon.

LARGE FIRES: Water spray, fog or fire fighting foam. Water may be ineffective for fighting the fire, but may be used to cool fire-exposed containers.

FIRE FIGHTING INSTRUCTIONS

Small fires in the incipient (beginning) stage may typically be extinguished using handheld portable fire extinguishers and other fire fighting equipment.

Firefighting activities that may result in potential exposure to high heat, smoke or toxic by-products of combustion should require NIOSH/MSHA- approved pressure-demand self-contained breathing apparatus with full facepiece and full protective clothing.

Isolate area around container involved in fire. Cool tanks, shells, and containers exposed to fire and excessive heat with water. For massive fires the use of unmanned hose holders or monitor nozzles may be advantageous to further minimize personnel exposure. Major fires may require withdrawal, allowing the tank to burn. Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied fire fighting foam.

See Section 16 for the NFPA 704 Hazard Rating.

6. ACCIDENTAL RELEASE MEASURES

ACTIVATE FACILITY SPILL CONTINGENCY or EMERGENCY PLAN.

Evacuate nonessential personnel and remove or secure all ignition sources. Consider wind direction; stay upwind and uphill, if possible. Evaluate the direction of product travel, diking, sewers, etc. to confirm spill areas. Product may release substantial amounts of flammable vapors and gases (e.g., methane, ethane, and propane), at or below ambient temperature depending on source and process conditions and pressure.

Carefully contain and stop the source of the spill, if safe to do so. Protect bodies of water by diking, absorbents, or absorbent boom, if possible. Do not flush down sewer or drainage systems, unless system is designed and permitted to handle such material. The use of fire fighting foam may be useful in certain situations to reduce vapors. The proper use of water spray may effectively disperse product vapors or the liquid itself, preventing contact with ignition sources or areas/equipment that require protection - do not discharge solid water stream patterns into the liquid resulting in splashing.

Take up with sand or other oil absorbing materials. Carefully shovel, scoop or sweep up into a waste container for reclamation or disposal. Response and clean-up crews must be properly trained and must utilize proper protective equipment (see Section 8).

7. HANDLING and STORAGE

HANDLING and STORAGE PRECAUTIONS

Handle as a flammable liquid. Keep away from heat, sparks, and open flame! Electrical equipment should be approved for classified area. Bond and ground containers during product transfer to reduce the possibility of static-initiated fire or explosion.



MATERIAL SAFETY DATA SHEET

Crude Oil (sweet)

MSDS No. 6607

STORAGE PRECAUTIONS

Keep away from flame, sparks, excessive temperatures and open flame. Use approved vented containers. Keep containers closed and clearly labeled. Empty product containers or vessels may contain explosive vapors. Do not pressurize, cut, heat, weld or expose such containers to sources of ignition.

Store in a well-ventilated area. This storage area should comply with NFPA 30 "Flammable and Combustible Liquid Code". Avoid storage near incompatible materials. The cleaning of tanks previously containing this product should follow API Recommended Practice (RP) 2013 "Cleaning Mobile Tanks In Flammable and Combustible Liquid Service" and API RP 2015 "Cleaning Petroleum Storage Tanks".

Hydrogen sulfide may accumulate in tanks and bulk transport compartments. Consider appropriate respiratory protection (see Section 8). Stand upwind. Avoid vapors when opening hatches and dome covers. Confined spaces should be ventilated prior to entry.

WORK/HYGIENIC PRACTICES

Emergency eye wash capability should be available in the near proximity to operations presenting a potential splash exposure. Use good personal hygiene practices. Avoid repeated and/or prolonged skin exposure. Wash hands before eating, drinking, smoking, or using toilet facilities. Do not use as a cleaning solvent on the skin. Do not use gasoline or solvents (naphtha, kerosene, etc.) for washing this product from exposed skin areas. Waterless hand cleaners are effective. Promptly remove contaminated clothing and launder before reuse. Use care when laundering to prevent the formation of flammable vapors which could ignite via washer or dryer. Consider the need to discard contaminated leather shoes and gloves.

Naturally Occurring Radioactive Materials (NORM):

Industry experience indicates that this material may contain small amounts of naturally-occurring uranium, thorium, and their decay products (NORM) which can accumulate in oil production and process equipment, particularly the equipment handling the water associated with crude oil production. Scales, other deposits, and sludges from this equipment may have a significant accumulation of NORM. Gamma radiation above background may be detected external to equipment contaminated with NORM. Production equipment should be assessed for external gamma radiation; access may need to be restricted in accordance with OSHA 29 CFR 1910.96 during operation. Such equipment should also be assumed to be internally contaminated with long half-life decay products that emit alpha radiation, which is a hazard if inhaled or ingested. Unless measurements indicate otherwise, steps should be taken to minimize skin and inhalation exposure to NORM dusts/mists by wearing personal protective clothing [such as disposable Tyvek® (DuPont)], utilizing respiratory protection (minimum of HEPA filter), and practicing good personal hygiene. Please refer to API Bulletin E2, "Bulletin on Management of Naturally Occurring Radioactive Materials in Oil and Gas Production," April 1, 1992, for additional information on managing NORM.

8. EXPOSURE CONTROLS and PERSONAL PROTECTION

EXPOSURE LIMITS

Components (CAS No.)		Source	Exposure Limits		Note
			TWA/STEL		
Petroleum Oil (8002-05-9)		OSHA ACGIH	PEL = 5 mg/m3 as mineral oil mist TLV = 5 mg/m3 as mineral oil mist Note: Sum of 15-NTP polynuclear aromatic hydrocarbons 0.005 mg/m3		A1
Benzene	(71-43-2)	OSHA ACGIH	PEL = 1ppm; STEL = 5 ppm TLV = 0.5 ppm; STEL = 2.5 ppm		A1; skin; BEI

ENGINEERING CONTROLS



MATERIAL SAFETY DATA SHEET

Crude Oil (sweet)

MSDS No. 6607

Use adequate ventilation to keep vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces.

EYE/FACE PROTECTION

Safety glasses or goggles are recommended where there is a possibility of splashing or spraying.

SKIN PROTECTION

Gloves constructed of nitrile or neoprene are recommended. Chemical protective clothing such as of E.I. DuPont Tyvek-Saranex 23®, Tychem®, Barricade® or equivalent recommended based on degree of exposure. Note: The resistance of specific material may vary from product to product as well as with degree of exposure. Consult manufacturer specifications for further information.

RESPIRATORY PROTECTION

A NIOSH/MSHA-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed exposure limits or for odor or irritation. Protection provided by air-purifying respirators is limited. Refer to OSHA 29 CFR 1910.134, ANSI Z88.2-1992, NIOSH Respirator Decision Logic, and the manufacturer for additional guidance on respiratory protection selection.

Use a positive pressure, air-supplied respirator if there is a potential for uncontrolled release, exposure levels are not known, in oxygen-deficient atmospheres, or any other circumstance where an air-purifying respirator may not provide adequate protection.

9. PHYSICAL and CHEMICAL PROPERTIES

APPEARANCE

Variable depending on its source; typical is a thick, dark yellow to brown or greenish black liquid

ODOR

A characteristic, petroleum/asphalt-type odor

BASIC PHYSICAL PROPERTIES

The properties of crude oil are highly variable depending on its source.

BOILING RANGE: AP 100 - 1000+ °F
VAPOR PRESSURE: Variable
VAPOR DENSITY (air = 1): 3 - 5 typical
SPECIFIC GRAVITY (H₂O = 1): AP 0.7 to 0.9 (varies)
PERCENT VOLATILES: Variable
EVAPORATION RATE: Variable
SOLUBILITY (H₂O): Insoluble to slightly soluble

10. STABILITY and REACTIVITY

STABILITY: Stable. Hazardous polymerization will not occur.

CONDITIONS TO AVOID and INCOMPATIBLE MATERIALS

Material is stable under normal conditions. Avoid high temperatures, open flames, sparks, welding, smoking and other ignition sources. Keep away from strong oxidizers.

HAZARDOUS DECOMPOSITION PRODUCTS

Carbon monoxide, carbon dioxide and non-combusted hydrocarbons (smoke).

11. TOXICOLOGICAL PROPERTIES

CHRONIC EFFECTS AND CARCINOGENICITY

Carcinogenicity: OSHA: NO IARC: NO NTP: NO ACGIH: 1997 NOIC: A1



MATERIAL SAFETY DATA SHEET

Crude Oil (sweet)

MSDS No. 6607

Dermal carcinogenicity: positive - mice

Studies have shown that similar products produce skin tumors in laboratory animals following repeated applications without washing or removal. The significance of this finding to human exposure has not been determined. Other studies with active skin carcinogens have shown that washing the animal's skin with soap and water between applications reduced tumor formation.

This product contains benzene. Human health studies indicate that prolonged and/or repeated overexposure to benzene may cause damage to the blood-forming system (particularly bone marrow), and serious blood disorders such as aplastic anemia and leukemia. Benzene is listed as a human carcinogen by the NTP, IARC, OSHA and ACGIH.

MUTAGENICITY (genetic effects)

Some crude oils and crude oil fractions have been positive in mutagenicity studies.

12. ECOLOGICAL INFORMATION

Keep out of sewers, drainage areas, and waterways. Report spills and releases, as applicable, under Federal and State regulations.

13. DISPOSAL CONSIDERATIONS

Consult federal, state and local waste regulations to determine appropriate disposal options.

14. TRANSPORTATION INFORMATION

DOT PROPER SHIPPING NAME:	PETROLEUM CRUDE OIL
DOT HAZARD CLASS and PACKING GROUP:	3, (Determine FP to accurately determine packing group)
DOT IDENTIFICATION NUMBER:	UN 1267
DOT SHIPPING LABEL:	FLAMMABLE LIQUID

PLACARD:



15. REGULATORY INFORMATION

U.S. FEDERAL, STATE, and LOCAL REGULATORY INFORMATION

Any spill or uncontrolled release of this product, including any substantial threat of release, may be subject to federal, state and/or local reporting requirements. This product and/or its constituents may also be subject to other regulations at the state and/or local level. Consult those regulations applicable to your facility/operation.

CLEAN WATER ACT (OIL SPILLS)

Any spill or release of this product to "navigable waters" (essentially any surface water, including certain wetlands) or adjoining shorelines sufficient to cause a visible sheen or deposit of a sludge or emulsion must be reported immediately to the National Response Center (1-800-424-8802) as required by U.S. Federal Law. Also contact appropriate state and local regulatory agencies as required.

CERCLA SECTION 103 and SARA SECTION 304 (RELEASE TO THE ENVIRONMENT)

The CERCLA definition of hazardous substances contains a "petroleum exclusion" clause which exempts crude oil, refined, and unrefined petroleum products and any indigenous components of such. However, other federal reporting requirements (e.g., SARA Section 304 as well as the Clean Water Act if the spill occurs on navigable waters) may still apply.

SARA SECTION 311/312 - HAZARD CLASSES

<u>ACUTE HEALTH</u>	<u>CHRONIC HEALTH</u>	<u>FIRE</u>	<u>SUDDEN RELEASE OF PRESSURE</u>	<u>REACTIVE</u>
---------------------	-----------------------	-------------	-----------------------------------	-----------------

**MATERIAL SAFETY DATA SHEET****Crude Oil (sweet)****MSDS No. 6607**

X

X

X

--

--

SARA SECTION 313 - SUPPLIER NOTIFICATION

This product contains the following toxic chemicals subject to the reporting requirements of section 313 of the Emergency Planning and Community Right-To-Know Act (EPCRA) of 1986 and of 40 CFR 372:

INGREDIENT NAME	CONCENTRATION PERCENT BY WEIGHT
Benzene CAS NUMBER: 71-43-2	< 0.1 to 2

CANADIAN REGULATORY INFORMATION (WHMIS)

Class B, Division 2 (flammable liquid)

Class D, Division 1B (Very toxic by other means)

CALIFORNIA PROPOSITION 65 LIST OF CHEMICALS

This product contains the following chemicals that are included on the Proposition 65 "List of Chemicals" required by the California Safe Drinking Water and Toxic Enforcement Act of 1986:

INGREDIENT NAME (CAS NUMBER)	Date Listed
Benzene	2/27/1987

NFPA® HAZARD RATING	HEALTH:	1
	FIRE:	3
	REACTIVITY:	0

Refer to NJPA 704 "Identification of the Fire Hazards of Materials" for further information

HMIS® HAZARD RATING	HEALTH:	1 *	Slight
	FIRE:	3	Moderate
	Physical:	0	Negligible
			* Chronic

SUPERSEDES MSDS DATED: 01/27/1999**ABBREVIATIONS:**

AP = Approximately < = Less than > = Greater than
N/A = Not Applicable N/D = Not Determined ppm = parts per million

ACRONYMS:

ACGIH	American Conference of Governmental Industrial Hygienists	MSHA	Mine Safety and Health Administration
AIHA	American Industrial Hygiene Association	NFPA	National Fire Protection Association (617)770-3000
ANSI	American National Standards Institute (212) 642-4900	NIOSH	National Institute of Occupational Safety and Health
API	American Petroleum Institute (202) 682-8000	NOIC	Notice of Intended Change (proposed change to ACGIH TLV)
CERCLA	Comprehensive Emergency Response, Compensation, and Liability Act	NTP	National Toxicology Program
DOT	U.S. Department of Transportation [General info: (800) 467-4922]	OPA	Oil Pollution Act of 1990
EPA	U.S. Environmental Protection Agency	OSHA	U.S. Occupational Safety & Health Administration
HMIS	Hazardous Materials Information System	PEL	Permissible Exposure Limit (OSHA)
IARC	International Agency For Research On Cancer	RCRA	Resource Conservation and Recovery Act
		REL	Recommended Exposure Limit (NIOSH)



MATERIAL SAFETY DATA SHEET

Crude Oil (sweet)

MSDS No. 6607

SARA	Superfund Amendments and Reauthorization Act of 1986 Title III	TLV	Threshold Limit Value (ACGIH)
SCBA	Self-Contained Breathing Apparatus	TSCA	Toxic Substances Control Act
SPCC	Spill Prevention, Control, and Countermeasures	TWA	Time Weighted Average (8 hr.)
STEL	Short-Term Exposure Limit (generally 15 minutes)	WEEL	Workplace Environmental Exposure Level (AIHA)
		WHMIS	Canadian Workplace Hazardous Materials Information System

DISCLAIMER OF EXPRESSED AND IMPLIED WARRANTIES

Information presented herein has been compiled from sources considered to be dependable, and is accurate and reliable to the best of our knowledge and belief, but is not guaranteed to be so. Since conditions of use are beyond our control, we make no warranties, expressed or implied, except those that may be contained in our written contract of sale or acknowledgment.

Vendor assumes no responsibility for injury to vendee or third persons proximately caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet. Additionally, vendor assumes no responsibility for injury to vendee or third persons proximately caused by abnormal use of the material, even if reasonable safety procedures are followed. Furthermore, vendee assumes the risk in their use of the material.



MATERIAL SAFETY DATA SHEET

Crude Oil (sour)

MSDS No. 6608

EMERGENCY OVERVIEW

CAUTION!

FLAMMABLE LIQUID - MAY EVOLVE TOXIC AND FLAMMABLE HYDROGEN SULFIDE GAS - SLIGHT TO MODERATE IRRITANT - EFFECTS CENTRAL NERVOUS SYSTEM - HARMFUL OR FATAL IF SWALLOWED

High fire hazard. Keep away from heat, spark, open flame, and other ignition sources.

HYDROGEN SULFIDE (toxic gas) may be released. High concentration may cause immediate unconsciousness - death may result unless victim is promptly and successfully resuscitated. Hydrogen sulfide causes eye irritation.

If ingested, do NOT induce vomiting, as this may cause chemical pneumonia (fluid in the lungs). Contact may cause eye, skin and mucous membrane irritation. Avoid prolonged breathing of vapors or mists. Inhalation may cause irritation, anesthetic effects (dizziness, nausea, headache, intoxication), and respiratory system effects.

Long-term exposure may cause effects to specific organs, such as to the liver, kidneys, blood, nervous system, and skin. Contains benzene, which can cause blood disease, including anemia and leukemia.



NFPA 704 (Section 16)

1. CHEMICAL PRODUCT AND COMPANY INFORMATION

Hess Corporation
1 Hess Plaza
Woodbridge, NJ 07095-0961

EMERGENCY TELEPHONE NUMBER:
COMPANY CONTACT (business hours):
MSDS Internet Website:

CHEMTREC (800) 424-9300
Corporate EHS 732-750-6000
www.hess.com

SYNONYMS: Crude Petroleum; Sour Crude
See Section 16 for abbreviations and acronyms.

2. COMPOSITION and CHEMICAL INFORMATION ON INGREDIENTS

INGREDIENT NAME (CAS No.)	CONCENTRATION PERCENT BY WEIGHT
Petroleum Oil (8002-05-9)	100
Hydrogen Sulfide (H ₂ S) (7783-06-4)	< highly variable - see below >
Benzene (71-43-2)	Variable AP 0.1 to 1.0

A natural product derived from various oil production field primarily consisting of a complex combination of paraffinic and aromatic hydrocarbons and small amounts of nitrogen and sulfur compounds.

Crude oils are generally referred to as "sour" if they can release dissolved hydrogen sulfide (H₂S) which could result in a hazardous condition. The amount of dissolved H₂S can vary considerably with the crude oil source. Some sour crude oils can have an appreciable percentage of H₂S.

3. HAZARDS IDENTIFICATION



MATERIAL SAFETY DATA SHEET

Crude Oil (sour)

MSDS No. 6608

EYES

Contact with eyes may cause moderate to severe irritation.

SKIN

Practically non-toxic if absorbed following acute (single) exposure. May cause skin irritation with prolonged or repeated contact. Liquid may be absorbed through the skin in toxic amounts if large areas of skin are exposed repeatedly. Rare, precancerous warts on the forearms, backs of hands and scrotum have been reported from prolonged or repeated skin contact.

INGESTION

The major health threat of ingestion occurs from the danger of aspiration (breathing) of liquid drops into the lungs, particularly from vomiting. Aspiration may result in chemical pneumonia (fluid in the lungs), severe lung damage, respiratory failure and even death.

Ingestion may cause gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous system (brain) effects similar to alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest, and death may occur.

INHALATION

Excessive exposure may cause irritations to the nose, throat, lungs and respiratory tract. Central nervous system (brain) effects may include headache, dizziness, loss of balance and coordination, unconsciousness, coma, respiratory failure, and death.

WARNING: Irritating and toxic hydrogen sulfide gas may be found in confined vapor spaces. Greater than 15 - 20 ppm continuous exposure can cause mucous membrane and respiratory tract irritation. 50 - 500 ppm can cause headache, nausea, and dizziness, loss of reasoning and balance, difficulty in breathing, fluid in the lungs, and possible loss of consciousness. Greater than 500 ppm can cause rapid or immediate unconsciousness due to respiratory paralysis and death by suffocation unless the victim is removed from exposure and successfully resuscitated.

The "rotten egg" odor of hydrogen sulfide is not a reliable indicator for warning of exposure, since olfactory fatigue (loss of smell) readily occurs, especially at concentrations above 50 ppm. At high concentrations, the victim may not even recognize the odor before becoming unconscious.

CHRONIC EFFECTS and CARCINOGENICITY

Similar products produced skin cancer and systemic toxicity in laboratory animals following repeated applications. This product contains polynuclear aromatic hydrocarbons which have been shown to be carcinogenic in laboratory animals after repeated and prolonged skin contact. The significance of these results to human exposures has not been determined - see Section 11, Toxicological Information.

Contains benzene, a regulated human carcinogen. Benzene has the potential to cause anemia and other blood diseases, including leukemia, after repeated and prolonged exposure.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE

Irritation from skin exposure may aggravate existing open wounds, skin disorders, and dermatitis (rash). Pre-existing chronic respiratory disease, liver or kidney dysfunction, or blood, cardiovascular and central nervous system disorders may be aggravated by exposure.

4. FIRST AID MEASURES

EYES

In case of contact with eyes, immediately flush with clean, low-pressure water for at least 15 min. Hold eyelids open to ensure adequate flushing. Seek medical attention.

SKIN



MATERIAL SAFETY DATA SHEET

Crude Oil (sour)

MSDS No. 6608

Remove contaminated clothing. Wash contaminated areas thoroughly with soap and water or waterless hand cleanser. Obtain medical attention if irritation or redness develops. Thermal burns require immediate medical attention depending on the severity and the area of the body burned.

INGESTION

DO NOT INDUCE VOMITING. Do not give liquids. Obtain immediate medical attention. If spontaneous vomiting occurs, lean victim forward to reduce the risk of aspiration. Monitor for breathing difficulties. Small amounts of material which enter the mouth should be rinsed out until the taste is dissipated.

INHALATION

Remove person to fresh air. If person is not breathing provide artificial respiration. If necessary, provide additional oxygen once breathing is restored if trained to do so. Seek medical attention immediately.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES:

FLASH POINT: < 73 to > 200 °F (< 23 to > 93 °C)
AUTOIGNITION TEMPERATURE: N/D
OSHA/NFPA FLAMMABILITY CLASS: 1B (flammable liquid)
LOWER EXPLOSIVE LIMIT (%): N/D
UPPER EXPLOSIVE LIMIT (%): N/D

FIRE AND EXPLOSION HAZARDS

Flash point and explosive limits are highly dependent on the crude oil source. Treat as an OSHA/NFPA flammable liquid unless otherwise indicated. Vapors may be ignited rapidly when exposed to heat, spark, open flame or other source of ignition. When mixed with air and exposed to an ignition source, flammable vapors can burn in the open or explode in confined spaces. Being heavier than air, vapors may travel long distances to an ignition source and flash back. Runoff to sewer may cause fire or explosion hazard.

EXTINGUISHING MEDIA

SMALL FIRES: Any extinguisher suitable for Class B fires, dry chemical, CO₂, water spray, fire fighting foam, or Halon.

LARGE FIRES: Water spray, fog or fire fighting foam. Water may be ineffective for fighting the fire, but may be used to cool fire-exposed containers.

FIRE FIGHTING INSTRUCTIONS

Small fires in the incipient (beginning) stage may typically be extinguished using handheld portable fire extinguishers and other fire fighting equipment.

Firefighting activities that may result in potential exposure to high heat, smoke or toxic by-products of combustion should require NIOSH/MSHA- approved pressure-demand self-contained breathing apparatus with full facepiece and full protective clothing.

Isolate area around container involved in fire. Cool tanks, shells, and containers exposed to fire and excessive heat with water. For massive fires the use of unmanned hose holders or monitor nozzles may be advantageous to further minimize personnel exposure. Major fires may require withdrawal, allowing the tank to burn. Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied fire fighting foam.

See Section 16 for the NFPA 704 Hazard Rating.

6. ACCIDENTAL RELEASE MEASURES



MATERIAL SAFETY DATA SHEET

Crude Oil (sour)

MSDS No. 6608

ACTIVATE FACILITY SPILL CONTINGENCY or EMERGENCY PLAN.

Evacuate nonessential personnel and remove or secure all ignition sources. Consider wind direction; stay upwind and uphill, if possible. Evaluate the direction of product travel, diking, sewers, etc. to confirm spill areas. Product may release substantial amounts of flammable vapors and gases (e.g., methane, ethane, and propane), at or below ambient temperature depending on source and process conditions and pressure.

Carefully contain and stop the source of the spill, if safe to do so. Protect bodies of water by diking, absorbents, or absorbent boom, if possible. Do not flush down sewer or drainage systems, unless system is designed and permitted to handle such material. The use of fire fighting foam may be useful in certain situations to reduce vapors. The proper use of water spray may effectively disperse product vapors or the liquid itself, preventing contact with ignition sources or areas/equipment that require protection - do not discharge solid water stream patterns into the liquid resulting in splashing.

Take up with sand or other oil absorbing materials. Carefully shovel, scoop or sweep up into a waste container for reclamation or disposal. Response and clean-up crews must be properly trained and must utilize proper protective equipment (see Section 8).

7. HANDLING and STORAGE

HANDLING and STORAGE PRECAUTIONS

Handle as a flammable liquid. Keep away from heat, sparks, and open flame! Electrical equipment should be approved for classified area. Bond and ground containers during product transfer to reduce the possibility of static-initiated fire or explosion.

STORAGE PRECAUTIONS

Keep away from flame, sparks, excessive temperatures and open flame. Use approved vented containers. Keep containers closed and clearly labeled. Empty product containers or vessels may contain explosive vapors. Do not pressurize, cut, heat, weld or expose such containers to sources of ignition.

Store in a well-ventilated area. This storage area should comply with NFPA 30 "Flammable and Combustible Liquid Code". Avoid storage near incompatible materials. The cleaning of tanks previously containing this product should follow API Recommended Practice (RP) 2013 "Cleaning Mobile Tanks In Flammable and Combustible Liquid Service" and API RP 2015 "Cleaning Petroleum Storage Tanks".

Hydrogen sulfide may accumulate in tanks and bulk transport compartments. Consider appropriate respiratory protection (see Section 8). Stand upwind. Avoid vapors when opening hatches and dome covers. Confined spaces should be ventilated prior to entry.

WORK/HYGIENIC PRACTICES

Emergency eye wash capability should be available in the near proximity to operations presenting a potential splash exposure. Use good personal hygiene practices. Avoid repeated and/or prolonged skin exposure. Wash hands before eating, drinking, smoking, or using toilet facilities. Do not use as a cleaning solvent on the skin. Do not use gasoline or solvents (naphtha, kerosene, etc.) for washing this product from exposed skin areas. Waterless hand cleaners are effective. Promptly remove contaminated clothing and launder before reuse. Use care when laundering to prevent the formation of flammable vapors which could ignite via washer or dryer. Consider the need to discard contaminated leather shoes and gloves.

Naturally Occurring Radioactive Materials (NORM):

Industry experience indicates that this material may contain small amounts of naturally-occurring uranium, thorium, and their decay products (NORM) which can accumulate in oil production and process equipment, particularly the equipment handling the water associated with crude oil production. Scales, other deposits, and sludges from this equipment may have a significant accumulation of NORM. Gamma



MATERIAL SAFETY DATA SHEET

Crude Oil (sour)

MSDS No. 6608

radiation above background may be detected external to equipment contaminated with NORM. Production equipment should be assessed for external gamma radiation; access may need to be restricted in accordance with OSHA 29 CFR 1910.96 during operation. Such equipment should also be assumed to be internally contaminated with long half-life decay products that emit alpha radiation, which is a hazard if inhaled or ingested. Unless measurements indicate otherwise, steps should be taken to minimize skin and inhalation exposure to NORM dusts/mists by wearing personal protective clothing [such as disposable Tyvek® (DuPont)], utilizing respiratory protection (minimum of HEPA filter), and practicing good personal hygiene. Please refer to API Bulletin E2, "Bulletin on Management of Naturally Occurring Radioactive Materials in Oil and Gas Production," April 1, 1992, for additional information on managing NORM.

8. EXPOSURE CONTROLS and PERSONAL PROTECTION

EXPOSURE LIMITS

Components (CAS No.)	Source	Exposure Limits	Note
		TWA/STEL	
Petroleum Oil (8002-05-9)	OSHA ACGIH	PEL = 5 mg/m ³ as mineral oil mist TLV = 5 mg/m ³ as mineral oil mist Note: Sum of 15-NTP polynuclear aromatic hydrocarbons 0.005 mg/m ³	A1
Hydrogen Sulfide (H ₂ S) (7783-06-4)	OSHA ACGIH	PEL = 20ppm; STEL = 50 ppm TLV = 10 ppm; STEL = 15 ppm	2006 NOIC 1/5 ppm
Benzene (71-43-2)	OSHA ACGIH	PEL = 1ppm; STEL = 5 ppm TLV = 0.5 ppm; STEL = 2.5 ppm	A1; skin; BEI

ENGINEERING CONTROLS

Use adequate ventilation to keep vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces.

EYE/FACE PROTECTION

Safety glasses or goggles are recommended where there is a possibility of splashing or spraying.

SKIN PROTECTION

Gloves constructed of nitrile or neoprene are recommended. Chemical protective clothing such as of E.I. DuPont Tyvek-Saranex 23®, Tychem®, Barricade® or equivalent recommended based on degree of exposure. Note: The resistance of specific material may vary from product to product as well as with degree of exposure. Consult manufacturer specifications for further information.

RESPIRATORY PROTECTION

If hydrogen sulfide hazard is present (that is, exposure potential above H₂S permissible exposure limit), use a positive-pressure SCBA or Type C supplied air respirator with escape bottle.

Where it has been determined that there is no hydrogen sulfide exposure hazard (that is, exposure potential below H₂S permissible exposure limit), a NIOSH/MSHA-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed exposure limits or for odor or irritation. Protection provided by air-purifying respirators is limited. Refer to OSHA 29 CFR 1910.134, ANSI Z88.2-1992, NIOSH Respirator Decision Logic, and the manufacturer for additional guidance on respiratory protection selection.

Use a positive pressure, air-supplied respirator if there is a potential for uncontrolled release, exposure levels are not known, in oxygen-deficient atmospheres, or any other circumstance where an air-purifying respirator may not provide adequate protection.



MATERIAL SAFETY DATA SHEET

Crude Oil (sour)

MSDS No. 6608

A NIOSH -approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed exposure limits or for odor or irritation. Protection provided by air-purifying respirators is limited. Refer to OSHA 29 CFR 1910.134, ANSI Z88.2-1992, NIOSH Respirator Decision Logic, and the manufacturer for additional guidance on respiratory protection selection.

9. PHYSICAL and CHEMICAL PROPERTIES

APPEARANCE

Variable depending on its source; typical is a thick, dark yellow to brown or greenish black liquid

ODOR

A characteristic, petroleum/asphalt-type odor

Hydrogen sulfide (H_2S) has a rotten egg "sulfurous" odor. This odor should not be used as a warning property of toxic levels because H_2S can overwhelm and deaden the sense of smell. Also, the odor of H_2S in heavy oils can easily be masked by the petroleum-like odor of the oil. Therefore, the smell of H_2S should not be used as an indicator of a hazardous condition - a H_2S meter or colorimetric indicating tubes are typically used to determine the concentration of H_2S .

BASIC PHYSICAL PROPERTIES

The properties of crude oil are highly variable depending on its source.

BOILING RANGE: AP 100 - 1000+ °F (> 260 °C)

VAPOR PRESSURE: Variable

VAPOR DENSITY (air = 1): 3 - 5 typical

SPECIFIC GRAVITY (H_2O = 1): AP 0.7 to 0.9 (varies)

PERCENT VOLATILES: Variable

EVAPORATION RATE: Variable

SOLUBILITY (H_2O): Insoluble to slightly soluble

10. STABILITY and REACTIVITY

STABILITY: Stable. Hazardous polymerization will not occur.

CONDITIONS TO AVOID and INCOMPATIBLE MATERIALS

Material is stable under normal conditions. Avoid high temperatures, open flames, sparks, welding, smoking and other ignition sources. Keep away from strong oxidizers.

HAZARDOUS DECOMPOSITION PRODUCTS

Carbon monoxide, carbon dioxide and non-combusted hydrocarbons (smoke). Contact with nitric and sulfuric acids will form nitrocresols that can decompose violently.

11. TOXICOLOGICAL PROPERTIES

CHRONIC EFFECTS AND CARCINOGENICITY

Carcinogenicity: OSHA: NO IARC: NO NTP: NO ACGIH:1997 NOIC: A1

Dermal carcinogenicity: positive - mice

Studies have shown that similar products produce skin tumors in laboratory animals following repeated applications without washing or removal. The significance of this finding to human exposure has not been determined. Other studies with active skin carcinogens have shown that washing the animal's skin with soap and water between applications reduced tumor formation.

This product contains benzene. Human health studies indicate that prolonged and/or repeated overexposure to benzene may cause damage to the blood-forming system (particularly bone marrow),



MATERIAL SAFETY DATA SHEET

Crude Oil (sour)

MSDS No. 6608

and serious blood disorders such as aplastic anemia and leukemia. Benzene is listed as a human carcinogen by the NTP, IARC, OSHA and ACGIH.

MUTAGENICITY (genetic effects)

Some crude oils and crude oil fractions have been positive in mutagenicity studies.

12. ECOLOGICAL INFORMATION

Keep out of sewers, drainage areas, and waterways. Report spills and releases, as applicable, under Federal and State regulations.

13. DISPOSAL CONSIDERATIONS

Consult federal, state and local waste regulations to determine appropriate disposal options.

14. TRANSPORTATION INFORMATION

DOT PROPER SHIPPING NAME:

DOT HAZARD CLASS and PACKING GROUP:

DOT IDENTIFICATION NUMBER:

DOT SHIPPING LABEL:

PETROLEUM CRUDE OIL

3, (Determine FP to accurately determine packing group)

UN 1267

FLAMMABLE LIQUID

PLACARD:



15. REGULATORY INFORMATION

U.S. FEDERAL, STATE, and LOCAL REGULATORY INFORMATION

Any spill or uncontrolled release of this product, including any substantial threat of release, may be subject to federal, state and/or local reporting requirements. This product and/or its constituents may also be subject to other regulations at the state and/or local level. Consult those regulations applicable to your facility/operation.

CLEAN WATER ACT (OIL SPILLS)

Any spill or release of this product to "navigable waters" (essentially any surface water, including certain wetlands) or adjoining shorelines sufficient to cause a visible sheen or deposit of a sludge or emulsion must be reported immediately to the National Response Center (1-800-424-8802) as required by U.S. Federal Law. Also contact appropriate state and local regulatory agencies as required.

CERCLA SECTION 103 and SARA SECTION 304 (RELEASE TO THE ENVIRONMENT)

The CERCLA definition of hazardous substances contains a "petroleum exclusion" clause which exempts crude oil, refined, and unrefined petroleum products and any indigenous components of such. However, other federal reporting requirements (e.g., SARA Section 304 as well as the Clean Water Act if the spill occurs on navigable waters) may still apply.

SARA SECTION 311/312 - HAZARD CLASSES

ACUTE HEALTH

X

CHRONIC HEALTH

X

FIRE

X

SUDDEN RELEASE OF PRESSURE

--

REACTIVE

--

SARA SECTION 313 - SUPPLIER NOTIFICATION

This product contains the following toxic chemicals subject to the reporting requirements of section 313 of the Emergency Planning and Community Right-To-Know Act (EPCRA) of 1986 and of 40 CFR 372:

INGREDIENT NAME

CONCENTRATION PERCENT BY WEIGHT

**MATERIAL SAFETY DATA SHEET****Crude Oil (sour)****MSDS No. 6608**

Benzene

CAS NUMBER: 71-43-2

< 0.1 to 2

CANADIAN REGULATORY INFORMATION (WHMIS)

Class B, Division 2 (flammable liquid)

Class D, Division 1A (Very toxic, acute)

Class D, Division 1B (Very toxic by other means)

CALIFORNIA PROPOSITION 65 LIST OF CHEMICALS

This product contains the following chemicals that are included on the Proposition 65 "List of Chemicals" required by the California Safe Drinking Water and Toxic Enforcement Act of 1986:

<u>INGREDIENT NAME (CAS NUMBER)</u>	<u>Date Listed</u>
Benzene	2/27/1987

<u>NFPA® HAZARD RATING</u>	HEALTH:	2
	FIRE:	3
	REACTIVITY:	0

Refer to NJPA 704 "Identification of the Fire Hazards of Materials" for further information

<u>HMIS® HAZARD RATING</u>	HEALTH:	3 *	Slight
	FIRE:	3	Moderate
	Physical:	0	Negligible
			* Chronic

SUPERSEDES MSDS DATED: 02/24/2000**ABBREVIATIONS:**

AP = Approximately < = Less than > = Greater than
N/A = Not Applicable N/D = Not Determined ppm = parts per million

ACRONYMS:

ACGIH	American Conference of Governmental Industrial Hygienists	NIOSH	National Institute of Occupational Safety and Health
AIHA	American Industrial Hygiene Association	NOIC	Notice of Intended Change (proposed change to ACGIH TLV)
ANSI	American National Standards Institute (212) 642-4900	NTP	National Toxicology Program
API	American Petroleum Institute (202) 682-8000	OPA	Oil Pollution Act of 1990
CERCLA	Comprehensive Emergency Response, Compensation, and Liability Act	OSHA	U.S. Occupational Safety & Health Administration
DOT	U.S. Department of Transportation [General info: (800) 467-4922]	PEL	Permissible Exposure Limit (OSHA)
EPA	U.S. Environmental Protection Agency	RCRA	Resource Conservation and Recovery Act
HMIS	Hazardous Materials Information System	REL	Recommended Exposure Limit (NIOSH)
IARC	International Agency For Research On Cancer	SARA	Superfund Amendments and Reauthorization Act of 1986 Title III
MSHA	Mine Safety and Health Administration	SCBA	Self-Contained Breathing Apparatus
NFPA	National Fire Protection Association (617)770-3000	SPCC	Spill Prevention, Control, and Countermeasures
		STEL	Short-Term Exposure Limit (generally 15 minutes)



MATERIAL SAFETY DATA SHEET

Crude Oil (sour)

MSDS No. 6608

TLV Threshold Limit Value (ACGIH)
TSCA Toxic Substances Control Act
TWA Time Weighted Average (8 hr.)

WEEL Workplace Environmental Exposure
 Level (AIHA)
WHMIS Canadian Workplace Hazardous
 Materials Information System

DISCLAIMER OF EXPRESSED AND IMPLIED WARRANTIES

Information presented herein has been compiled from sources considered to be dependable, and is accurate and reliable to the best of our knowledge and belief, but is not guaranteed to be so. Since conditions of use are beyond our control, we make no warranties, expressed or implied, except those that may be contained in our written contract of sale or acknowledgment.

Vendor assumes no responsibility for injury to vendee or third persons proximately caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet. Additionally, vendor assumes no responsibility for injury to vendee or third persons proximately caused by abnormal use of the material, even if reasonable safety procedures are followed. Furthermore, vendee assumes the risk in their use of the material.

Soil Boring No:
Monitor Well No:

624 E Comanche Farmington, NM 87401
Tel. (505) 564-2281 Fax (505) 324-2022

Project: _____
Client: _____
Location: _____
Driller: _____
Drilling Method: _____
Depth to Water (ft): _____

Project No.: _____
 Date: _____
 Elevation: _____
 Datum: _____
 Logged by: _____
 Diameter (in.): _____

[illegible]

Water Sampling Record**Animas Environmental Services**

Monitor Well No: _____

624 E. Comanche, Farmington NM 87401

Tel. (505) 564-2281 Fax (505) 324-2022

Project: _____

Project No.: _____

Site: _____

Date: _____

Location: _____

Time: _____

Sampler: _____

Weather: _____

Sampling Method: _____

Air Temperature: _____

Depth of Well (ft): _____

Well Diam. (in.): _____

Depth to Water (ft): _____

Site Elevation (ft): _____

Time	Temp (deg C)	Conductivity (μ S) (mS)	DO (mg/L)	pH	ORP (mV)	PURGED VOLUME (gallons)	Notes/Observations

Analytical Parameters Sampled For (include Method #):**Disposal of Purged Water:****Chain of Custody Record Complete? (Y/N)****Analytical Laboratory:****Equipment Used During Sampling:****Other Notes/Comments**



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 1 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

CONTENTS

1.0	SCOPE AND APPLICATION
2.0	METHOD SUMMARY
3.0	SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE
4.0	POTENTIAL PROBLEMS
5.0	EQUIPMENT
6.0	REAGENTS
7.0	PROCEDURES
7.1	Preparation
7.2	Sample Collection
7.2.1	Surface Soil Samples
7.2.2	Sampling at Depth with Augers and Thin Wall Tube Samplers
7.2.3	Sampling at Depth with a Trier
7.2.4	Sampling at Depth with a Split Spoon (Barrel) Sampler
7.2.5	Test Pit/Trench Excavation
8.0	CALCULATIONS
9.0	QUALITY ASSURANCE/QUALITY CONTROL
10.0	DATA VALIDATION
11.0	HEALTH AND SAFETY
12.0	REFERENCES
13.0	APPENDIX
	Figures



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 2 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to describe the procedures for the collection of representative soil samples. Sampling depths are assumed to be those that can be reached without the use of a drill rig, direct-push, or other mechanized equipment (except for a back-hoe). Analysis of soil samples may determine whether concentrations of specific pollutants exceed established action levels, or if the concentrations of pollutants present a risk to public health, welfare, or the environment.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the actual procedures used should be documented and described in an appropriate site report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

Soil samples may be collected using a variety of methods and equipment depending on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), and the soil type. Near-surface soils may be easily sampled using a spade, trowel, and scoop. Sampling at greater depths may be performed using a hand auger, continuous flight auger, a trier, a split-spoon, or, if required, a backhoe.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Chemical preservation of solids is not generally recommended. Samples should, however, be cooled and protected from sunlight to minimize any potential reaction. The amount of sample to be collected and proper sample container type are discussed in ERT/REAC SOP #2003 Rev. 0.0 08/11/94, *Sample Storage, Preservation and Handling*.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary potential problems associated with soil sampling - cross contamination of samples and improper sample collection. Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection can involve using contaminated equipment, disturbance of the matrix resulting in compaction of the sample, or inadequate homogenization of the samples where required, resulting in variable, non-representative results.

5.0 EQUIPMENT



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 3 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

Soil sampling equipment includes the following:

- Maps/plot plan
- Safety equipment, as specified in the site-specific Health and Safety Plan
- Survey equipment or global positioning system (GPS) to locate sampling points
- Tape measure
- Survey stakes or flags
- Camera and film
- Stainless steel, plastic, or other appropriate homogenization bucket, bowl or pan
- Appropriate size sample containers
- Ziplock plastic bags
- Logbook
- Labels
- Chain of Custody records and custody seals
- Field data sheets and sample labels
- Cooler(s)
- Ice
- Vermiculite
- Decontamination supplies/equipment
- Canvas or plastic sheet
- Spade or shovel
- Spatula
- Scoop
- Plastic or stainless steel spoons
- Trowel(s)
- Continuous flight (screw) auger
- Bucket auger
- Post hole auger
- Extension rods
- T-handle
- Sampling trier
- Thin wall tube sampler
- Split spoons
- Vehimeyer soil sampler outfit
 - Tubes
 - Points
 - Drive head
 - Drop hammer
 - Puller jack and grip
- Backhoe



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 4 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

Reagents are not used for the preservation of soil samples. Decontamination solutions are specified in ERT/REAC SOP #2006 Rev. 0.0 08/11/94, *Sampling Equipment Decontamination*, and the site specific work plan.

7.0 PROCEDURES

7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies required.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or pre-clean equipment, and ensure that it is in working order.
4. Prepare schedules and coordinate with staff, client, and regulatory agencies, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site specific Health and Safety Plan.
6. Use stakes, flagging, or buoys to identify and mark all sampling locations. Specific site factors, including extent and nature of contaminant, should be considered when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations should be utility-cleared by the property owner or the On-Scene-Coordinator (OSC) prior to soil sampling; and utility clearance should always be confirmed before beginning work.

7.2 Sample Collection

7.2.1 Surface Soil Samples

Collection of samples from near-surface soil can be accomplished with tools such as spades, shovels, trowels, and scoops. Surface material is removed to the required depth and a stainless steel or plastic scoop is then used to collect the sample.

This method can be used in most soil types but is limited to sampling at or near the ground surface. Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the sample team member. A flat, pointed mason trowel to cut a block of the desired soil is helpful when undisturbed profiles are required. Tools plated with chrome or other materials should not be used. Plating is particularly common with garden implements such as potting trowels.

The following procedure is used to collect surface soil samples:



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 5 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

1. Carefully remove the top layer of soil or debris to the desired sample depth with a pre-cleaned spade.
2. Using a pre-cleaned, stainless steel scoop, plastic spoon, or trowel, remove and discard a thin layer of soil from the area which came in contact with the spade.
3. If volatile organic analysis is to be performed, transfer the sample directly into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval or location into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

7.2.2 Sampling at Depth with Augers and Thin Wall Tube Samplers

This system consists of an auger, or a thin-wall tube sampler, a series of extensions, and a "T" handle (Figure 1, Appendix A). The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin wall tube sampler. The system is then lowered down the borehole, and driven into the soil to the completion depth. The system is withdrawn and the core is collected from the thin wall tube sampler.

Several types of augers are available; these include: bucket type, continuous flight (screw), and post-hole augers. Bucket type augers are better for direct sample recovery because they provide a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly from the flights. The continuous flight augers are satisfactory when a composite of the complete soil column is desired. Post-hole augers have limited utility for sample collection as they are designed to cut through fibrous, rooted, swampy soil and cannot be used below a depth of approximately three feet.

The following procedure is used for collecting soil samples with the auger:

1. Attach the auger bit to a drill rod extension, and attach the "T" handle to the drill rod.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 6 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

2. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, litter). It may be advisable to remove the first three to six inches of surface soil for an area approximately six inches in radius around the drilling location.
3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole, and avoids possible contamination of the surrounding area.
4. After reaching the desired depth, slowly and carefully remove the auger from the hole. When sampling directly from the auger, collect the sample after the auger is removed from the hole and proceed to Step 10.
5. Remove auger tip from the extension rods and replace with a pre-cleaned thin wall tube sampler. Install the proper cutting tip.
6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Do not scrape the borehole sides. Avoid hammering the rods as the vibrations may cause the boring walls to collapse.
7. Remove the tube sampler, and unscrew the drill rods.
8. Remove the cutting tip and the core from the device.
9. Discard the top of the core (approximately 1 inch), as this possibly represents material collected before penetration of the layer of concern. Place the remaining core into the appropriate labeled sample container. Sample homogenization is not required.
10. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly.

When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 7 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.
12. Abandon the hole according to applicable state regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

7.2.3 Sampling with a Trier

The system consists of a trier, and a "T" handle. The auger is driven into the soil to be sampled and used to extract a core sample from the appropriate depth.

The following procedure is used to collect soil samples with a sampling trier:

1. Insert the trier (Figure 2, Appendix A) into the material to be sampled at a 0° to 45° angle from horizontal. This orientation minimizes the spillage of sample.
2. Rotate the trier once or twice to cut a core of material.
3. Slowly withdraw the trier, making sure that the slot is facing upward.
4. If volatile organic analyses are required, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

7.2.4 Sampling at Depth with a Split Spoon (Barrel) Sampler

Split spoon sampling is generally used to collect undisturbed soil cores of 18 or 24 inches in length. A series of consecutive cores may be extracted with a split spoon sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extracted.

When split spoon sampling is performed to gain geologic information, all work should



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 8 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

be performed in accordance with ASTM D1586-98, "Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils".

The following procedures are used for collecting soil samples with a split spoon:

1. Assemble the sampler by aligning both sides of barrel and then screwing the drive shoe on the bottom and the head piece on top.
2. Place the sampler in a perpendicular position on the sample material.
3. Using a well ring, drive the tube. Do not drive past the bottom of the head piece or compression of the sample will result.
4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, and the number of blows required to obtain this depth.
5. Withdraw the sampler, and open by unscrewing the bit and head and splitting the barrel. The amount of recovery and soil type should be recorded on the boring log. If a split sample is desired, a cleaned, stainless steel knife should be used to divide the tube contents in half, longitudinally. This sampler is typically available in 2 and 3 1/2 inch diameters. A larger barrel may be necessary to obtain the required sample volume.
6. Without disturbing the core, transfer it to appropriate labeled sample container(s) and seal tightly.

7.2.5 Test Pit/Trench Excavation

A backhoe can be used to remove sections of soil, when detailed examination of soil characteristics are required. This is probably the most expensive sampling method because of the relatively high cost of backhoe operation.

The following procedures are used for collecting soil samples from test pits or trenches:

1. Prior to any excavation with a backhoe, it is important to ensure that all sampling locations are clear of overhead and buried utilities.
2. Review the site specific Health & Safety plan and ensure that all safety precautions including appropriate monitoring equipment are installed as required.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 9 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

3. Using the backhoe, excavate a trench approximately three feet wide and approximately one foot deep below the cleared sampling location. Place excavated soils on plastic sheets. Trenches greater than five feet deep must be sloped or protected by a shoring system, as required by OSHA regulations.
4. A shovel is used to remove a one to two inch layer of soil from the vertical face of the pit where sampling is to be done.
5. Samples are taken using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose fresh soil for sampling. In many instances, samples can be collected directly from the backhoe bucket.
6. If volatile organic analyses are required, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.
7. Abandon the pit or excavation according to applicable state regulations. Generally, shallow excavations can simply be backfilled with the removed soil material.

8.0 CALCULATIONS

This section is not applicable to this SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance (QA) activities which apply to the implementation of these procedures. However, the following QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 10 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

activities must occur prior to sampling/operation, and they must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and corporate health and safety procedures, in addition to the procedures specified in the site specific Health & Safety Plan..

12.0 REFERENCES

Mason, B.J. 1983. Preparation of Soil Sampling Protocol: Technique and Strategies. EPA-600/4-83-020.

Barth, D.S. and B.J. Mason. 1984. Soil Sampling Quality Assurance User's Guide. EPA-600/4-84-043.

U.S. Environmental Protection Agency. 1984 Characterization of Hazardous Waste Sites - A Methods Manual: Volume II. Available Sampling Methods, Second Edition. EPA-600/4-84-076.

de Vera, E.R., B.P. Simmons, R.D. Stephen, and D.L. Storm. 1980. Samplers and Sampling Procedures for Hazardous Waste Streams. EPA-600/2-80-018.

ASTM D 1586-98, ASTM Committee on Standards, Philadelphia, PA.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 11 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

APPENDIX A
Figures
SOP #2012
February 2000



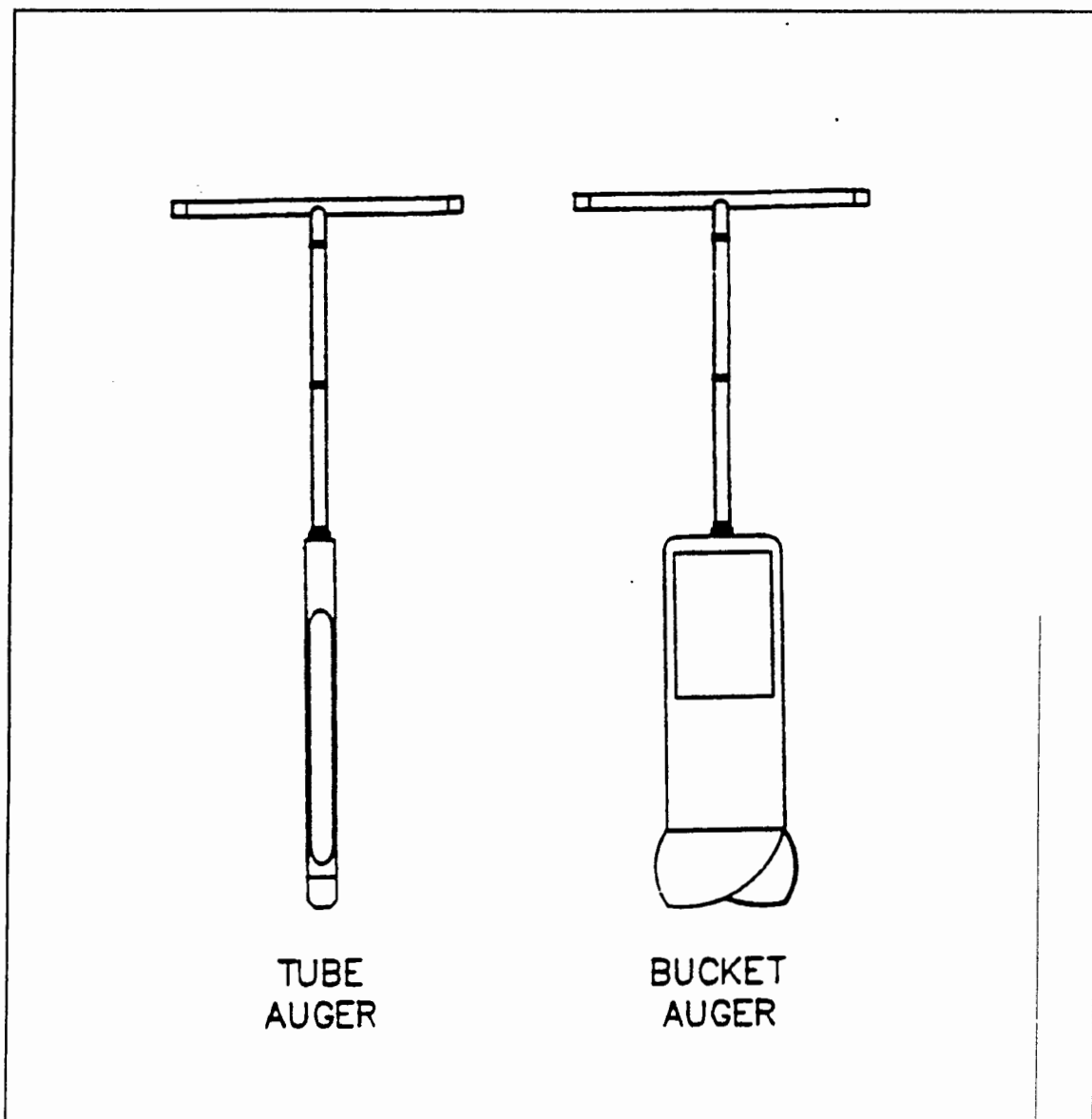
U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 12 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

FIGURE 1. Sampling Augers





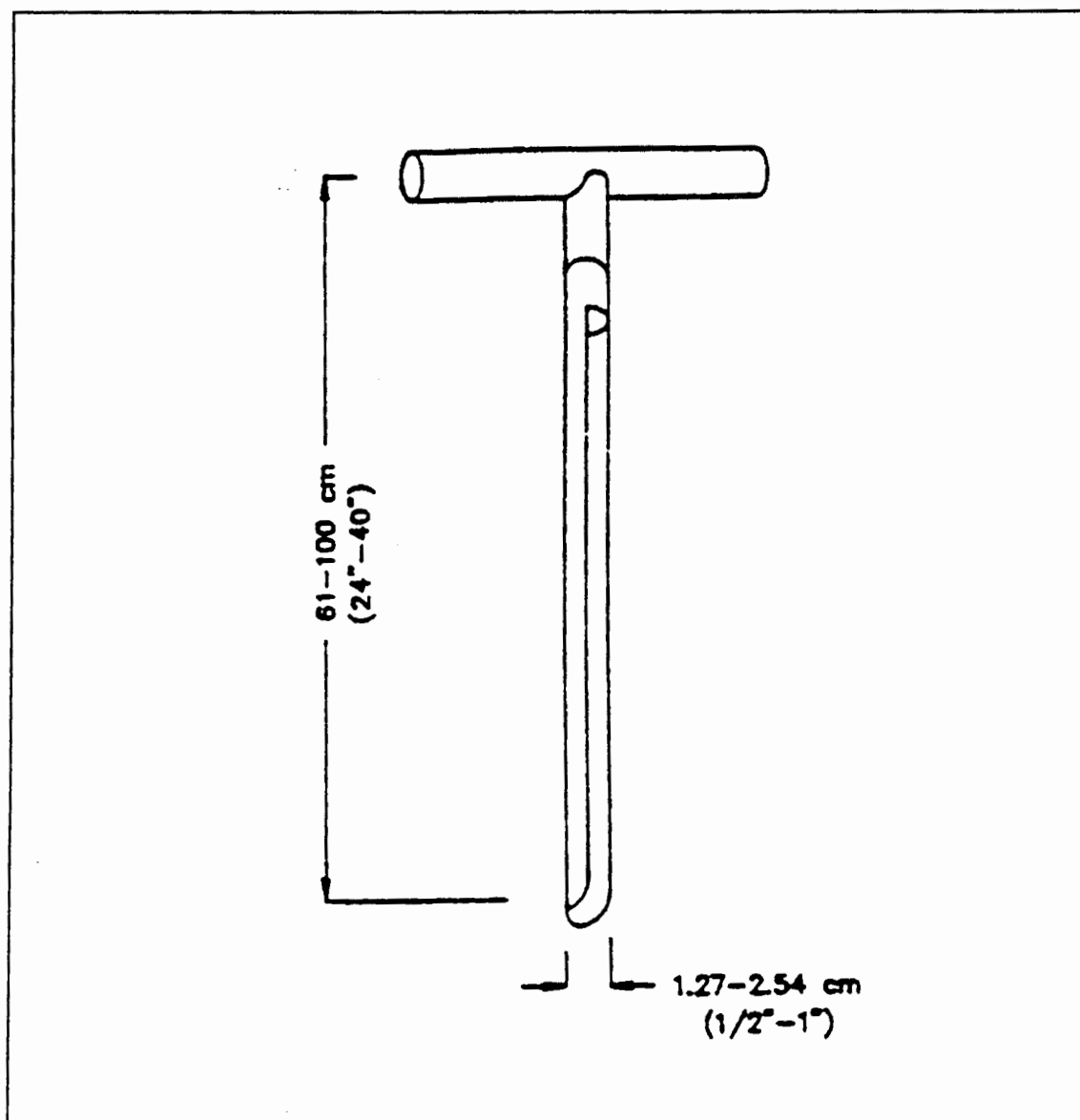
U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2012
PAGE: 13 of 13
REV: 0.0
DATE: 02/18/00

SOIL SAMPLING

FIGURE 2. Sampling Trier



THIS PAGE INTENTIONALLY LEFT BLANK



PHOTOIONIZATION DETECTOR (PID) HNU

SOP#: 2114
DATE: 10/06/94
REV. #: 0.0

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to describe the procedure for using a photoionization detector (PID). The PID is a portable, nonspecific, vapor/gas detector employing the principle of photoionization to detect a variety of chemical compounds, both organic and inorganic, in air. This procedure is applicable to the HNU PI-101, HNU ISPI-101, and HW-101 used for air monitoring.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

The PID is a useful general survey instrument at hazardous waste sites. A PID is capable of detecting and measuring real-time concentrations of many organic and inorganic vapors in air. A PID is similar to a flame ionization detector (FID) in application; however, the PID has somewhat broader capabilities in that it can detect certain inorganic vapors. Conversely, the PID is unable to respond to certain low molecular weight hydrocarbons, such as methane and ethane, that are readily detected by FID instruments.

The PID employs the principle of photoionization. The analyzer will respond to most vapors that have an ionization potential less than or equal to that supplied by the ionization source, which is an ultraviolet (UV) lamp. Photoionization occurs when an atom or molecule absorbs a photon of sufficient energy to

release an electron and form a positive ion. This will occur when the ionization potential of the molecule in electron volts (eV) is less than the energy of the photon. The sensor is housed in a probe and consists of a sealed ultraviolet light source that emits photons with an energy level high enough to ionize many trace organics, but not enough to ionize the major components of air (e.g., nitrogen, oxygen, carbon dioxide). The ionization chamber exposed to the light source contains a pair of electrodes, one a bias electrode, and the second the collector electrode. When a positive potential is applied to the bias electrode, an electro-magnetic field is created in the chamber. Ions formed by the adsorption of photons are driven to the collector electrode. The current produced is then measured and the corresponding concentration displayed on a meter, directly, in units above background. Several probes are available for the PID, each having a different eV lamp and a different ionization potential. The selection of the appropriate probe is essential in obtaining useful field results. Though it can be calibrated to a particular compound, the instrument cannot distinguish between detectable compounds in a mixture of gases and, therefore, indicates an integrated response to the mixture.

Three probes, each containing a different UV light source, are available for use with the HNU. Energies are 9.5, 10.2, and 11.7 eV. All three detect many aromatic and large molecular hydrocarbons. The 10.2 eV and 11.7 eV probes, in addition, detect some smaller organic molecules and some halogenated hydrocarbons. The 10.2 eV probe is the most useful for environmental response work, as it is more durable than the 11.7 eV probe and detects more compounds than the 9.5 eV probe.

Gases with ionization potentials near to or less than that of the lamp will be ionized. These gases will thus be detected and measured by the analyzer. Gases with ionization potentials higher than that of the lamp will not be detected. Ionization potentials for various atoms, molecules, and compounds are given in

Table 1 (Appendix A). The ionization potential of the major components of air, oxygen, nitrogen, and carbon dioxide, range from about 12.0 eV to about 15.6 eV and are not ionized by any of the three lamps.

Table 2 (Appendix A) illustrates ionization sensitivities for a large number of individual species when exposed to photons from a 10.2 eV lamp. Applications of each probe are included in Table 3 (Appendix A).

While the primary use of the HNU is as a quantitative instrument, it can also be used to detect certain contaminants, or at least to narrow the range of possibilities. Noting instrument response to a contaminant source with different probes can eliminate some contaminants from consideration. For instance, a compound's ionization potential may be such that the 9.5 eV probe produces no response, but the 10.2 eV and 11.7 eV probes do elicit a response.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

4.1 PID Instrument Limitations

1. The PID is a nonspecific total vapor detector. It cannot be used to identify unknown substances; it can only roughly quantify them.
2. The PID must be calibrated to a specific compound.
3. The PID does not respond to certain low molecular weight hydrocarbons, such as methane and ethane. In addition, the HNU does not detect a compound if the probe has a lower energy than the compound's ionization potential.
4. Certain toxic gases and vapors, such as carbon tetrachloride and hydrogen cyanide, have high ionization potentials and cannot be detected with a PID.

5. Certain models of PID instruments are not intrinsically safe. The HNU PI-101 and HW-101 are not designed for use in potentially flammable or combustible atmospheres. Therefore, these models should be used in conjunction with a Combustible Gas Indicator. The ISPI-101 is intrinsically safe, however.
6. Electrical power lines or power transformers may cause interference with the instrument and thus cause measurement errors. Static voltage sources such as power lines, radio transmissions, or transformers may also interfere with measurements.
7. High winds and high humidity will affect measurement readings. The HNU may become unusable under foggy or humid conditions. An indication of this is the needle dropping below zero, or a slow constant climb on the read-out dial.
8. The lamp window must be periodically cleaned to ensure ionization of the new compounds by the probe (i.e., new air contaminants).
9. The HNU measures concentrations from about 1-2000 ppm, although the response is not linear over this entire range. For example, if calibrated to benzene, the response is linear from about 0-600 units above background. This means the HNU reads a true concentration of benzene only between 0 and 600. Greater concentrations are detected at a lower level than the true value.
10. This instrument is not to be exposed to precipitation (rain). The units are not designed for this service.
11. Do not use this instrument for head space analysis where liquids can inadvertently be drawn into the probe.

4.2 Regulatory Limitations

Transport of calibration gas cylinders by passenger and cargo aircraft must comply with International Air Transport Association (IATA) Dangerous Goods

Regulations or the U.S. Code of Federal Regulations, 49 CFR Parts 100-177. A typical calibration gas included with a PID is isobutylene. It is classified as a non-flammable gas, UN #1556 and the proper shipping name is Compressed Gas. It must be shipped by cargo aircraft only.

5.0 EQUIPMENT/APPARATUS

The following equipment is required for PID operation:

- C PID (HNU)
- C Operating manual
- C Probes: 9.5 eV, 10.2 eV, or 11.7 eV
- C Battery charger for PID
- C Spare batteries
- C Jeweler's screwdriver for adjustments
- C Tygon tubing
- C NBS traceable calibration gas
- C "T" valve for calibration
- C Field Data Sheets/Site Logbook
- C Intake assembly extension
- C Strap for carrying PID
- C Teflon tubing for downhole measurements
- C Plastic bags for protecting the PID from moisture and dirt

Note: Battery charge status - This instrument may be kept on continuous charge without battery damage.

6.0 REAGENTS

- C Isobutylene standards for calibration
- C Benzene reference standard
- C Methanol for cleaning ionization chamber (GC grade)
- C Mild soap solution for cleaning unit surfaces
- C Specific gas standards when calibrating to a specific compound
- C Light source cleaning compound Cat. No. PA101534-A1 (For use only with 9.5 and 10.2 lamps)

The HNU is calibrated in accordance with the operations manual using isobutylene as the calibration standard. The operations manual may also be referred to for alternate calibration to a specific compound.

7.0 PROCEDURES

7.1 Preparation

Check out and ensure the proper operation of the PID, as appropriate, using the equipment checklist provided in Sections 5.0 and 6.0 and the steps listed below.

7.2 Start-Up Procedures

1. Allow the temperature of the unit to equilibrate to its surrounding. This should take about five minutes.
2. Attach the probe to the read-out unit. Match the alignment key, then twist the connector clockwise until a distinct locking is felt. Make sure the microswitch (red button) is depressed by the locking ring.
3. Turn the FUNCTION switch to the battery check position. Check to ensure that the indicator reads within or beyond the green battery arc on the scale plate. If the indicator is below the green arc, or if the red LED comes on, the battery must be charged prior to using.
4. To zero the instrument, turn the FUNCTION switch to the STANDBY position and rotate the ZERO POTENTIOMETER until the meter reads zero. Wait 15-20 seconds to ensure that the zero adjustment is stable; if not, then readjust.
5. Check to see that the SPAN POTENTIOMETER is set at the appropriate setting for the probe being used (i.e., 9.8 for the 10.2 eV probe, 5.0 for the 11.7 eV probe, 1 for the 9.5 eV probe. Note: The setting may vary based on the intensity of the light source).
6. Set the FUNCTION switch to the desired range (i.e., 0-20, 0-200, 0-2000).
7. Listen for the fan operation to verify fan function.

8. Look for ultraviolet light source in the probe to verify function. Do not look at light source from closer than six inches with unprotected eyes, observe only briefly.
9. Check instrument with an organic point source, such as a magic marker, prior to survey to verify instrument function.
10. Routinely during the day, verify the useful battery life by turning the function switch to BATT and schedule the instrument's use accordingly.

7.3 Field Operation

7.3.1 Field Calibration

1. Follow the start-up procedure in Section 7.2.
2. Set the FUNCTION switch to the range setting which includes the concentration of the calibration gas.
3. Attach a regulator to a disposable cylinder of calibration gas. Connect the regulator to the probe of the HNU with a piece of clean tygon tubing. Open the valve on the regulator.
4. After 15 seconds, the meter reading should equal the response value as indicated on the calibration gas cylinder used. If the reading is within $\pm 15\%$ of the response value, then the instrument can be field calibrated to the response value using the external SPAN ADJUSTMENT control. The SPAN ADJUSTMENT control should be adjusted to a lower setting until the correct reading has been obtained. The lower the number on the SPAN ADJUSTMENT control, the greater the instrument sensitivity. If the SPAN ADJUSTMENT control has to be adjusted below a setting of 4.00, the unit should be red-tagged and returned for repairs.
5. If the meter reading is greater than $\pm 15\%$ of the response value of the calibration gas used, then the instrument should be red-tagged and returned for re-calibration.

6. Record the following information in the site logbook: the instrument ID number (U.S. EPA decal or serial number if the instrument is a rental), the initial and final span settings, the date and time, concentration and type of calibration gas used, and the name of the person who field calibrated the instrument.
7. If the PID does not start up, check out, or calibrate properly, the instrument should not be used. Under no circumstances is work requiring air monitoring with a PID to be done without a proper functioning instrument.
8. In some field applications, with the exception of the probe's inlet and exhaust, the PID should be wrapped in clear plastic to prevent it from becoming contaminated and to prevent water from getting inside in the event of precipitation.

7.3.2 Operation

1. All readings are to be recorded in the site logbook. Readings should be recorded, following background readings, as "units above background," not ppm.
2. As with any field instrument, accurate results depend on the operator being completely familiar with the operator's manual. The instructions in the operating manual should be followed explicitly in order to obtain accurate results.
3. Position the probe assembly close to the area to be monitored because the low sampling rate allows for only very localized readings. Under no circumstances should the probe tip assembly be immersed in fluid.
4. While taking care to prevent the PID from being exposed to excessive moisture, dirt, or contamination, monitor the work activity as specified in the site Health and Safety Plan. The PID survey should be conducted at a slow to moderate rate of speed and the intake assembly (the probe) slowly swept from side to side. There is a three to five second delay in read-out depending upon the instruments sensitivity to the contaminant.

5. During drilling activities, PID monitoring is performed at regular intervals downhole, at the headspace, and in the breathing zone. In addition, where elevated organic vapor levels are encountered, monitoring may be performed in the breathing zone during actual drilling. When the activity being monitored is other than drilling, readings should emphasize breathing zone conditions.
6. When the activity is completed or at the end of the day, carefully clean the outside of the PID with a damp disposable towel to remove any visible dirt.

7.4 Post Operation

1. Turn FUNCTION Switch to OFF.
2. Return the PID to a secure area and check the calibration (Section 7.3.1.) before charging. Connect the instrument to charger and plug in the charger. The probe must be connected to the readout unit to charge the HNU.
3. Complete logbook entries, verifying the accuracy of entries and signing/initialing all pages. Following completion of a series of "0" readings, verify the instrument is working as in Section 7.3.1.
4. Check the equipment, repair or replace damaged equipment, and charge the batteries.

7.5 Equipment Calibration

1. Follow the start-up procedure in Section 7.2.
2. Set the FUNCTION switch to the range setting which includes the concentration of the calibration gas.
3. Attach a regulator to a cylinder of calibration gas. Connect the regulator to the probe of the NHU with a piece of clean tygon tubing. Open the valve on the regulator.
4. After 15 seconds, the meter reading should equal the response value as indicated on the calibration gas cylinder used. If the reading is greater than $\pm 15\%$ of the actual

concentration, an internal calibration is necessary. Unlock the SPAN POTENTIOMETER dial before adjusting it. Adjust the SPAN POTENTIOMETER to the span setting recommended for the probe being used (i.e., 9.8 for the 10.2 eV probe, 5.0 for the 11.7 eV probe, 1 for the 9.5 eV probe). To calibrate the instrument, unscrew the bottom support screw and lift the instrument out of the case. Locate and adjust the trimpot "R-32" (near the top of the printed circuit board) by inserting a small screwdriver and gently turning. When the instrument gives the correct reading for the calibration gas being used, reassemble it.

5. Record the following information in the calibration logbook: the instrument identification number (U.S. EPA barcode number or serial number if the instrument is a rental), the initial and final span settings, the date and time, concentration and type of calibration gas used, and the name of the person who calibrated the instrument. Affix a sticker to the instrument indicating the person who performed the calibration, the date of calibration, and the due date of the next calibration.
6. Turn the FUNCTION switch to OFF and connect the instrument to the charger. The probe must be connected to the readout unit to ensure that the unit accepts a charge.

8.0 CALCULATIONS

The HNU is a direct reading instrument. Readings are interpreted as units above background rather than ppm.

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in

accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, or corporate health and safety practices.

The HNU is certified by OSHA standards for use in Class 1, Division 2, Groups A, B, C, and D locations.

12.0 REFERENCES

HNU Systems, Inc. 1975. "Instruction Manual for Model PI-101 Photoionization Analyzer."

U.S. Code of Federal Regulations, 49 CFR Parts 100 to 177, Transportation, revised November 1, 1985.

U.S. Environmental Protection Agency. 1984. "Characterization of Hazardous Waste Sites - A Methods Manual: Volume II, Available Sampling Methods, Second Edition", EPA-600/4-84-076, Environmental Monitoring Systems Laboratory, Office of Research and Development, Las Vegas, Nevada.

International Air Transport Association Dangerous Goods Regulations

APPENDIX A (Cont'd)

Tables

TABLE 1. Ionization Potentials (Continued)

<u>AROMATIC COMPOUNDS</u>			
Molecule	IP (eV)	Molecule	IP (eV)
Benzene	9.245	Phenyl isothiocyanate	8.520
Toluene	8.82	Benzonitrile	9.705
Ethyl benzene	3.76	Nitrobenzene	9.92
n-propyl benzene	8.72	Aniline	7.70
i-propyl benzene	8.69	Fluoro-benzene	9.195
n-butyl benzene	8.69	Chloro-benzene	9.07
s-butyl benzene	8.68	Bromo-benzene	8.98
t-butyl benzene	8.68	Iodo-benzene	8.73
o-xylene	8.56	o-dichlorobenzene	9.07
m-xylene	8.56	m-dichlorobenzene	9.12
p-xylene	8.445	p-dichlorobenzene	8.94
Mesitylene	8.40	1-chloro-2-fluorobenzene	9.155
Durene	8.025	1-chloro-3-fluorobenzene	9.21
Styrene	8.47	1-bromo-4-fluorobenzene	8.99
o-methyl styrene	8.35	o-fluorotoluene	8.915
Ethynylbenzene	8.815	m-fluorotoluene	8.915
Napthalene	8.12	p-fluorotoluene	8.785
1-methylnapthalene	7.69	o-chlorotoluene	8.83
2-methylnapthalene	7.955	m-chlorotoluene	8.83
Biphenyl	8.27	p-chlorotoluene	8.70
Phenol	8.50	o-bromotoluene	8.79
Anisole	8.22	m-bromotoluene	8.81
Phenetole	8.13	p-bromotoluene	8.67
Benzaldehyde	9.53	o-iodotoluene	8.62
Acetophenone	9.27	m-iodotoluene	8.61
Benzenethiol	8.33	p-iodotoluene	8.50
Phenyl isocyanate	8.77	Benzotrifluoride	9.68
		o-fluorophenol	8.66



MONITOR WELL INSTALLATION

SOP#: 2048
DATE: 03/18/96
REV. #: 0.0

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide an overview of the methods used for groundwater monitor wells. Monitor well installation create permanent access for collection of samples to assess groundwater quality and the hydrogeologic properties of the aquifer in which contaminants may exist. Such wells should not alter the medium which is being monitored.

The most commonly used drilling methods are: the hollow-stem auger, cable tool, and hydraulic rotary. Rotary drilling can utilize mud rotary or air rotary methods.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, depending on site conditions, equipment limitations, or limitations imposed by the procedures themselves. In all instances, the ultimate procedures employed should be documented and described in the final report as well as in logbooks.

Mention of trade names or commercial products does not constitute United States Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

There is no ideal monitor well installation method for all conditions therefore, hydrogeologic conditions at the site as well as project objectives must be considered before deciding which drilling method is appropriate.

2.1 Hollow-Stem Augering

Outside diameters of hollow-stem augers generally range from 6 1/4 inches to 22 inches with corresponding inner diameters ranging from 2 1/4 inches to 13 inches. Auger lengths are usually 5 feet

which allows easy handling. However, lengths of 10 or 20 feet may be used for deeper holes drilled with machines capable of handling the extended lengths. Formation samples can be taken in a number of ways, depending on the accuracy required. Cuttings may suffice for shallow depths but become less representative with depth, particularly below the water table. The most accurate samples are obtained with various coring devices, such as split spoons or shelly tubes which can be used inside the augers. Continuous cores can also be taken with a thin-walled tube which is inserted into the lowest auger and locked in place. The tube is retracted with a wire line and hoist after the hole has been advanced the length of the auger. A bottom plug in the cutting head or bit prevents cuttings from entering the augers until the first core sample is taken and the plug is knocked out.

In unconsolidated material, the augers serve as a temporary casing and gravel-packed wells can be constructed inside the augers and then the augers withdrawn. Well development is usually less difficult than with wells drilled by the mud rotary method because a bentonite drilling fluid is not normally used.

2.2 Cable Tool Drilling

Cable tool drilling is a percussion method in which a bit, attached to a drilling string, is lifted and dropped. The drilling string, consists (bottom to top) of the bit, drill stem, drilling jars, socket, and wire cable. A walking beam on the drilling rig provides the lifting and dropping motion to the wire cable and hence to the drilling string. The repeated action breaks or loosens the formation material which mixes with formation water or water added to the hole by the operator to form a slurry. The slurry facilitates removal of the cuttings which are periodically removed from the hole with a bailer. In unconsolidated formations, steel casing must be driven or pushed into the ground as the drilling progresses in order to prevent hole collapse. A hardened steel drive shoe on the bottom end of the

casing prevents damage during driving. A well may then be constructed inside the steel casing and the casing pulled back. In consolidated formations, the casing may be driven through the weathered zone, and seated in solid rock. The hole below the casing may remain open or may be fitted with a smaller diameter inner casing and screen, depending on the sampling requirements. Depending on formation material, extensive well development may often not be necessary.

2.3 Rotary Drilling

2.3.1 Mud Rotary Method

In the mud rotary method the drill bit is rotated rapidly to cut the formation material and advance the borehole. The drill bit is attached to hollow drilling rods which transfer power from the rig to the bit. In conventional rotary drilling, cuttings are removed by pumping drilling fluid (water, or water mixed with bentonite or other additives) down through the drill rods and bit, and up the annulus between the borehole and the drill rods. The drilling fluid flows into a mud pit where the cuttings settle out and then is pumped back down the drill rods. The drilling fluid also cools the bit and prevents the borehole from collapsing in unconsolidated formations.

Sampling may be done from the cuttings but samples are generally mixed and the amount of fine material may not be accurately represented. Coring may be done through the drill rods and bit if a coring bit (with a center opening big enough to allow passage of the coring tube) is used. When drilling unconsolidated formations, a temporary surface or shallow casing may have to be installed in order to prevent cross-contamination, hole collapse, or wall erosion by the drilling fluid. Casing (riser pipe), screen, and gravel pack are usually installed in the open hole or through the surface casing. Once the well is constructed, extensive well development may be necessary in order to remove drilling fluid from the formation.

2.3.2 Air Rotary Method

The air rotary method uses air as the drilling fluid. Air is forced down the drill rods by an air compressor, escapes out of the bit and returns to the surface in the annular space between the hole wall and the drill string. Cuttings are moved out of the hole by the ascending air and collect around the rig. Cuttings are

mixed and may not always be representative of the depth currently being drilled. In the conventional air rotary method, the drill string operates in a manner similar to that described for the mud rotary system. In a "hammer" or "down-the-hole" air rotary method, the bit is pneumatically driven rapidly against the rock in short strokes while the drilling string slowly rotates. The use of air rotary methods are generally limited to consolidated and semi-consolidated formations. Casing is often used in semi-consolidated formations and through the weathered portion of consolidated formations to prevent hole collapse. In environmental work, the air supply must be filtered to prevent introduction of contamination into the borehole.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Often, a primary objective of the drilling program is to obtain representative lithologic or environmental samples. The most common techniques for retrieving samples are:

In unconsolidated formations:

- C Split spoon sampling, carried out continuously or at discrete intervals during drilling, as summarized in ASTM Method D-1586-84, Split Barrel Sampling
- C Shelby tube sampling when an undisturbed sample is required from clayey or silty soils, especially for geotechnical evaluation or chemical analysis
- C Cutting collection when a general lithologic description and approximate depths are sufficient

In consolidated formations:

- C Rock coring at continuous or discrete intervals
- C Cutting collection when a general lithologic description and approximate depths are sufficient

When collecting environmental samples, the amount of sample to be collected and the proper sample container type (i.e., glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest. Sample preservation, containers, handling

and storage for air and waste samples are discussed in the specific SOPs for the technique selected.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Advantages and disadvantages of the various drilling methods are summarized below.

4.1 Auger Drilling

The advantages of auger drilling are:

- C Relatively fast and inexpensive
- C Because augers act as temporary casing, drilling fluids are not used resulting in reduced well development

The disadvantages of auger drilling are:

- C Very slow or impossible to use in coarse materials such as cobble or boulders
- C Cannot be used in consolidated formations and is generally limited to depths of approximately 100 feet in order to be efficient

4.2 Cable Tool Drilling

The advantages of cable tool drilling are:

- C Relatively inexpensive with minimum labor requirements
- C The water table and water bearing zones are easily identified
- C Driven casing stabilizes borehole and minimizes potential for cross-contamination
- C Especially successful in drilling caving formations or formations containing boulders
- C Accurate formation samples can usually be obtained from cuttings

The disadvantages of cable tool drilling are:

- C Extremely slow rate of drilling

- C Necessity to drive casing may limit depth in large diameter holes.

4.3 Rotary Drilling

4.3.1 Mud Rotary Drilling

The advantages of mud rotary drilling are:

- C Fast, more than 100 feet of borehole advancement per day is common
- C Provides an open borehole, necessary for some types of geophysical logging and other tests

The disadvantages of mud rotary drilling are:

- C Potential for cross-contamination of water-bearing zones
- C Drill cuttings may be mixed and not accurately represent lithologies at a given drilling depth
- C Drilling mud may alter the groundwater chemistry
- C Water levels can only be determined by constructing wells
- C Drilling mud may change local permeability of the formation and may not be entirely removed during well development
- C Disposal of large volumes of drilling fluid and cuttings may be necessary if they are contaminated

4.3.2 Air Rotary Drilling

The advantages of air rotary drilling are:

- C Fast, more than 100 feet of borehole advancement a day is possible
- C Preliminary estimates of well yields and water levels are often possible
- C No drilling fluid to plug the borehole

The disadvantages of air rotary drilling are:

- C Generally cannot be used in unconsolidated formations
- C In contaminated zones, the use of high-pressure air may pose a significant hazard to the drill crew because of transport of contaminated material up the hole
- C Introduction of air to the groundwater could reduce concentration of volatile organic compounds

5.0 EQUIPMENT

The following equipment is necessary for the site geologist:

- C Metal clipboard box case (container for well logs)
- C Ruler
- C Depth sounder
- C Water level indicator
- C All required health and safety gear
- C Sample collection jars
- C Trowels
- C Description aids (Munsell color chart, grain size charts, etc.)
- C Geolis® Logbooks (Appendix A)
- C Field Logbook

Equipment and tools to install the well are normally provided by the drilling contractor.

6.0 REAGENTS

Reagents are not required for preservation of soil samples. Samples should, however, be cooled to 4° C and protected from sunlight in order to minimize any potential reaction due to the light sensitivity of the sample. Decontamination of drilling equipment should follow the Sampling Equipment Decontamination SOP and the site-specific work plan.

7.0 PROCEDURES

7.1 Preparation

All drilling and well installation programs must be planned and supervised by a professional geologist/hydrogeologist.

The planning, selection and implementation of any

monitor well installation program should include the following:

- C Review of existing data on site geology and hydrogeology including publications, air photos, water quality data, and existing maps. These may be obtained from local, state or federal agencies
- C Assessment of the site to determine potential access problems for drill rig, locate water supply sources, establish equipment storage area, and observe outcrops
- C Perform utilities check, note location of underground utilities and of overhead electrical wires
- C Preparation of a Site Safety Plan
- C Select drilling, sampling and well development methods
- C Determination of well construction specifications (i.e., casing and screen materials, casing and screen diameter, screen length and screen interval, filter pack and screen slot size)
- C Determination of the need for containing drill cuttings and fluids and their method of disposal
- C Preparation of work plan including all of the above
- C Preparation of and execute the drilling contract

7.2 Field Preparation

Prior to mobilization, the drill rig and all associated equipment should be thoroughly decontaminated by a steam/pressure washer to remove all oil, grease, mud, etc. Before drilling each boring, all the "down-the-hole" drill equipment should be steam cleaned and rinsed with potable water to minimize cross-contamination. Special attention should be given to the threaded section of the casings, and to the drill rods. All drilling equipment should be steam-cleaned at completion of the project to ensure that no contamination is transported to or from the sampling site.

7.3 Well Construction

The well casing material should not interact with the groundwater. Well casings for environmental projects are usually constructed of polyvinyl chloride (PVC), Teflon™, fiberglass, or stainless steel. Details of the construction methods are given in Sections 7.3.1 and 7.3.2.

7.3.1 Bedrock Wells

Wells completed in bedrock will be drilled using the air or mud rotary method. Crystalline rock wells are usually drilled most efficiently with the air rotary method while consolidated sedimentary formations are drilled using either the air rotary or mud rotary method. The compressed air supply will be filtered prior to introduction into the borehole to remove oil or other contaminants. Bedrock wells may be completed as an open-hole, providing that borehole cave-in is not a possibility.

Bedrock wells will be advanced with air or mud rotary methods until a minimum of 5 feet of competent rock has been drilled. Minimum borehole diameter will be 8 inches. The drill string will then be pulled from the borehole and 6-inch I.D. Schedule 80 or 40 PVC casing inserted. Portland cement/bentonite grout will be pumped into the hole and up the annular space outside the casing. After the grout has set (minimum of 24 hours), the cement will be drilled out and the borehole advanced to the desired depth. Figure 1 (Appendix B) shows typical construction details for an open-hole bedrock well.

The preferred method of well completion for the bedrock wells will be open-hole. However, if the open borehole is subject to cave-in, the well(s) will be completed as screened and cased sand-packed wells. For details of completion see Section 7.3.2.

7.3.2 Overburden Well Construction

Any of the drilling methods discussed in this SOP can be used to drill or set a well in the overburden. The hollow-stem method is the preferred choice for shallow (<100 ft.) overburden wells because the well can be constructed inside of the augers. Details of the construction are provided below and are shown in Figure 2 (Appendix B).

1. The screen slot size will be determined by the site hydrologist, based upon sand-pack size. The length of screen used will be site-dependent. Casing sections will be flush-threaded. Screw-threaded bottom plugs will be used. To prevent introduction of contaminants into the well, no glue-connected fittings will be used. Each piece of PVC pipe, screen, and the bottom plug will be steam-cleaned before lowering into the borehole. The site hydrogeologist is responsible for the supervision of all steam cleaning procedures.
2. The annular space between the well screen and the borehole wall will be filled with a uniform gravel/sand pack to serve as a filter media. For wells deeper than approximately 50 feet, or when recommended by the site geologist, the sand pack will be emplaced using a tremie pipe. A sand slurry composed of sand and potable water will be pumped through the tremie pipe into the annulus throughout the entire screened interval, and over the top of the screen. Allowance must be made for settlement of the sand pack.
3. The depth of the top of the sand will be determined using the tremie pipe, thus verifying the thickness of the sand pack. Additional sand shall be added to bring the top of the sand pack to approximately 2 to 3 feet above the top of the well screen. Under no circumstances should the sand pack extend into any aquifer other than the one to be monitored. In most cases, the well design can be modified to allow for a sufficient sand pack without threat of crossflow between producing zones through the sand pack.
4. In materials that will not maintain an open hole using hollow-stem augers, the temporary or outer casing will be withdrawn gradually during placement of sand pack/grout. For example, after filling two feet with sand pack, the outer casing should be withdrawn 2 feet. This step of placing more gravel and withdrawing the outer casing should be repeated until the level of the sand pack is approximately 3 feet above the top of the well screen. This ensures that there is no locking of the permanent (inner) casing in the outer casing.

5. A bentonite seal of a minimum 2-foot vertical thickness will be placed in the annular space above the sand pack to separate the sand pack from the cement surface seal. The bentonite will be placed through a tremie pipe or poured directly into the annular space, depending upon the depth and site conditions. The bentonite will be pourable pellets. The hydrogeologist will record the start and stop times of the bentonite seal emplacement, the interval of the seal, the amount of bentonite that was used, and problems that arise. The type of bentonite and the supplier will also be recorded.

A cap placed over the top of the well casing before pouring the bentonite pellets will prevent pellets from entering the well casing.
6. If a slurry of bentonite is used as annular seal, it is prepared by mixing powdered or granular bentonite with potable water. The slurry must be of sufficiently high specific gravity and viscosity to prevent its displacement by the grout to be emplaced above it. As a precaution (regardless of depth) and depending on fluid viscosity, a few handfuls of bentonite pellets may be added to solidify the bentonite slurry surface.
7. Cement and/or bentonite grout is placed from the top of the bentonite seal to the ground surface.

Only Type I or II cement without accelerator additives may be used. An approved source of potable water must be used for mixing grouting materials. The following mixes are acceptable:
 - C Neat cement, a maximum of 6 gallons of water per 94 pound bag of cement
 - C Granular bentonite, 1.5 pounds of bentonite per 1 gallon of water
 - C Cement-bentonite, 5 pounds of pure bentonite per 94 pound bag of cement with 7-8 gallons of water
 - C Cement-bentonite, 6 to 8 pounds of pure bentonite per 94 pound bag of cement with 8-10 gallons of water, if water mixed
- C Non-expandable cement, mixed at 7.5 gallons of water to one half (1/2) teaspoon of Aluminum Hydroxide, 94 pounds of neat cement (Type I) and 4 pounds of bentonite
- C Non-expandable cement, mixed at 7 gallons of water to one half (1/2) teaspoon of Aluminum Hydroxide, 94 pounds of neat cement (Type I and Type II)
8. Grout is pumped through a tremie pipe (normally a 1.25-inch PVC or steel pipe) to the bottom of the annulus until undiluted grout flows from the annulus at the ground surface
9. In materials that will not maintain an open hole, the temporary steel casing should be withdrawn in a manner that prevents the level of grout from dropping below the bottom of the casing.
10. Additional grout may be added to compensate for the removal of the temporary casing and the tremie pipe to ensure that the top of the grout is at or above ground surface. After the grout has set (about 24 hours), any depression due to settlement is filled with a grout mix similar to that described above.
11. The protective casing should now be set. Casing may be a 5 foot minimum length of black iron or galvanized pipe extending about 1.5 to 3 feet above the ground surface, and set in concrete or cement grout. The protective casing diameter should be 4 inches greater than the well casing. A 0.5-inch drain hole may be installed near ground level. A flush-mount protective casing may also be used in areas of high traffic or where access to other areas would be limited by a well stick-up.
12. A protective steel cap, secured to the protective casing by a padlock, should be installed.
13. Steel guard posts should be installed around the protective casing in areas where vehicle traffic may be a problem. Posts should have a minimum diameter of 3 inches and be a

minimum of 4 feet high.

14. All monitor wells should be labelled and dated with paint or steel tags.

7.4 Well Development

Well development is the process by which the aquifer's hydraulic conductivity is restored by removing drilling fluids, and fine-grained formation material from newly installed wells. Two methods of well development that are commonly used are surging and bailing, and overpumping. A well is considered developed when the pH and conductivity of the groundwater stabilizes and the measured turbidity is <50 nephelometric turbidity units (NTUs).

Surging and bailing will be performed as follows:

1. Measure the total depth (TD) of the well and depth to water (DTW).
2. Using an appropriately sized surge block, surge 5-foot sections of well screen, using 10-20 up/down cycles per section. Periodically remove the surge block and bail accumulated sediment from the well, as required.
3. For open-hole wells, a 6-inch surge block will be used inside the cased portion of the well. Sediments will be bailed periodically, as required. Overpumping may be used in combination with surging and bailing for development of bedrock wells. The method(s) used will be based on field conditions encountered, and will be determined by the site hydrogeologist. However, sediment will initially be removed from the wells by bailing in order to minimize the volume of development water generated.

The pump used must be rated to achieve the desired yield at a given depth. The pump system should include the following:

- C A check valve to prevent water from running back into the well when the pump is shut off
- C Flexible discharge hose
- C Safety cable or rope to remove the pump from the well

- C Flow meter monitoring system (measuring bucket or inline flow meter)
- C Generator
- C Amp meter, to measure electrical current (load)

The amp meter is used to monitor pump performance. If the pump becomes clogged, the current will increase due to stress on the pump. If the water level drops below the intake ports, the current will drop due to decreased resistance on the pump.

8.0 CALCULATIONS

To maintain an open borehole during rotary drilling, the drilling fluid must exert a pressure greater than the formation pore pressure. Typical pore pressures for unconfined and confined aquifers are 0.433 define (psi/ft) and 0.465 psi/ft, respectively.

The relationship for determining the hydrostatic pressure of the drilling fluid is:

$$\text{Hydrostatic Pressure (psi)} = \text{Fluid Density (lb/gal)} \times \text{Height of Fluid Column (ft)} \times 0.052$$

The minimum grout volume necessary to grout a well can be calculated using:

$$\text{Grout Vol (ft}^3\text{)} = \text{Vol of Borehole (ft}^3\text{)} - \text{Vol of Casing (ft}^3\text{)} = L (r_B^2 - r_C^2)$$

where:

- L = length of borehole to be grouted (ft)
- r_B = radius of boring (ft)
- r_C = radius of casing (ft)

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities that apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented on standard well completion forms, field data sheets or within field/site logbooks. Descriptive logs, pump tests, and well completion date are entered on Geolis® forms. The Geolis® forms are used to ensure data is collected uniformly by all Site Geologists and provide

input to a standardized computer well file. Appendix A contains examples of Geolis® forms used to record descriptions of geologic samples.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

Drilling rigs and equipment present a variety of safety hazards. REAC personnel working around drilling rigs should know the position of the emergency "kill" switch. Wirelines and ropes should be inspected and frayed or damaged sections discarded. Swivels and blocks should turn freely. Gages should be operational and controls clearly marked. All underground utilities should be clearly marked, and drillers should be aware of any overhead hazards such as power lines. Avoid drilling in these areas. Ear protection should be worn when working around drilling equipment for extended periods of time, particularly air rotary equipment. Failure to follow safety procedure or wear the proper personal protection gear on the part of either the drilling crew or REAC personnel may result in dismissal from the job.

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and corporate health and safety practices.

12.0 REFERENCES

American Society for Testing and Materials. 1991. Annual Book of ASTM Standards. Designation: D5092-90 Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers. p. 1081-1092. Philadelphia, PA.

Boateng, K., P.C. Evens, and S.M. Testa. 1984. "Groundwater Contamination of Two Production Wells: A Case History." *Groundwater Monitoring Review*, V.4, No. 2, p. 24-31.

Keely, J.F. and Kwasi Boateng. 1987. "Monitoring Well Installation, Purging, and Sampling Techniques - Part 1: Conceptualizations." *Groundwater* V. 25, No. 3, p. 300-313.

Keely, J.F. and Kwasi Boateng. 1987. "Monitoring Well Installation, Purging, and Sampling Techniques - Part 2: Case Histories." *Groundwater* V. 25, No. 4, p. 427-439.

Driscoll, F.G. 1986. *Groundwater and Wells* (2nd ed.): Johnson Division, UOP Inc., St. Paul, MN. p. 1089


U.S. EPA. 1987. A Compendium of Superfund Field Operations Methods. EPA/540/p-87/001 Office of Emergency and Remedial Responses. Washington, DC.

APPENDIX A

Geolis Forms

Form 1. Geolis® Borehole Logging Form

GEOLIS® Borehole Logging Form

COMPANY: _____		LOCATION ID: _____		
CLIENT: _____		DATE: _____		
PROJECT: _____		LOGGER: _____		
SITE / AREA: _____		SIGNATURE: _____		

SAMPLING METHOD: 8PS - CBS - STB - CTS - CUT - COR - NS		FLUID ENTRY/ LOSS ZONES: _____ FT/M BGS _____ GPM	
OTHER: _____		_____ FT/M BGS _____ GPM	
SAMPLING INTERVAL: _____ TO _____ FT/M BGS		ANALYTICAL SAMPLE ID _____ INTERVAL (FT/M BGS) _____	
RECOVERY: _____ / _____ FT/M NA		TYPE / LAB: UND - DIS - CMP / MOB - GEO - CHM -	
BLOW COUNT: <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> / <input type="text"/> IN/CM NA		/ _____	
RQD: _____ % NA		TYPE / LAB: UND - DIS - CMP / MOB - GEO - CHM -	

SAMPLING INTERVAL No.: _____		LITHOLOGY ARCHIVED? YES - NO NO RECOVERY	MATERIAL: NATURAL - FILL - UNCERTAIN	
LITHOLOGIC INTERVAL No.: _____			OBSERVED: 8TN - 8HN - ODR - PRD - NA - OTHER: _____	
LITHOLOGIC INTERVAL: _____ TO _____ FT/M BGS			INSTRUMENT 1 TYPE: _____ READING: _____	
			INSTRUMENT 2 TYPE: _____ READING: _____	

OVERBURDEN SECONDARY TYPE: NA - BED - CLB - MIX COLOR: MUN - GSA COLORATION: UNI - STN - MOT - VAR BOULDERS: _____ % MAX DIAM: _____ IN COBBLES: _____ % MAX DIAM: _____ IN TEXTURE: C - M - F GRAVEL: _____ % SAND: _____ % SILT: _____ % CLAY: _____ % ORGANIC: _____ % ROUNDNESS: GRAVEL: FAC - STR - ANG - SUB - RND - NA SAND: ANG - SUB - RND - NA SORTING: WEL - MOD - POR - NA PLASTICITY: NON - LOW - MOD - HGH - NA MOISTURE: DRY - MST - WET - SAT - NA CEMENTATION: NON - SLT - MOD - WEL - NA GRAIN TYPE: QTZ - FRG - FOS - BIO - NA MATRIX: MSM - CSM - CAL - OXD - ARG - SIL - NA STRENGTH: COHESIVE: VBF - SFT - FRM - STF - VBT - HRD NONCOHESIVE: VDN - DEN - FIR - LSE - NA UPPER CONTACT: 8HP - GRD - DIF - 8ME - NA BEDDING THICK: _____ IN/CM No.: _____ TYPE: XBD - RPL - HOR - INC - NA MAS - LNS - LAM - GRU - GRD STRAT UNIT: <input type="text"/> NOTE LINE: <input type="text"/>	GRAPHIC LOG	BEDROCK SECONDARY TYPE: NA - BED - VEN - MIX COLOR: MUN - GSA ROCK TYPE: OTHER: SED: 8HL - 8LT - 8ST - CGL - LST - DOL - COL MET: 8LA - PHY - 8HS - GNS - HRN - QZT - MBL IGN: GRN - RHY - 8SL - GBR - TUF - BRC TEXTURE: C - M - F NA GRAVEL: _____ % SAND: _____ % SILT: _____ % CLAY/UME MUD: _____ % GRAIN TYPE: QTZ - FRG - FOS - BIO - NA MATRIX: CAL - MIC - OXD - ARG - SIL - ORG - NA STRENGTH: EWK - VWK - WEK - MOD 8TR - VBT - EST UPPER CONTACT: 8HP - GRD - DIF - 8AM - NA SECONDARY: VUG - FRC - BED - NA - OTHER POROSITY: HGH - MOD - LOW WEATHERING: FRB - SLT - MOD - HGH - CPL - NA
--	-------------	---

NATURAL FRACTURE SETS				
INTERVAL (FT/M BGS)	#/FT-M	DIP	DIR	FILL SHAPE/ROUGH/SURFACE
—				FILL: OPN - PRT - FUL SHAPE: PLN - CUR - UND - STP - IRR ROUGH: SMH - MOD - RGH SURFACE: CLN - MIN - OXD - STN - WTH
—				FILL: OPN - PRT - FUL SHAPE: PLN - CUR - UND - STP - IRR ROUGH: SMH - MOD - RGH SURFACE: CLN - MIN - OXD - STN - WTH
—				FILL: OPN - PRT - FUL SHAPE: PLN - CUR - UND - STP - IRR ROUGH: SMH - MOD - RGH SURFACE: CLN - MIN - OXD - STN - WTH
—				FILL: OPN - PRT - FUL SHAPE: PLN - CUR - UND - STP - IRR ROUGH: SMH - MOD - RGH SURFACE: CLN - MIN - OXD - STN - WTH

NEXT SAMP/UTH No. _____	DEPTH INTERVAL _____	NOT SAMPLED _____
INTERVAL: _____ / _____	TO _____	NO RECOVERY _____

COMMENTS: (1) _____

(2) _____


APPENDIX A (Cont'd)

Geolis Forms

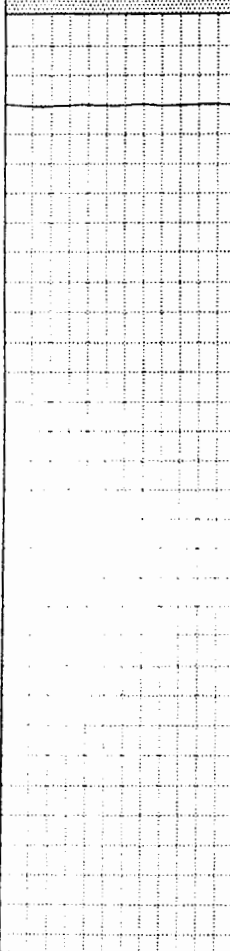
Form 2. Geolis® Well Construction Form

GEOLIS® Well Construction Form

Sheet _____ of _____

COMPANY: _____		LOCATION ID: _____		
PROJECT: _____		DATE: _____		
PROPERTY: _____		LOGGER: _____		
SITE/AREA: _____ / _____		SIGNATURE: _____		

START DATE: _____	SURVEYED ELEVATIONS (MSL)	DEPTH TO WATER	DATE / TIME
COMPLETION DATE: _____	GROUND LEVEL: _____ FT/M	_____ FT/M (TOC)	
WELL STATUS: PMP - ABN - COL - NOR	MEASURING POINT: _____ FT/M	_____ FT/M (TOC)	
STATUS DATE: _____		_____ FT/M (TOC)	

WELL DIAGRAM - NOT TO SCALE	DEPTH (FT. BGS)	WELL CODE	WELL TYPE: SCREEN - MULTIPLE SCREEN - OPEN HOLE - NESTED - PROBE	
	0	GRS	CASING: SINGLE - DOUBLE - TRIPLE COMPLETION: FLUSH - PROT - VAULT - CAP - NA	
			TOTAL NO. OF SCREENS/WELLS: _____ SCREEN/WELL NO.: _____	
			WELL USE: DOM - PUB - IRR - RIR - MON - HYD - EXT - DEW - RCH - VEW - INJ - OTH: _____	
			WELL DESIGN CONSTRUCTION	
			CASING #1: DIAMETER: _____ IN/CM INTERVAL: _____ TO _____ FT/M BGS	
			TYPE: PVC - STN - LCS - GAL - _____ SCHEDULE: 5 - 10 - 20 - 40 - 60 - _____	
			CASING JOINTS: FLT - BUT - EUT - SOL - WLD - SCW - CAM - OTH: _____	
			CASING #2: DIAMETER: _____ IN/CM INTERVAL: _____ TO _____ FT/M BGS	
			TYPE: PVC - STN - LCS - GAL - _____ SCHEDULE: 5 - 10 - 20 - 40 - 60 - _____	
			CASING #3: DIAMETER: _____ IN/CM INTERVAL: _____ TO _____ FT/M BGS	
TYPE: PVC - STN - LCS - GAL - _____ SCHEDULE: 5 - 10 - 20 - 40 - 60 - _____				
STICK UP: INNER CASING: _____ FT/M OUTER CASING: _____ FT/M				
GROUT: TYPE: CMT - C/S - BEN - HSB - OTH: _____				
INTERVAL: _____ TO _____ FT/M BGS				
PLACEMENT: TRM - PRS - GRV CENTRALIZERS: NON - 1 - 2 - 3 - OTH: _____				
SEAL: TYPE 1: _____ INTERVAL: _____ TO _____ FT/M BGS				
TYPE 2: _____ INTERVAL: _____ TO _____ FT/M BGS				
SAND PACK: TYPE: _____ INTERVAL: _____ TO _____ FT/M BGS				
SCREEN OR DEVICE: DIAMETER: _____ IN/MM INTERVAL: _____ TO _____ FT/M BGS				
TYPE: PVC - STN - LCS - TEF - CER - HDP - OTH: _____				
SLOTS: CON - SLH - SLV - BRG - CUT - OTH: _____				
SLOT SIZE: 6 - 10 - 20 - 30 - 40 - _____ SLOT				
STRAT UNIT MONITORED: _____				
ESTIMATED WELL YIELD: _____ GPM/LPM DRAWDOWN: _____ FT/M BMP				
WATER SAMPLING SYSTEM: NON - PMP - PKR - MLS TYPE: _____				
SEAL INTERVAL: _____ TO _____ FT/M BGS INTAKE DEPTH: _____ FT/M BGS				
NOTES: _____				
OPEN HOLE: DIAMETER 1: _____ IN/CM INTERVAL: _____ TO _____ FT/M BGS				
DIAMETER 2: _____ IN/CM INTERVAL: _____ TO _____ FT/M BGS				
SILT TRAP/SUMP: YES - NO INTERVAL: _____ TO _____ FT/M BGS				
INSIDE WELL T.D.: _____ FT/M BGS COLLAPSE/BACKFILL: COL - BFL - BTH - NON				
COLLAPSE INTERVAL: _____ TO _____ FT/M BGS				
BACKFILL INTERVAL: _____ TO _____ FT/M BGS TYPE: _____				

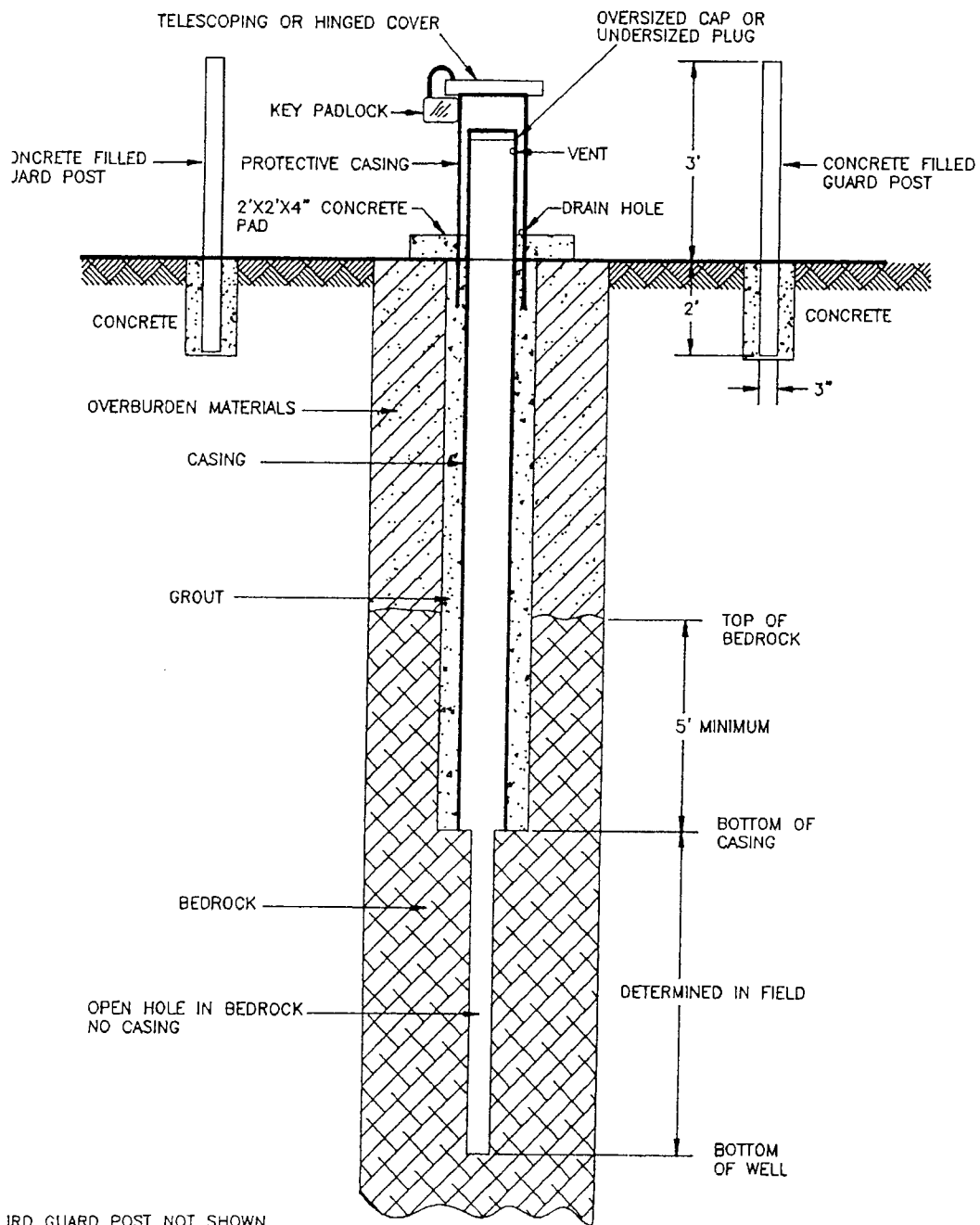
WELL CONSTRUCTION CODES			
GRS - GROUND SURFACE	TSC - TOP OF SCREEN	TST - TOP OF SILT TRAP	WTD - TOTAL DEPTH INSIDE WELL
SFC - BOTTOM OF PROTECTIVE CASING	TRM - TOP OF BENTONITE SEAL	WTD - BOREHOLE TOTAL DEPTH	TOC - TOP OF CASING (INNER)
TRM - TOP OF BEDROCK	BGS - BOTTOM OF OUTER CASING	TOC - TOP OF CASING (INNER)	BGS - BELOW GROUND SURFACE
TST - TOP OF SAND PACK			

COMMENTS: _____

APPENDIX B

Figures

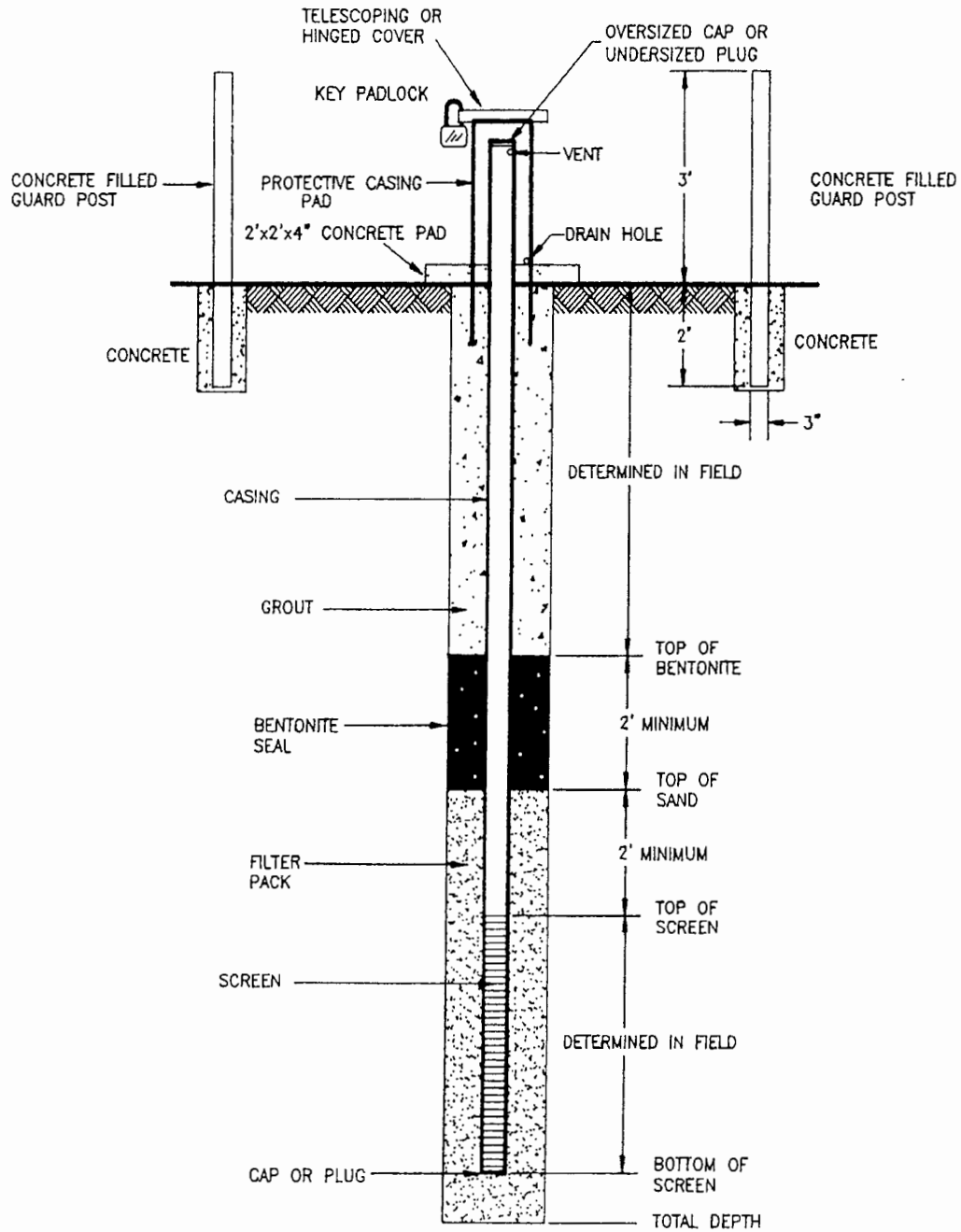
FIGURE 1. Typical Bedrock Well Construction



APPENDIX B (Cont'd)

Figures

FIGURE 2. Typical Overburden Well Construction



THIS PAGE INTENTIONALLY LEFT BLANK



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2044
PAGE: 1 of 8
REV: 0.1
DATE: 10/23/01

MONITOR WELL DEVELOPMENT

CONTENTS

- 1.0 SCOPE AND APPLICATION*
- 2.0 METHOD SUMMARY*
- 3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE
- 4.0 INTERFERENCES AND POTENTIAL PROBLEMS*
- 5.0 EQUIPMENT/APPARATUS*
- 6.0 REAGENTS
- 7.0 PROCEDURES
 - 7.1 Preparation
 - 7.2 Operation*
 - 7.3 Post-Operation
- 8.0 CALCULATIONS*
- 9.0 QUALITY ASSURANCE/QUALITY CONTROL*
- 10.0 DATA VALIDATION
- 11.0 HEALTH AND SAFETY
- 12.0 REFERENCES*
- 13.0 APPENDICES*

*These sections affected by Revision 0.1.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2044
PAGE: 2 of 8
REV: 0.1
DATE: 10/23/01

MONITOR WELL DEVELOPMENT

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide an overview of monitor well development practices. The purpose of monitor well development is to ensure removal of fine grained sediments (fines) from the vicinity of the well screen. This allows the water to flow freely from the formation into the well, and also reduces the turbidity of the water during sampling. The most common well development methods are: surging, jetting, overpumping, and bailing.

Surging involves raising and lowering a surge block or surge plunger inside the well. The resulting surging motion forces water into the formation and loosens sediment, pulled from the formation into the well. Occasionally, sediments must be removed from the well with a sand bailer to prevent sand locking of the surge block. This method may cause the sand pack around the screen to be displaced to a degree that damages its value as a filtering medium. Channels or voids may form near the screen if the filter pack sloughs away during surging (Keel and Boating, 1987).

Surging with compressed air is done by injecting a sudden charge of compressed air into the well with an air line so that water is forced through the well screen. The air is then turned off so that the water column falls back into the well and the process is repeated. Periodically, the air line is pulled up into a pipe string (educator) and water is pumped from the well using air as the lifting medium (air-lift pumping). The process is repeated until the well is sediment free. Method variations include leaving the air line in the pipe string at all times or using the well casing as the educator pipe.

Jetting involves lowering a small diameter pipe into the well and injecting a high velocity horizontal stream of water or air through the pipe into the screen openings. This method is especially effective at breaking down filter cakes developed during mud rotary drilling. Simultaneous air-lift pumping is usually used to remove fines.

Overpumping involves pumping at a rate rapid enough to draw the water level in the well as low as possible, and then allowing the well to recharge to the original level. This process is repeated until sediment-free water is produced.

Bailing includes the use of a simple manually operated check-valve bailer to remove water from the well. The bailing method, like other methods, should be repeated until sediment free water is produced. Bailing may be the method of choice in a shallow well or well that recharges slowly.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with a final report.

Mention of trade names or commercial products does not constitute United States Environmental Protection



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2044
PAGE: 3 of 8
REV: 0.1
DATE: 10/23/01

MONITOR WELL DEVELOPMENT

Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

After installation, development of a well should occur as soon as it is practical. It should not occur any sooner than 48 hours after grouting is completed, especially if a vigorous well development method (i.e. surging) is being used. If a less vigorous method (i.e. bailing) is used, it may be initiated shortly after installation. The method used for development should not interfere with the setting of the well seal.

Several activities must take place prior to well development. First, open the monitor well, take initial measurements (i.e., head space air monitoring readings, water level, total depth of the well) and record results in the site logbook. Develop the well by the appropriate method to accommodate site conditions and project objectives. Continue until the development water is clear and free of sediments, or until parameters such as pH, temperature, and specific conductivity stabilize. Containerize all purge water from wells with known or suspected contamination. Record final measurements in the site logbook. Decontaminate equipment as appropriate prior to use in the next well.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The following problems may be associated with well development:

1. Overpumping is not as vigorous as surging and jetting, and is probably the most desirable method for monitor well development. The possibility of disturbing the filter pack is greatest with surging and jetting well development methods.
2. The introduction of external water or air by jetting may alter the hydro chemistry of the aquifer.
3. Surging with air may produce "air locking" in some formations, preventing water from flowing into the well.
4. The use of surge blocks in formations containing clay may cause plugging of the screen.
5. Small (2-inch nominal diameter) submersible pumps that will fit in 2-inch diameter well casing are especially susceptible to clogging if used in well development applications.
6. Chemicals/reagents used during the decontamination of drilling equipment may complicate well development.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2044
PAGE: 4 of 8
REV: 0.1
DATE: 10/23/01

MONITOR WELL DEVELOPMENT

5.0 EQUIPMENT/APPARATUS

The type of equipment used for well development is dependent on the diameter of the well and the development method. For example, the diameter of most submersible pumps is too large to fit into a two-inch inner diameter (I.D.) well, and other development methods should be used. Obtaining the highest possible yield is not usually an objective in developing monitor wells and vigorous development is not always necessary. Many monitor wells are constructed in fine-grained formations that would not normally be considered aquifers. Specifications for the drilling contract should include the necessary well development equipment (air compressors, pumps, air lines, surge blocks, generators).

6.0 REAGENTS

The use of chemicals in developing wells that will be used to monitor groundwater quality should be avoided if possible; however, polyphosphates (a dispersing agent), acids, or disinfectants are often used in general well development. Polyphosphates should not be used in thinly bedded sequences of sands and clays. The use of decontamination solutions may also be necessary. If decontamination of equipment is required at a well, refer to Environmental Response Team/Response Engineering and Analytical Contract (ERT/REAC) SOP #2006, *Sampling Equipment Decontamination* and the site specific work plan.

7.0 PROCEDURES

7.1 Preparation

1. Coordinate site access and obtain keys to well locks.
2. Obtain information on each well to be developed (i.e., drilling method, well diameter, well depth, screened interval, anticipated contaminants).
3. Obtain a water level meter, a depth sounder, air monitoring instruments, materials for decontamination, and water quality instrumentation capable of measuring, at a minimum, pH, specific conductivity, temperature, and turbidity. Dissolved oxygen (DO) and salinity are also useful parameters.
4. Assemble containers for temporary storage of water produced during well development. Containers must be structurally sound, compatible with anticipated contaminants, and easy to manage in the field. The use of truck-mounted or roll-off tanks may be necessary in some cases; alternately, a portable water treatment unit (i.e., activated carbon) may be used to decontaminate the purge water.

7.2 Operation



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2044
PAGE: 5 of 8
REV: 0.1
DATE: 10/23/01

MONITOR WELL DEVELOPMENT

Development should be performed as soon as it is practical after the well is installed, but no sooner than 48 hours after well completion.

1. Assemble necessary equipment on a plastic sheet surrounding the well.
2. Record pertinent information in the site or personal logbook (personnel, time, location ID, etc.).
3. Open monitor well, take air monitor reading at the top of casing and in the breathing zone as appropriate.
4. Measure depth to water and the total depth of the monitor well. Calculate the water column volume of the well (Equation 1, Section 8.0).
5. Begin development and measure the initial pH, temperature, turbidity, and specific conductivity of the water and record in the site logbook. Note the initial color, clarity, and odor of the water.
6. Continue to develop the well and periodically measure the water quality parameters indicated in step 5 (above). Depending on project objectives and available time, development should proceed until these water quality parameters stabilize, or until the water has a turbidity of less than 50 nephelometric turbidity units (NTUs).
7. All water produced by development of contaminated or suspected contaminated wells must be containerized or treated. Each container must be clearly labeled with the location ID, date collected, and sampling contractor. Determination of the appropriate disposal method will be based on the analytical results from each well.
8. No water shall be added to the well to assist development without prior approval by the appropriate U.S. EPA ERT Work Assignment Manager (WAM) and/or appropriate state personnel. In some cases, small amounts of potable water may be added to help develop a poor yielding well. It is essential that at least five times the amount of water injected must be recovered from the well in order to assure that all injected water is removed from the formation.
9. Note the final water quality parameters in the site or personal logbook along with the following data:

Well designation (location ID)
Date(s) of well installation
Date(s) and time of well development



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2044
PAGE: 6 of 8
REV: 0.1
DATE: 10/23/01

MONITOR WELL DEVELOPMENT

Static water level before and after development
Quantity of water removed, and initial and completion time
Type and capacity of pump or bailer used
Description of well development techniques

7.3 Post-Operation

1. Decontaminate all equipment;
2. Secure holding tanks or containers of development water;
3. Review analytical results and determine the appropriate water disposal method. Actual disposal of the purge water is generally carried out by the On-Scene Coordinator (OSC).

8.0 CALCULATIONS

To calculate the volume of water in the well, the following equation is used:

$$\text{Well Volume (V)} = r^2 h (cf) \quad [\text{Equation 1}]$$

where:

r = pi (3.14)
= radius of monitoring well in feet (ft)
 h = height of the water column in ft. [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]
 cf = conversion factor in gallons per cubic foot (gal/ft^3) = $7.48 \text{ gal}/\text{ft}^3$. [In this equation, $7.48 \text{ gal}/\text{ft}^3$ is the necessary conversion factor.]

Monitor well diameters are typically 2-, 3-, 4-, or 6-inches. A number of standard conversion factors can be used to simplify the above equation using the diameter of the monitor well. The volume, in gallons per linear foot, for various standard monitor well diameters can be calculated as follows:

where:

$$V (\text{gal}/\text{ft}) = r^2 (cf) \quad [\text{Equation 2}]$$

r = pi
= radius of monitoring well (feet)
 cf = conversion factor ($7.48 \text{ gal}/\text{ft}^3$)



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2044
PAGE: 7 of 8
REV: 0.1
DATE: 10/23/01

MONITOR WELL DEVELOPMENT

For example, a two inch diameter well, the volume per linear foot can be calculated as follows:

$$\begin{aligned} V \text{ (gal/ft)} &= r^2 \text{ (cf)} \quad [\text{Equation 2}] \\ &= 3.14 (1/12 \text{ ft})^2 \quad 7.48 \text{ gal/ft}^3 \\ &= 0.1631 \text{ gal/ft} \end{aligned}$$

NOTE: The diameter must be converted to the radius in feet as follows:

$$\frac{\text{Well Diameter (inches)}}{12} \times 0.5 = \text{Well Radius (feet)} \quad [\text{Equation 3}]$$

The volume in gallons/feet for the common size monitor wells are as follows:

Well diameter (inches)	2	3	4	6
Volume (gal/ft)	0.1631	0.3670	0.6524	1.4680

If you utilize the volumes for the common size wells above, Equation 1 is modified as follows:
where:

$$\text{Well volume} = (h)(f) \quad [\text{Equation 4}]$$

$$\begin{aligned} h &= \text{height of water column (feet)} \\ f &= \text{the volume in gal/ft calculated from Equation 2} \end{aligned}$$

9.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance activities, which apply to the implementation of these procedures. However, the following general quality assurance/quality control (QA/QC) procedures apply:

1. All data must be documented in site and/or personal logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2044
PAGE: 8 of 8
REV: 0.1
DATE: 10/23/01

MONITOR WELL DEVELOPMENT

When working with potentially hazardous materials, follow U.S. EPA, Occupational Safety and Health (OSHA), and corporate health and safety practices.

12.0 REFERENCES

Driscoll, F. G. 1986. "Development of Water Wells." In: *Groundwater and Wells*. Second Edition. Chapter 15. Johnson Filtration Division, St. Paul, Minnesota. p. 497-533.

Freeze, Allan R. and John A. Cherry. 1979. *Groundwater*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Keel, J.F. and Kwasi Boating. 1987. "Monitoring Well Installation, Purging, and Sampling Techniques - Part 1: Conceptualizations". *Groundwater*, 25(3):300-313.

Keel, J.F. and Kwasi Boating. 1987. "Monitoring Well Installation, Purging, and Sampling Techniques - Part 2: Case Histories". *Groundwater*, 25(4):427-439.

13.0 APPENDICES

This section is not applicable to this SOP.

THIS PAGE INTENTIONALLY LEFT BLANK



GROUNDWATER WELL SAMPLING

SOP#: 2007
DATE: 01/26/95
REV. #: 0.0

1.0 SCOPE AND APPLICATION

The objective of this standard operating procedure (SOP) is to provide general reference information on sampling of ground water wells. This guideline is primarily concerned with the collection of water samples from the saturated zone of the subsurface. Every effort must be made to ensure that the sample is representative of the particular zone of water being sampled. These procedures are designed to be used in conjunction with analyses for the most common types of ground water contaminants (e.g., volatile and semi-volatile organic compounds, pesticides, metals, biological parameters).

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

In order to obtain a representative groundwater sample for chemical analysis it is important to remove stagnant water in the well casing and the water immediately adjacent to the well before collection of the sample. This may be achieved with one of a number of instruments. The most common of these are the bailer, submersible pump, non-contact gas bladder pump, inertia pump and suction pump. At a minimum, three well volumes should be purged, if possible. Equipment must be decontaminated prior to use and between wells. Once purging is completed and the correct laboratory-cleaned sample containers have been prepared, sampling may proceed. Sampling may be conducted with any of the above instruments,

and need not be the same as the device used for purging. Care should be taken when choosing the sampling device as some will affect the integrity of the sample. Sampling should occur in a progression from the least to most contaminated well, if this information is known.

The growing concern over the past several years over low levels of volatile organic compounds in water supplies has led to the development of highly sophisticated analytical methods that can provide detection limits at part per trillion levels. While the laboratory methods are extremely sensitive, well controlled and quality assured, they cannot compensate for a poorly collected sample. The collection of a sample should be as sensitive, highly developed and quality assured as the analytical procedures.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The type of analysis for which a sample is being collected determines the type of bottle, preservative, holding time, and filtering requirements. Samples should be collected directly from the sampling device into appropriate laboratory cleaned containers. Check that a Teflon liner is present in the cap, if required. Attach a sample identification label. Complete a field data sheet, a chain of custody form, and record all pertinent data in the site logbook.

Samples shall be appropriately preserved, labelled, logged, and placed in a cooler to be maintained at 4EC. Samples must be shipped well before the holding time is up and ideally should be shipped within 24 hours of sample collection. It is imperative that samples be shipped or delivered daily to the analytical laboratory in order to maximize the time available for the laboratory to perform the analyses. The bottles should be shipped with adequate packing and cooling to ensure that they arrive intact.

Sample retrieval systems suitable for the valid collection of volatile organic samples are: positive displacement bladder pumps, gear driven submersible pumps, syringe samplers and bailers (Barcelona, 1984; Nielsen, 1985). Field conditions and other constraints will limit the choice of appropriate systems. The focus of concern must remain to provide a valid sample for analysis, one which has been subjected to the least amount of turbulence possible.

Treatment of the sample with sodium thiosulfate preservative is required only if there is residual chlorine in the water that could cause free radical chlorination and change the identity of the original contaminants. It should not be used if there is no chlorine in the water.

Holding time for volatiles analysis is seven days. It is imperative that the sample be shipped or delivered daily to the analytical laboratory. The bottles must be shipped on their sides to aid in maintaining the airtight seal during shipment, with adequate packing and cooling to ensure that they arrive intact.

For collection of volatile organic samples, refer to the work plan to ensure that 40 mL glass sample vials with Teflon lined septa are ordered and in sufficient numbers. Check sampling supplies; field kit for chlorine, preservatives, Parafilm, foam sleeves and coolers. Due to the extreme trace levels at which volatile organics are detectable, cross contamination and introduction of contaminants must be avoided. Trip blanks are incorporated into the shipment package to provide a check against cross contamination.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

4.1 General

The primary goal in performing ground water sampling is to obtain a representative sample of the ground water body. Analysis can be compromised by field personnel in two primary ways: (1) taking an unrepresentative sample, or (2) by incorrect handling of the sample. There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and utilizing trained field personnel.

4.2 Purging

In a nonpumping well, there will be little or no vertical mixing of the water, and stratification will occur. The well water in the screened section will mix with the ground water due to normal flow patterns, but the well water above the screened section will remain isolated, become stagnant, and may lack the contaminants representative of the ground water. Persons sampling should realize that stagnant water may contain foreign material inadvertently or deliberately introduced from the surface, resulting in an unrepresentative sample. To safeguard against collecting nonrepresentative stagnant water, the following guidelines and techniques should be adhered to during sampling:

1. As a general rule, all monitor wells should be pumped or bailed prior to sampling. Purge water should be containerized on site or handled as specified in the site specific project plan. Evacuation of a minimum of one volume of water in the well casing, and preferably three to five volumes, is recommended for a representative sample. In a high-yielding ground water formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical. However, in all cases where the monitoring data is to be used for enforcement actions, evacuation is recommended.
2. When purging with a pump (not a bailer), the pump should be set at the screened interval, or if the well is an open-rock well, it should be set at the same depth the sample will be collected. When sampling a screened well, the sample should also be collected from the same depth the pump was set at.
3. The well should be sampled as soon as possible after purging.
4. Analytical parameters typically dictate whether the sample should be collected through the purging device, or through a separate sampling instrument.
5. For wells that can be pumped or bailed to dryness with the equipment being used, the well should be evacuated and allowed to

recover prior to collecting a sample. If the recovery rate is fairly rapid and time allows, evacuation of more than one volume of water is preferred. If recovery is slow, sample the well upon recovery after one evacuation.

6. A non-representative sample can also result from excessive pre-pumping of the monitoring well. Stratification of the leachate concentration in the ground water formation may occur, or heavier-than-water compounds may sink to the lower portions of the aquifer. Excessive pumping can dilute or increase the contaminant concentrations from what is representative of the sampling point of interest.

4.3 Materials

Materials of construction for samplers and evacuation equipment (bladders, pump, bailers, tubing, etc.) should be limited to stainless steel, Teflon[®], and glass in areas where concentrations are expected to be at or near the detection limit. The tendency of organics to leach into and out of many materials make the selection of materials critical for trace analyses. The use of plastics, such as PVC or polyethylene, should be avoided when analyzing for organics. However, PVC may be used for evacuation equipment as it will not come in contact with the sample, and in highly contaminated wells, disposable equipment (i.e., polypropylene bailers) may be appropriate to avoid cross-contamination.

Materials of construction (bladders/ pumps, bailers, tubing, etc.) suitable for collecting and handling Volatile Organic Samples should be limited to stainless steel, Teflon and glass in areas which detection limit range concentrations are expected. The tendency of organics to leach into and out of many materials, make the selection of materials critical for these trace analyses. The use of plastics, e.g., PVC etc., should be avoided. There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and utilization of trained personnel.

4.4 Advantages/Disadvantages of Certain Equipment

4.4.1 Bailers

Advantages

- C Only practical limitations on size and materials
- C No power source needed
- C Portable
- C Inexpensive, so it can be dedicated and hung in a well, thereby reducing the chances of cross contamination
- C Minimal outgassing of volatile organics while sample is in bailer
- C Readily available
- C Removes stagnant water first
- C Rapid, simple method for removing small volumes of purge water

Disadvantages

- C Time-consuming to flush a large well of stagnant water
- C Transfer of sample may cause aeration
- C Stoppers at the bottom of the bailer usually leak thus the bailer must be brought to the surface rapidly
- C If the bailer is allowed to hit the bottom of the well boring, gravel can displace the ball valve not allowing the bailer to hold water

4.4.2 Submersible Pumps

Advantages

- C Portable and can be transported to several wells
- C Depending upon the size of the pump and the pumping depths, relatively high pumping rates are possible
- C Generally very reliable and does not require priming

Disadvantages

- C Potential for effects on analysis of trace organics
- C Heavy and cumbersome to deal with, particularly in deeper wells
- C Expensive
- C Power source needed
- C Sediment in water may cause problems with the pumps
- C Impractical in low yielding or shallow wells

4.4.3 Non-Contact Gas Bladder Pumps

Advantages

- C Maintains integrity of sample
- C Easy to use
- C Can sample from discrete locations within the monitor well

Disadvantages

- C Difficulty in cleaning, though dedicated tubing and bladder may be used
- C Only useful to about 100 feet
- C Supply of gas for operation, gas bottles and/or compressors are often difficult to obtain and are cumbersome
- C Relatively low pumping rates
- C Requires air compressor or pressurized gas source and control box

4.4.4 Suction Pumps

Advantages

- C Portable, inexpensive, and readily available

Disadvantages

- C Restricted to areas with water levels within 20 to 25 feet of the ground surface
- C Vacuum can cause loss of dissolved gasses and volatile organics
- C Pump must be primed and vacuum is often difficult to maintain during initial stages of pumping

4.4.5 Inertia Pumps

Advantages

- C Portable, inexpensive, and readily available
- C Offers a rapid method for purging relatively shallow wells

Disadvantages

- C Restricted to areas with water levels within 70 feet of the ground surface
- C May be time consuming to purge wells with these manual pumps
- C Labor intensive
- C WaTerra pumps are only effective in 2-inch diameter wells

5.0 EQUIPMENT APPARATUS

5.1 Equipment Checklist

5.1.1 General

- C Water level indicator
 - electric sounder
 - steel tape
 - transducer
 - reflection sounder
 - airline
- C Depth sounder
- C Appropriate keys for well cap locks
- C Steel brush
- C HNU or OVA (whichever is most appropriate)
- C Logbook
- C Calculator
- C Field data sheets and samples labels

- C Chain of custody records and seals
- C Sample containers
- C Engineer's rule
- C Sharp knife (locking blade)
- C Tool box (to include at least: screwdrivers, pliers, hacksaw, hammer, flashlight, adjustable wrench)
- C Leather work gloves
- C Appropriate Health & Safety gear
- C 5-gallon pail
- C Plastic sheeting
- C Shipping containers
- C Packing materials
- C Bolt cutters
- C Ziploc plastic bags
- C Containers for evacuation liquids
- C Decontamination solutions
- C Tap water
- C Non phosphate soap
- C Several brushes
- C Pails or tubs
- C Aluminum foil
- C Garden sprayer
- C Preservatives
- C Distilled or deionized water
- C Fire extinguisher (if using a generator for your power source)

5.1.2 Bailers

- C Clean, decontaminated bailers of appropriate size and construction material
- C Nylon line, enough to dedicate to each well
- C Teflon coated bailer wire
- C Sharp knife
- C Aluminum foil (to wrap clean bailers)
- C Five gallon bucket

5.1.3 Submersible Pump

- C Pump(s)
- C Generator (110, 120, or 240 volt) or 12 volt battery if inaccessible to field vehicle - amp meter is useful
- C 1" black PVC coil tubing - enough to dedicate to each well
- C Hose clamps
- C Safety cable
- C Tool box supplement
- pipe wrenches

- wire strippers
- electrical tape
- heat shrink
- hose connectors
- Teflon tape

- C Winch, pulley or hoist

- C Gasoline for generator/gas can

- C Flow meter with gate valve

- C 1" nipples and various plumbing (i.e., pipe connectors)

- C Control box (if necessary)

5.1.4 Non-Gas Contact Bladder Pump

- C Non-gas contact bladder pump
- C Compressor or nitrogen gas tank
- C Batteries and charger
- C Teflon tubing - enough to dedicate to each well
- C Swagelock fitting
- C Toolbox supplements - same as submersible pump
- C Control box (if necessary)

5.1.5 Suction Pump

- C Pump
- C 1" black PVC coil tubing - enough to dedicate to each well
- C Gasoline - if required
- C Toolbox
- C Plumbing fittings
- C Flow meter with gate valve

5.1.6 Inertia Pump

- C Pump assembly (WaTerra pump, piston pump)
- C Five gallon bucket

6.0 REAGENTS

Reagents may be utilized for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be performed. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

7.0 PROCEDURE

7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed (i.e, diameter and depth of wells to be sampled).
2. Obtain necessary sampling and monitoring equipment, appropriate to type of contaminant being investigated. For collection of volatile organic samples, refer to the work plan to ensure that 40 mL glass sample vials with Teflon lined septa are ordered and in sufficient numbers. Check sampling supplies; field kit for chlorine, preservatives, Parafilm, foam sleeves and coolers. Due to extreme trace levels at which volatile organics are detectable, cross contamination and introduction of contaminants must be avoided. Trip blanks are incorporated into the shipment package to provide a check against cross contamination.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site specific Health and Safety Plan.
6. Identify and mark all sampling locations.

7.2 Field Preparation

1. Start at the least contaminated well, if known.
2. Lay plastic sheeting around the well to minimize likelihood of contamination of equipment from soil adjacent to the well.
3. Remove locking well cap, note location, time of day, and date in field notebook or appropriate log form.
4. Remove well casing cap.

5. Screen headspace of well with an appropriate monitoring instrument to determine the presence of volatile organic compounds and record in site logbook.

6. Lower water level measuring device or equivalent (i.e., permanently installed transducers or airline) into well until water surface is encountered.

7. Measure distance from water surface to reference measuring point on well casing or protective barrier post and record in site logbook. Alternatively, if no reference point, note that water level measurement is from top of steel casing, top of PVC riser pipe, from ground surface, or some other position on the well head.

If floating organics are of concern, this can be determined by measuring the water level with an oil/water interface probe which measures floating organics.

8. Measure total depth of well (at least twice to confirm measurement) and record in site logbook or on field data sheet.
9. Calculate the volume of water in the well and the volume to be purged using the calculations in Section 8.0.
10. Select the appropriate purging and sampling equipment.
11. If residual chlorine is suspected, use the Hach Field Test Kit for chlorine to determine if there is residual chlorine in the water to be sampled. If there is, treat the sample vial with a crystal of sodium thiosulfate prior to sample collection.

7.3 Purging

The amount of flushing a well receives prior to sample collection depends on the intent of the monitoring program as well as the hydrogeologic conditions. Programs where overall quality determination of water resources are involved may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume can be determined prior to sampling so that the sample is

a collected after a known volume of the water is evacuated from the aquifer, or the well can be pumped until the stabilization of parameters such as temperature, electrical conductance, pH, or turbidity has occurred.

However, monitoring for defining a contaminant plume requires a representative sample of a small volume of the aquifer. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce flow from other areas. Generally, three well volumes are considered effective, or calculations can be made to determine, on the basis of the aquifer parameters and well dimensions, the appropriate volume to remove prior to sampling.

During purging, water level measurements may be taken regularly at 15-30 second intervals. This data may be used to compute aquifer transmissivity and other hydraulic characteristics. The following well evacuation devices are most commonly used. Other evacuation devices are available, but have been omitted in this discussion due to their limited use.

7.3.1 Bailers

Bailers are the simplest purging device used and have many advantages. They generally consist of a rigid length of tube, usually with a ball check-valve at the bottom. A line is used to lower the bailer into the well and retrieve a volume of water. The three most common types of bailer are PVC, Teflon, and stainless steel.

This manual method of purging is best suited to shallow or narrow diameter wells. For deep, larger diameter wells which require evacuation of large volumes of water, other mechanical devices may be more appropriate.

7.3.1.1 Operation

Equipment needed will include a clean decontaminated bailer, Teflon or nylon line, a sharp knife, and plastic sheeting.

1. Determine the volume of water to be purged as described in 8.0, calculations.
2. Lay plastic sheeting around the well to prevent contamination of the bailer line with

foreign materials.

3. Attach the line to the bailer and slowly lower until the bailer is completely submerged, being careful not to drop the bailer to the water, causing turbulence and the possible loss of volatile organic contaminants.
4. Pull bailer out ensuring that the line either falls onto a clean area of plastic sheeting or never touches the ground.
5. Empty the bailer into a pail until full to determine the number of bails necessary to achieve the required purge volume.
6. Thereafter, pour the water into a container and dispose of purge waters as specified in the site specific sampling plan.

7.3.2 Submersible Pumps

The use of submersible pumps for sample collection is permissible provided they are constructed of suitably noncontaminating materials. The chief drawback, however, is the difficulty avoiding cross-contamination between wells. Although some units can be disassembled easily to allow surfaces contacted by contaminants to be cleaned, field decontamination may be difficult and require solvents that can affect sample analysis. The use of submersible pumps in multiple well-sampling programs, therefore, should be carefully considered against other sampling mechanisms (bailers, bladder pumps). In most cases, a sample can be collected by bailer after purging with a submersible pump, however, submersible pumps may be the only practical sampling device for extremely deep wells (greater than 300 feet of water). Under those conditions, dedicated pump systems should be installed to eliminate the potential for cross-contamination of well samples.

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas or air. Electric powered pumps can run off a 12 volt DC rechargeable battery, or a 110 or 220 volt AC power supply. Those units powered by compressed air normally use a small electric or gas-powered air compressor. They may also utilize compressed gas (i.e., nitrogen) from bottles. Different size pumps are available for different depth or diameter monitoring wells.

7.3.2.1 Operation

1. Determine the volume of water to be purged as described in 8.0 Calculations.
2. Lay plastic sheeting around the well to prevent contamination of pumps, hoses or lines with foreign materials.
3. Assemble pump, hoses and safety cable, and lower the pump into the well. Make sure the pump is deep enough so all the water is not evacuated. (Running the pump without water may cause damage.)
4. Attach flow meter to the outlet hose to measure the volume of water purged.
5. Use a ground fault circuit interrupter (GFCI) or ground the generator to avoid possible electric shock.
6. Attach power supply, and purge the well until the specified volume of water has been evacuated (or until field parameters, such as temperature, pH, conductivity, etc, have stabilized). Do not allow the pump to run dry. If the pumping rate exceeds the well recharge rate, lower the pump further into the well, and continue pumping.
7. Collect and dispose of purge waters as specified in the site specific sampling plan.

7.3.3 Non-Contact Gas Bladder Pumps

For this procedure, an all stainless-steel and Teflon Middleburg-squeeze bladder pump (e.g., IEA, TIMCO, Well Wizard, Geoguard, and others) is used to provide the least amount of material interference to the sample (Barcelona, 1985). Water comes into contact with the inside of the bladder (Teflon) and the sample tubing, also Teflon, that may be dedicated to each well. Some wells may have permanently installed bladder pumps, (i.e., Well Wizard, Geoguard), that will be used to sample for all parameters.

7.3.3.1 Operation

1. Assemble Teflon tubing, pump and charged control box.
2. Procedure for purging with a bladder pump is

the same as for a submersible pump (Section 7.3.2.1).

3. Be sure to adjust flow rate to prevent violent jolting of the hose as sample is drawn in.

7.3.4 Suction Pumps

There are many different types of suction pumps. They include: centrifugal, peristaltic and diaphragm. Diaphragm pumps can be used for well evacuation at a fast pumping rate and sampling at a low pumping rate. The peristaltic pump is a low volume pump that uses rollers to squeeze the flexible tubing thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. Peristaltic pumps, however, require a power source.

7.3.4.1 Operation

1. Assembly of the pump, tubing, and power source if necessary.
2. Procedure for purging with a suction pump is exactly the same as for a submersible pump (Section 7.3.2.1).

7.3.5 Inertia Pumps

Inertia pumps such as the WaTerra pump and piston pump, are manually operated. They are most appropriate to use when wells are too deep to bail by hand, or too shallow or narrow (or inaccessible) to warrant an automatic (submersible, etc.) pump. These pumps are made of plastic and may be either decontaminated or discarded.

7.3.5.1 Operation

1. Determine the volume of water to be purged as described in 8.0, Calculations.
2. Lay plastic sheeting around the well to prevent contamination of pumps or hoses with foreign materials.
3. Assemble pump and lower to the appropriate depth in the well.
4. Begin pumping manually, discharging water into a 5 gallon bucket (or other graduated vessel). Purge until specified volume of water has been evacuated (or until field parameters such as temperature, pH,

conductivity, etc. have stabilized).

5. Collect and dispose of purge waters as specified in the site specific project plan.

7.4 Sampling

Sample withdrawal methods require the use of pumps, compressed air, bailers, and samplers. Ideally, purging and sample withdrawal equipment should be completely inert, economical to manufacture, easily cleaned, sterilized, reusable, able to operate at remote sites in the absence of power resources, and capable of delivering variable rates for sample collection.

There are several factors to take into consideration when choosing a sampling device. Care should be taken when reviewing the advantages or disadvantages of any one device. It may be appropriate to use a different device to sample than that which was used to purge. The most common example of this is the use of a submersible pump to purge and a bailer to sample.

7.4.1 Bailers

The positive-displacement volatile sampling bailer is perhaps the most appropriate for collection of water samples for volatile analysis. Other bailer types (messenger, bottom fill, etc.) are less desirable, but may be mandated by cost and site conditions.

7.4.1.1 Operation

1. Surround the monitor well with clean plastic sheeting. If using the GPI bailer, insert a vial into the claim and assemble the unit.
2. Attach a line to a clean decontaminated bailer.
3. Lower the bailer slowly and gently into the well, taking care not to shake the casing sides or to splash the bailer into the water. Stop lowering at a point adjacent to the screen.
4. Allow bailer to fill and then slowly and gently retrieve the bailer from the well avoiding contact with the casing, so as not to knock flakes of rust or other foreign materials into the bailer. If using the GPI bailer for collecting volatile organic samples,

once at the surface, remove the bailer from the cable. Carefully open the GPI bailer unit and remove the vial. Begin slowly pouring from the bailer, and collect the duplicate samples from the midstream sample.

5. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated. See Section 7.7 for special considerations on VOA samples.
6. Begin slowly pouring from the bailer.
7. Filter and preserve samples as required by sampling plan.
8. Cap the sample container tightly and place prelabeled sample container in a carrier.
9. Replace the well cap.
10. Log all samples in the site logbook and on field data sheets and label all samples.
11. Package samples and complete necessary paperwork.
12. Transport sample to decontamination zone for preparation for transport to analytical laboratory.

7.4.2 Submersible Pumps

Although it is recommended that samples not be collected with a submersible pump due to the reasons stated in Section 4.4.2, there are some situations where they may be used.

7.4.2.1 Operation

1. Allow the monitor well to recharge after purging, keeping the pump just above screened section.
2. Attach gate valve to hose (if not already fitted), and reduce flow of water to a manageable sampling rate.
3. Assemble the appropriate bottles.
4. If no gate valve is available, run the water

down the side of a clean jar and fill the sample bottles from the jar.

5. Cap the sample container tightly and place prelabeled sample container in a carrier.
6. Replace the well cap.
7. Log all samples in the site logbook and on the field data sheets and label all samples.
8. Package samples and complete necessary paperwork.
9. Transport sample to decontamination zone for preparation for transport to the analytical laboratory.
10. Upon completion, remove pump and assembly and fully decontaminate prior to setting into the next sample well. Dedicate the tubing to the hole.

7.4.3 Non-Contact Gas Bladder Pumps

The use of a non-contact gas positive displacement bladder pump is often mandated by the use of dedicated pumps installed in wells. These pumps are also suitable for shallow (less than 100 feet) wells. They are somewhat difficult to clean, but may be used with dedicated sample tubing to avoid cleaning. These pumps require a power supply and a compressed gas supply (or compressor). They may be operated at variable flow and pressure rates making them ideal for both purging and sampling.

Barcelona (1984) and Nielsen (1985) report that the non-contact gas positive displacement pumps cause the least amount of alteration in sample integrity as compared to other sample retrieval methods.

7.4.3.1 Operation

1. Allow well to recharge after purging.
2. Assemble the appropriate bottles.
3. Turn pump on, increase the cycle time and reduce the pressure to the minimum that will allow the sample to come to the surface.
4. Cap the sample container tightly and place

prelabeled sample container in a carrier.

5. Replace the well cap.
6. Log all samples in the site logbook and on field data sheets and label all samples.
7. Package samples and complete necessary paperwork.
8. Transport sample to decontamination zone for preparation for transport to analytical laboratory.
9. On completion, remove the tubing from the well and either replace the Teflon tubing and bladder with new dedicated tubing and bladder or rigorously decontaminate the existing materials.
10. Nonfiltered samples shall be collected directly from the outlet tubing into the sample bottle.
11. For filtered samples, connect the pump outlet tubing directly to the filter unit. The pump pressure should remain decreased so that the pressure build up on the filter does not blow out the pump bladder or displace the filter. For the Geotech barrel filter, no actual connections are necessary so this is not a concern.

7.4.4 Suction Pumps

In view of the limitations of these type pumps, they are not recommended for sampling purposes.

7.4.5 Inertia Pumps

Inertia pumps may be used to collect samples. It is more common, however, to purge with these pumps and sample with a bailer (Section 7.4.1).

7.4.5.1 Operation

1. Following well evacuation, allow the well to recharge.
2. Assemble the appropriate bottles.
3. Since these pumps are manually operated,

the flow rate may be regulated by the sampler. The sample may be discharged from the pump outlet directly into the appropriate sample container.

4. Cap the sample container tightly and place prelabeled sample container in a carrier.
5. Replace the well cap.
6. Log all samples in the site logbook and on field data sheets and label all samples.
7. Package samples and complete necessary paperwork.
8. Transport sample to decontamination zone for preparation for transport to the analytical laboratory.
9. Upon completion, remove pump and decontaminate or discard, as appropriate.

7.4.6. Sample Retrieval - Syringe

A limited number of commercial syringe type samplers are available, (IEA, TIMCO, etc.) some are homemade devices. These devices are claimed to provide good quality samples for volatile analysis, but are severely limited in sample volume and are specific to sampling for volatiles. Essentially, they operated with an evacuated chamber that is lowered down the well, and allowed to fill with the pressure of the water. The entire mechanism is then brought to the surface with the sample. The sample may then be transferred to a sample vial, or the entire unit may be sent as the sample container.

1. Evacuate the syringe if necessary, and lower the sampling device to just below the well screen.
2. Remove the constriction from the device and allow the sample to fill the syringe, apply slight suction as necessary.
3. Bring unit to the surface. If necessary, transfer the sample to vials, as outlined in steps 2 through 7 above.

7.5 Filtering

For samples requiring filtering, such as total metals analysis, the filter must be decontaminated prior to and between uses. Filters work by two methods. A barrel filter such as the "Geotech" filter works with a bicycle pump, used to build up positive pressure in the chamber containing the sample which is then forced through the filter paper (minimum size 0.45 μm) into a jar placed underneath. The barrel itself is filled manually from the bailer or directly via the hose of the sampling pump. The pressure must be maintained up to 30 lbs/in² by periodic pumping.

A vacuum type filter involves two chambers; the upper chamber contains the sample and a filter (minimum size 0.45 μm) divides the chambers. Using a hand pump or a Gilian type pump, air is withdrawn from the lower chamber, creating a vacuum and thus causing the sample to move through the filter into the lower chamber where it is drained into a sample jar. Repeated pumping may be required to drain all the sample into the lower chamber. If preservation of the sample is necessary, this should be done after filtering.

7.6 Post Operation

After all samples are collected and preserved, the sampling equipment should be decontaminated prior to sampling another well to prevent cross-contamination of equipment and monitor wells between locations.

1. Decontaminate all equipment.
2. Replace sampling equipment in storage containers.
3. Prepare and transport ground water samples to the laboratory. Check sample documentation and make sure samples are properly packed for shipment.

7.7 Special Considerations for VOA Sampling

The proper collection of a sample for volatile organics requires minimal disturbance of the sample to limit volatilization and therefore a loss of volatiles from the sample.

Sample retrieval systems suitable for the valid collection of volatile organic samples are: positive displacement bladder pumps, gear driven submersible pumps, syringe samplers and bailers (Barcelona, 1984; Nielsen, 1985). Field conditions and other constraints will limit the choice of appropriate systems. The focus of concern must be to provide a valid sample for analysis, one which has been subjected to the least amount of turbulence possible.

The following procedures should be followed:

1. Open the vial, set cap in a clean place, and collect the sample during the middle of the cycle. When collecting duplicates, collect both samples at the same time.
2. Fill the vial to just overflowing. Do not rinse the vial, nor excessively overflow it. There should be a convex meniscus on the top of the vial.
3. Check that the cap has not been contaminated (splashed) and carefully cap the vial. Place the cap directly over the top and screw down firmly. Do not overtighten and break the cap.
4. Invert the vial and tap gently. Observe vial for at least ten (10) seconds. If an air bubble appears, discard the sample and begin again. It is imperative that no entrapped air is in the sample vial.
5. Immediately place the vial in the protective foam sleeve and place into the cooler, oriented so that it is lying on its side, not straight up.
6. The holding time for VOAs is seven days. Samples should be shipped or delivered to the laboratory daily so as not to exceed the holding time. Ensure that the samples remain at 4EC, but do not allow them to freeze.

8.0 CALCULATIONS

If it is necessary to calculate the volume of the well, utilize the following equation:

$$\text{Well volume} = \pi r^2 h (cf) \quad [\text{Equation 1}]$$

where:

$$\begin{aligned} \pi &= \text{pi} \\ r &= \text{radius of monitoring well (feet)} \\ h &= \text{height of the water column (feet)} \\ & \quad [\text{This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.}] \\ cf &= \text{conversion factor (gal/ft}^3\text{)} = 7.48 \text{ gal/ft}^3 \text{ [In this equation, 7.48 gal/ft}^3 \text{ is the necessary conversion factor.]} \end{aligned}$$

Monitor well diameters are typically 2", 3", 4", or 6". Knowing the diameter of the monitor well, there are a number of standard conversion factors which can be used to simplify the equation above.

The volume, in gallons per linear foot, for various standard monitor well diameters can be calculated as follows:

$$v(\text{gal/ft}) = \pi r^2 (cf) \quad [\text{Equation 2}]$$

where:

$$\begin{aligned} \pi &= \text{pi} \\ r &= \text{radius of monitoring well (feet)} \\ cf &= \text{conversion factor (7.48 gal/ft}^3\text{)} \end{aligned}$$

For a 2" diameter well, the volume per linear foot can be calculated as follows:

$$\begin{aligned} \text{vol/linear ft} &= \pi r^2 (cf) \quad [\text{Equation 2}] \\ &= 3.14 (1/12 \text{ ft})^2 7.48 \text{ gal/ft}^3 \\ &= 0.1632 \text{ gal/ft} \end{aligned}$$

Remember that if you have a 2" diameter well, you must convert this to the radius in feet to be able to use the equation.

The conversion factors for the common size monitor wells are as follows:

Well diameter	2"	3"	4"	6"
Volume (gal/ft.)	0.1632	0.3672	0.6528	1.4688

If you utilize the conversion factors above, Equation

1 should be modified as follows:

$$\text{Well volume} = (h)(cf) \quad [\text{Equation 3}]$$

where:

h = height of water column (feet)
 cf = the conversion factor calculated from Equation 2

The well volume is typically tripled to determine the volume to be purged.

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance (QA) activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.
3. The collection of rinsate blanks is recommended to evaluate potential for cross contamination from the purging and/or sampling equipment.
4. Trip blanks are required if analytical parameters include VOAs.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA or REAC health and safety guidelines. More specifically, depending upon the site specific contaminants, various protective programs

must be implemented prior to sampling the first well. The site health and safety plan should be reviewed with specific emphasis placed on the protection program planned for the well sampling tasks. Standard safe operating practices should be followed such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and disposable clothing.

When working around volatile organic contaminants:

1. Avoid breathing constituents venting from the well.
2. Pre-survey the well head-space with an FID/PID prior to sampling.
3. If monitoring results indicate organic constituents, sampling activities may be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.

Physical hazards associated with well sampling:

1. Lifting injuries associated with pump and bailers retrieval; moving equipment.
2. Use of pocket knives for cutting discharge hose.
3. Heat/cold stress as a result of exposure to extreme temperatures and protective clothing.
4. Slip, trip, fall conditions as a result of pump discharge.
5. Restricted mobility due to the wearing of protective clothing.
6. Electrical shock associated with use of submersible pumps is possible. Use a GFCI or a copper grounding stake to avoid this problem.

12.0 REFERENCES

Barcelona, M.J., Helfrich, J.A., Garske, E.E., and J.P. Gibb, Spring 1984. "A Laboratory Evaluation of Groundwater Sampling Mechanisms," Groundwater

- Monitoring Review, 1984 pp. 32-41.
- Barcelona, M.J., Helfrich, J.A., and Garske, E.E., "Sampling Tubing Effects on Groundwater Samples", *Analy. Chem.*, Vol. 57, 1985 pp. 460-463.
- Driscoll, F.G., *Groundwater and Wells* (2nd ed.) Johnson Division, UOP Inc., St. Paul, Minnesota, 1986, 1089 pp.
- Gibb, J.P., R.M. Schuller, and R.A. Griffin., *Monitoring Well Sampling and Preservation Techniques*, EPA-600/9-80-010, 1980. March, 1980.
- Instrument Specialties Company, (January). *Instruction Manual, Model 2100 Wastewater Sampler*, Lincoln, Nebraska, 1980.
- Keely, J.F. and Kwasi Boateng, *Monitoring Well Installation, Purging and Sampling Techniques - Part I: Conceptualizations*, *Groundwater V25*, No. 3, 1987 pp. 300-313.
- Keith, Lawrence H., *Principles of Environmental Sampling*, American Chemical Society, 1988.
- Korte, Nic, and Dennis Ealey., *Procedures for Field Chemical Analyses of Water Samples*, U.S. Department of Energy, GJ/TMC-07, Technical Measurements Center, Grand Junction Project Office, 1983.
- Korte, Nic, and Peter Kearl., *Procedures for the Collection and Preservation of Groundwater and Surface Water Samples and for the Installation of Monitoring Wells: Second Edition*, U.S. Department of Energy, GJ/TMC-08, Technical Measurements Center, Grand Junction Projects Office, 1985.
- National Council of the Paper Industry for Air and Stream Improvement, Inc.,. *A Guide to Groundwater Sampling*, Technical Bulletin No. 362, Madison, New York. January, 1982.
- Nielsen, David M. and Yeates, Gillian L., Spring. "A Comparison of Sampling Mechanisms Available for Small-Diameter Groundwater Monitoring Wells," *Groundwater Monitoring Review*, 1985 pp. 83-99.
- Salf, et al. (M.J. Salf, McNabb, W. Dunlap, R. Crosby, and J. Fryberger),. *Manual for Groundwater Sampling Procedures*. R.S. Kerr Environmental Research Laboratory, Office of Research and Development. 1980, Ada, OK.
- Sisk, S.W. NEIC Manual for Ground/Surface Investigations at Hazardous Waste Sites, EPA-330/9-81-002, 1981.
- U.S. Department of the Interior, *National Handbook of Recommended Methods for Water-Data Acquisition*, Reston, Virginia.
- U.S. Environmental Protection Agency, 1977. *Procedures Manual for Groundwater Monitoring at Solid Waste Disposal Facilities*. EPA-530/SW-611. August, 1977.
- U.S. Code of Federal Regulations, 49 CFR Parts 100 to 177, Transportation revised November 1, 1985.
- U.S. Environmental Protection Agency, 1982. *Handbook for Chemical and Sample Preservation of Water and Wastewater*, EPA-600/4-82-029, Washington, D.C.
- U.S. Environmental Protection Agency, 1983. *Methods for Chemical Analysis of Water and Waste*, EPA-600/4-79-020, Washington, D.C.
- U.S. Environmental Protection Agency, 1984. *Test Methods for Evaluation of Solid Waste*, EPA-SW-846, Second Edition, Washington, D.C.
- U.S. Environmental Protection Agency, 1981. *Manual of Groundwater Quality Sampling Procedures*, EPA-600/2-81-160, Washington, D.C.
- U.S. Environmental Protection Agency, 1985. *Practical Guide for Groundwater Sampling*, EPA-600/2-85/104, September, 1985.
- U.S. Environmental Protection Agency, 1986. *RCRA Groundwater Monitoring Technical Enforcement Guidance Document*, OSWER-9950-1, September, 1986.
- Weston, 1987. *Standard Operations Procedures for Monitor Well Installation*. MOUND IGMP/RIP.
- U.S. Environmental Protection Agency, 1982. Handbook for Sampling and Sample Preservation of Water and Wastewater, EPA-600/4-82-029, Washington, D.C.
- 1981. Manual of Groundwater Quality

Sampling Procedures, EPA-600/2-81-160,
Washington, D.C.

--- 1985. Practice Guide for Groundwater
Sampling, EPA-600/2/85-104, September
1985.

Nielsen, David M. and Yeates, Gillian L., Spring
1985. "A Comparison of Sampling Mechanisms
Available for Small-Diameter Groundwater
Monitoring Wells," Groundwater Monitoring Review,
pp. 83-99.

WESTON, 1987. Standard Operating Procedures for
Monitor Well Installation. MOUND IGMP/RIP

Barcelona, M.J. Helfrich, J.A., and Garske, E.E.,
"Sampling Tubing Effects on Groundwater Samples".
1985, *Analy. Chem.*, Vol. 57, pp. 460-463.



SAMPLING EQUIPMENT DECONTAMINATION

SOP#: 2006
DATE: 08/11/94
REV. #: 0.0

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide a description of the methods used for preventing, minimizing, or limiting cross-contamination of samples due to inappropriate or inadequate equipment decontamination and to provide general guidelines for developing decontamination procedures for sampling equipment to be used during hazardous waste operations as per 29 Code of Federal Regulations (CFR) 1910.120. This SOP does not address personnel decontamination.

These are standard (i.e. typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitation, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

Removing or neutralizing contaminants from equipment minimizes the likelihood of sample cross contamination, reduces or eliminates transfer of contaminants to clean areas, and prevents the mixing of incompatible substances.

Gross contamination can be removed by physical decontamination procedures. These abrasive and non-abrasive methods include the use of brushes, air and wet blasting, and high and low pressure water cleaning.

The first step, a soap and water wash, removes all visible particulate matter and residual oils and grease. This may be preceded by a steam or high pressure

water wash to facilitate residuals removal. The second step involves a tap water rinse and a distilled/deionized water rinse to remove the detergent. An acid rinse provides a low pH media for trace metals removal and is included in the decontamination process if metal samples are to be collected. It is followed by another distilled/deionized water rinse. If sample analysis does not include metals, the acid rinse step can be omitted. Next, a high purity solvent rinse is performed for trace organics removal if organics are a concern at the site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water. Acetone is typically chosen because it is an excellent solvent, miscible in water, and not a target analyte on the Priority Pollutant List. If acetone is known to be a contaminant of concern at a given site or if Target Compound List analysis (which includes acetone) is to be performed, another solvent may be substituted. The solvent must be allowed to evaporate completely and then a final distilled/deionized water rinse is performed. This rinse removes any residual traces of the solvent.

The decontamination procedure described above may be summarized as follows:

1. Physical removal
2. Non-phosphate detergent wash
3. Tap water rinse
4. Distilled/deionized water rinse
5. 10% nitric acid rinse
6. Distilled/deionized water rinse
7. Solvent rinse (pesticide grade)
8. Air dry
9. Distilled/deionized water rinse

If a particular contaminant fraction is not present at the site, the nine (9) step decontamination procedure specified above may be modified for site specificity. For example, the nitric acid rinse may be eliminated if metals are not of concern at a site. Similarly, the solvent rinse may be eliminated if organics are not of

THIS PAGE INTENTIONALLY LEFT BLANK

concern at a site. Modifications to the standard procedure should be documented in the site specific work plan or subsequent report.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The amount of sample to be collected and the proper sample container type (i.e., glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest.

More specifically, sample collection and analysis of decontamination waste may be required before beginning proper disposal of decontamination liquids and solids generated at a site. This should be determined prior to initiation of site activities.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

- C The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free (specifically for the contaminants of concern).
- C The use of an untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal or industrial water treatment system.
- C If acids or solvents are utilized in decontamination they raise health and safety, and waste disposal concerns.
- C Damage can be incurred by acid and solvent washing of complex and sophisticated sampling equipment.

5.0 EQUIPMENT/APPARATUS

Decontamination equipment, materials, and supplies are generally selected based on availability. Other considerations include the ease of decontaminating or disposing of the equipment. Most equipment and supplies can be easily procured. For example, soft-

bristle scrub brushes or long-handled bottle brushes can be used to remove contaminants. Large galvanized wash tubs, stock tanks, or buckets can hold wash and rinse solutions. Children's wading pools can also be used. Large plastic garbage cans or other similar containers lined with plastic bags can help segregate contaminated equipment. Contaminated liquid can be stored temporarily in metal or plastic cans or drums.

The following standard materials and equipment are recommended for decontamination activities:

5.1 Decontamination Solutions

- C Non-phosphate detergent
- C Selected solvents (acetone, hexane, nitric acid, etc.)
- C Tap water
- C Distilled or deionized water

5.2 Decontamination Tools/Supplies

- C Long and short handled brushes
- C Bottle brushes
- C Drop cloth/plastic sheeting
- C Paper towels
- C Plastic or galvanized tubs or buckets
- C Pressurized sprayers (H₂O)
- C Solvent sprayers
- C Aluminum foil

5.3 Health and Safety Equipment

Appropriate personal protective equipment (i.e., safety glasses or splash shield, appropriate gloves, aprons or coveralls, respirator, emergency eye wash)

5.4 Waste Disposal

- C Trash bags
- C Trash containers
- C 55-gallon drums
- C Metal/plastic buckets/containers for storage and disposal of decontamination solutions

6.0 REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions. Table 1 (Appendix A) lists solvent rinses which may be required for elimination of particular chemicals. In

general, the following solvents are typically utilized for decontamination purposes:

- C 10% nitric acid is typically used for inorganic compounds such as metals. An acid rinse may not be required if inorganics are not a contaminant of concern.
- C Acetone (pesticide grade)⁽¹⁾
- C Hexane (pesticide grade)⁽¹⁾
- C Methanol⁽¹⁾

⁽¹⁾ - Only if sample is to be analyzed for organics.

7.0 PROCEDURES

As part of the health and safety plan, a decontamination plan should be developed and reviewed. The decontamination line should be set up before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- C The number, location, and layout of decontamination stations.
- C Decontamination equipment needed.
- C Appropriate decontamination methods.
- C Methods for disposal of contaminated clothing, equipment, and solutions.
- C Procedures can be established to minimize the potential for contamination. This may include: (1) work practices that minimize contact with potential contaminants; (2) using remote sampling techniques; (3) covering monitoring and sampling equipment with plastic, aluminum foil, or other protective material; (4) watering down dusty areas; (5) avoiding laying down equipment in areas of obvious contamination; and (6) use of disposable sampling equipment.

7.1 Decontamination Methods

All samples and equipment leaving the contaminated area of a site must be decontaminated to remove any contamination that may have adhered to equipment. Various decontamination methods will remove contaminants by: (1) flushing or other physical action, or (2) chemical complexing to inactivate

contaminants by neutralization, chemical reaction, disinfection, or sterilization.

Physical decontamination techniques can be grouped into two categories: abrasive methods and non-abrasive methods, as follows:

7.1.1 Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The mechanical abrasive cleaning methods are most commonly used at hazardous waste sites. The following abrasive methods are available:

Mechanical

Mechanical methods of decontamination include using metal or nylon brushes. The amount and type of contaminants removed will vary with the hardness of bristles, length of time brushed, degree of brush contact, degree of contamination, nature of the surface being cleaned, and degree of contaminant adherence to the surface.

Air Blasting

Air blasting equipment uses compressed air to force abrasive material through a nozzle at high velocities. The distance between nozzle and surface cleaned, air pressure, time of application, and angle at which the abrasive strikes the surface will dictate cleaning efficiency. Disadvantages of this method are the inability to control the amount of material removed and the large amount of waste generated.

Wet Blasting

Wet blast cleaning involves use of a suspended fine abrasive. The abrasive/water mixture is delivered by compressed air to the contaminated area. By using a very fine abrasive, the amount of materials removed can be carefully controlled.

7.1.2 Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off a surface with pressure. In general, the equipment surface is not removed using non-abrasive methods.

Low-Pressure Water

This method consists of a container which is filled with water. The user pumps air out of the container to create a vacuum. A slender nozzle and hose allow the user to spray in hard-to-reach places.

High-Pressure Water

This method consists of a high-pressure pump, an operator controlled directional nozzle, and a high-pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) and flow rates usually range from 20 to 140 liters per minute.

Ultra-High-Pressure Water

This system produces a water jet that is pressured from 1,000 to 4,000 atmospheres. This ultra-high-pressure spray can remove tightly-adhered surface films. The water velocity ranges from 500 meters/second (m/s) (1,000 atm) to 900 m/s (4,000 atm). Additives can be used to enhance the cleaning action.

Rinsing

Contaminants are removed by rinsing through dilution, physical attraction, and solubilization.

Damp Cloth Removal

In some instances, due to sensitive, non-waterproof equipment or due to the unlikelihood of equipment being contaminated, it is not necessary to conduct an extensive decontamination procedure. For example, air sampling pumps hooked on a fence, placed on a drum, or wrapped in plastic bags are not likely to become heavily contaminated. A damp cloth should be used to wipe off contaminants which may have adhered to equipment through airborne contaminants or from surfaces upon which the equipment was set.

Disinfection/Sterilization

Disinfectants are a practical means of inactivating infectious agents. Unfortunately, standard sterilization methods are impractical for large equipment. This method of decontamination is typically performed off-site.

7.2 Field Sampling Equipment Decontamination Procedures

The decontamination line is setup so that the first station is used to clean the most contaminated item. It progresses to the last station where the least contaminated item is cleaned. The spread of contaminants is further reduced by separating each decontamination station by a minimum of three (3) feet. Ideally, the contamination should decrease as the equipment progresses from one station to another farther along in the line.

A site is typically divided up into the following boundaries: Hot Zone or Exclusion Zone (EZ), the Contamination Reduction Zone (CRZ), and the Support or Safe Zone (SZ). The decontamination line should be setup in the Contamination Reduction Corridor (CRC) which is in the CRZ. Figure 1 (Appendix B) shows a typical contaminant reduction zone layout. The CRC controls access into and out of the exclusion zone and confines decontamination activities to a limited area. The CRC boundaries should be conspicuously marked. The far end is the hotline, the boundary between the exclusion zone and the contamination reduction zone. The size of the decontamination corridor depends on the number of stations in the decontamination process, overall dimensions of the work zones, and amount of space available at the site. Whenever possible, it should be a straight line.

Anyone in the CRC should be wearing the level of protection designated for the decontamination crew. Another corridor may be required for the entry and exit of heavy equipment. Sampling and monitoring equipment and sampling supplies are all maintained outside of the CRC. Personnel don their equipment away from the CRC and enter the exclusion zone through a separate access control point at the hotline. One person (or more) dedicated to decontaminating equipment is recommended.

7.2.1 Decontamination Setup

Starting with the most contaminated station, the decontamination setup should be as follows:

Station 1: Segregate Equipment Drop

Place plastic sheeting on the ground (Figure 2, Appendix B). Size will depend on amount of

equipment to be decontaminated. Provide containers lined with plastic if equipment is to be segregated. Segregation may be required if sensitive equipment or mildly contaminated equipment is used at the same time as equipment which is likely to be heavily contaminated.

Station 2: Physical Removal With A High-Pressure Washer (Optional)

As indicated in 7.1.2, a high-pressure wash may be required for compounds which are difficult to remove by washing with brushes. The elevated temperature of the water from the high-pressure washers is excellent at removing greasy/oily compounds. High pressure washers require water and electricity.

A decontamination pad may be required for the high-pressure wash area. An example of a wash pad may consist of an approximately 1 1/2 foot-deep basin lined with plastic sheeting and sloped to a sump at one corner. A layer of sand can be placed over the plastic and the basin is filled with gravel or shell. The sump is also lined with visqueen and a barrel is placed in the hole to prevent collapse. A sump pump is used to remove the water from the sump for transfer into a drum.

Typically heavy machinery is decontaminated at the end of the day unless site sampling requires that the machinery be decontaminated frequently. A separate decontamination pad may be required for heavy equipment.

Station 3: Physical Removal With Brushes And A Wash Basin

Prior to setting up Station 3, place plastic sheeting on the ground to cover areas under Station 3 through Station 10.

Fill a wash basin, a large bucket, or child's swimming pool with non-phosphate detergent and tap water. Several bottle and bristle brushes to physically remove contamination should be dedicated to this station. Approximately 10 - 50 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.

Station 4: Water Basin

Fill a wash basin, a large bucket, or child's swimming

pool with tap water. Several bottle and bristle brushes should be dedicated to this station. Approximately 10-50 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.

Station 5: Low-Pressure Sprayers

Fill a low-pressure sprayer with distilled/deionized water. Provide a 5-gallon bucket or basin to contain the water during the rinsing process. Approximately 10-20 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.

Station 6: Nitric Acid Sprayers

Fill a spray bottle with 10% nitric acid. An acid rinse may not be required if inorganics are not a contaminant of concern. The amount of acid will depend on the amount of equipment to be decontaminated. Provide a 5-gallon bucket or basin to collect acid during the rinsing process.

Station 7: Low-Pressure Sprayers

Fill a low-pressure sprayer with distilled/deionized water. Provide a 5-gallon bucket or basin to collect water during the rinsate process.

Station 8: Organic Solvent Sprayers

Fill a spray bottle with an organic solvent. After each solvent rinse, the equipment should be rinsed with distilled/deionized water and air dried. Amount of solvent will depend on the amount of equipment to decontaminate. Provide a 5-gallon bucket or basin to collect the solvent during the rinsing process.

Solvent rinses may not be required unless organics are a contaminant of concern, and may be eliminated from the station sequence.

Station 9: Low-Pressure Sprayers

Fill a low-pressure sprayer with distilled/deionized water. Provide a 5-gallon bucket or basin to collect water during the rinsate process.

Station 10: Clean Equipment Drop

Lay a clean piece of plastic sheeting over the bottom

plastic layer. This will allow easy removal of the plastic in the event that it becomes dirty. Provide aluminum foil, plastic, or other protective material to wrap clean equipment.

7.2.2 Decontamination Procedures

Station 1: Segregate Equipment Drop

Deposit equipment used on-site (i.e., tools, sampling devices and containers, monitoring instruments radios, clipboards, etc.) on the plastic drop cloth/sheet or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross contamination. Loose leaf sampling data sheets or maps can be placed in plastic zip lock bags if contamination is evident.

Station 2: Physical Removal With A High-Pressure Washer (Optional)

Use high pressure wash on grossly contaminated equipment. Do not use high- pressure wash on sensitive or non-waterproof equipment.

Station 3: Physical Removal With Brushes And A Wash Basin

Scrub equipment with soap and water using bottle and bristle brushes. Only sensitive equipment (i.e., radios, air monitoring and sampling equipment) which is waterproof should be washed. Equipment which is not waterproof should have plastic bags removed and wiped down with a damp cloth. Acids and organic rinses may also ruin sensitive equipment. Consult the manufacturers for recommended decontamination solutions.

Station 4: Equipment Rinse

Wash soap off of equipment with water by immersing the equipment in the water while brushing. Repeat as many times as necessary.

Station 5: Low-Pressure Rinse

Rinse sampling equipment with distilled/deionized water with a low-pressure sprayer.

Station 6: Nitric Acid Sprayers (required only if metals are a contaminant of concern)

Using a spray bottle rinse sampling equipment with nitric acid. Begin spraying (inside and outside) at one end of the equipment allowing the acid to drip to the other end into a 5-gallon bucket. A rinsate blank may be required at this station. Refer to Section 9.

Station 7: Low-Pressure Sprayers

Rinse sampling equipment with distilled/deionized water with a low-pressure sprayer.

Station 8: Organic Solvent Sprayers

Rinse sampling equipment with a solvent. Begin spraying (inside and outside) at one end of the equipment allowing the solvent to drip to the other end into a 5-gallon bucket. Allow the solvent to evaporate from the equipment before going to the next station. A QC rinsate sample may be required at this station.

Station 9: Low-Pressure Sprayers

Rinse sampling equipment with distilled/deionized water with a low-pressure washer.

Station 10: Clean Equipment Drop

Lay clean equipment on plastic sheeting. Once air dried, wrap sampling equipment with aluminum foil, plastic, or other protective material.

7.2.3 Post Decontamination Procedures

1. Collect high-pressure pad and heavy equipment decontamination area liquid and waste and store in appropriate drum or container. A sump pump can aid in the collection process. Refer to the Department of Transportation (DOT) requirements for appropriate containers based on the contaminant of concern.
2. Collect high-pressure pad and heavy equipment decontamination area solid waste and store in appropriate drum or container. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.
3. Empty soap and water liquid wastes from basins and buckets and store in appropriate

drum or container. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.

4. Empty acid rinse waste and place in appropriate container or neutralize with a base and place in appropriate drum. pH paper or an equivalent pH test is required for neutralization. Consult DOT requirements for appropriate drum for acid rinse waste.
5. Empty solvent rinse sprayer and solvent waste into an appropriate container. Consult DOT requirements for appropriate drum for solvent rinse waste.
6. Using low-pressure sprayers, rinse basins, and brushes. Place liquid generated from this process into the wash water rinse container.
7. Empty low-pressure sprayer water onto the ground.
8. Place all solid waste materials generated from the decontamination area (i.e., gloves and plastic sheeting, etc.) in an approved DOT drum. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.
9. Write appropriate labels for waste and make arrangements for disposal. Consult DOT regulations for the appropriate label for each drum generated from the decontamination process.

8.0 CALCULATIONS

This section is not applicable to this SOP.

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

A rinsate blank is one specific type of quality control sample associated with the field decontamination process. This sample will provide information on the effectiveness of the decontamination process employed in the field.

Rinsate blanks are samples obtained by running analyte free water over decontaminated sampling

equipment to test for residual contamination. The blank water is collected in sample containers for handling, shipment, and analysis. These samples are treated identical to samples collected that day. A rinsate blank is used to assess cross contamination brought about by improper decontamination procedures. Where dedicated sampling equipment is not utilized, collect one rinsate blank per day per type of sampling device samples to meet QA2 and QA3 objectives.

If sampling equipment requires the use of plastic tubing it should be disposed of as contaminated and replaced with clean tubing before additional sampling occurs.

10.0 DATA VALIDATION

Results of quality control samples will be evaluated for contamination. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow OSHA, U.S. EPA, corporate, and other applicable health and safety procedures.

Decontamination can pose hazards under certain circumstances. Hazardous substances may be incompatible with decontamination materials. For example, the decontamination solution may react with contaminants to produce heat, explosion, or toxic products. Also, vapors from decontamination solutions may pose a direct health hazard to workers by inhalation, contact, fire, or explosion.

The decontamination solutions must be determined to be acceptable before use. Decontamination materials may degrade protective clothing or equipment; some solvents can permeate protective clothing. If decontamination materials do pose a health hazard, measures should be taken to protect personnel or substitutions should be made to eliminate the hazard. The choice of respiratory protection based on contaminants of concern from the site may not be appropriate for solvents used in the decontamination process.

Safety considerations should be addressed when using abrasive and non-abrasive decontamination

equipment. Maximum air pressure produced by abrasive equipment could cause physical injury. Displaced material requires control mechanisms.

Material generated from decontamination activities requires proper handling, storage, and disposal. Personal Protective Equipment may be required for these activities.

Material safety data sheets are required for all decontamination solvents or solutions as required by the Hazard Communication Standard (i.e., acetone, alcohol, and trisodiumphosphate).

In some jurisdictions, phosphate containing detergents (i.e., TSP) are banned.

12.0 REFERENCES

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, February, 1988.

A Compendium of Superfund Field Operations Methods, EPA 540/p-87/001.

Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, USEPA Region IV, April 1, 1986.

Guidelines for the Selection of Chemical Protective Clothing, Volume 1, Third Edition, American Conference of Governmental Industrial Hygienists, Inc., February, 1987.

Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH/OSHA/USCG/EPA, October, 1985.

APPENDIX A

Table

Table 1. Soluble Contaminants and Recommended Solvent Rinse

TABLE 1 Soluble Contaminants and Recommended Solvent Rinse		
SOLVENT ⁽¹⁾	EXAMPLES OF SOLVENTS	SOLUBLE CONTAMINANTS
Water	Deionized water Tap water	Low-chain hydrocarbons Inorganic compounds Salts Some organic acids and other polar compounds
Dilute Acids	Nitric acid Acetic acid Boric acid	Basic (caustic) compounds (e.g., amines and hydrazines)
Dilute Bases	Sodium bicarbonate (e.g., soap detergent)	Acidic compounds Phenol Thiols Some nitro and sulfonic compounds
Organic Solvents ⁽²⁾	Alcohols Ethers Ketones Aromatics Straight chain alkalines (e.g., hexane) Common petroleum products (e.g., fuel, oil, kerosene)	Nonpolar compounds (e.g., some organic compounds)
Organic Solvent ⁽²⁾	Hexane	PCBs

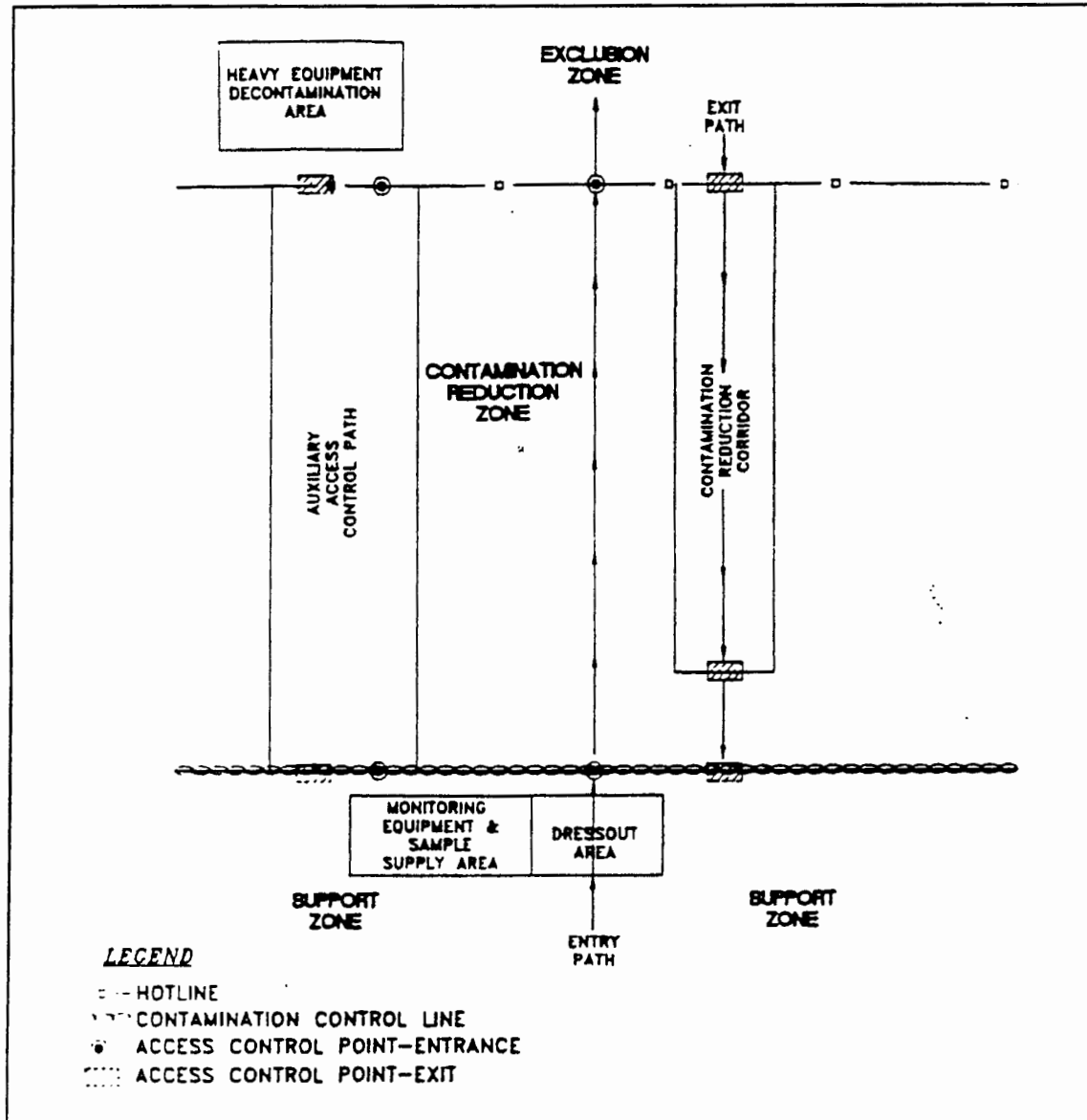
⁽¹⁾ - Material safety data sheets are required for all decontamination solvents or solutions as required by the Hazard Communication Standard

⁽²⁾ - WARNING: Some organic solvents can permeate and/or degrade the protective clothing

APPENDIX B

Figures

Figure 1. Contamination Reduction Zone Layout



APPENDIX B (Cont'd.)

Figures

Figure 2. Decontamination Layout

