

**Bioremediation  
of  
Crude Oil Spills**

**A Non-Technical Field Guide**

**Developed By  
The**

**Ohio Department of Natural Resources  
Division of Mineral Resources Management**

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by**

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## **PREFACE**

This guideline has been prepared by the Ohio Department of Natural Resources (ODNR) Division of Mineral Resources Management (Division) and was funded through a research grant from the United States Department of Energy. The purpose of this field guide is to serve as a general, non-technical guideline for the remediation of certain soils contaminated by Resource Conservation and Recovery Act (RCRA) exempt petroleum hydrocarbon spills on soils.

The bioremediation process and procedures described herein are part of a comprehensive waste management plan being developed by the Division. We have included brief discussions related to legal authority and reporting requirements, approval processes, a cost evaluation worksheet and certain conditions necessary to successfully complete the bioremediation process. References are provided for supplies, materials and equipment. In addition, references for geologic, water and soil survey information are listed.

This guideline contains many descriptive sections that explain how the process works and why certain procedures should be followed. The actual steps to be followed are found in Chapter 4, entitled "GETTING STARTED."

Most bioremediation projects will be completed within a 12 month period. If a project occurs during warm weather and the procedures outlined in this document are followed, the project may be completed in as little as 2 to 3 months. Associated brine spills could extend the remediation process by several months.

Care must be taken to properly contain, report and remediate hydrocarbon spills. Companies are encouraged to include bioremediation processes as a viable method to correct certain crude oil spills.

## INTRODUCTION

### **What is Bioremediation?**

Bioremediation is the process by which populations of bacteria, fungi, algae and actinomycete (bugs) cause the metabolic degradation (breakdown) of hydrocarbons. These naturally occurring microbes or "bugs" produce enzymes which break down hydrocarbons such as crude oil, so it may be used as a food source. As the hydrocarbons are consumed, less complex hydrocarbons are formed. When the process is complete, the remaining waste or by-products are mainly carbon dioxide, water, fatty acids and paraffin. The remaining hydrocarbons are relatively non-toxic and immobile in the soil environment.

Most soils contain "bugs" which may degrade a variety of hydrocarbons. The hydrocarbon food sources are not limited to crude oil. They may include other hydrocarbons such as diesel fuel, gasoline, hydraulic fluid and lubricating oils. Collectively, these materials will be referred to as hydrocarbons throughout this guideline.

### **How does bioremediation work?**

Various strains of "bugs" which are found in most soils are able to utilize hydrocarbons as a food source. Enzymes (chemicals) released by the "bugs" break down hydrocarbons into components that may then be consumed. However, without some help, the "bugs" consume hydrocarbons very slowly. This process may be so slow that hydrocarbons may remain in soils for decades. To speed up the process, we must provide an ideal growing environment, or home, for the "bugs." This may often be accomplished with minimal effort and expense. Very simply, we must provide an environment with the proper amount of water (soil moisture), oxygen (by tilling), pH (soil acidity), nutrients (fertilizer) and the proper range of soil temperatures (40 - 90° F) to accelerate the natural bioremediation process. By providing optimal amounts or concentrations for these simple parameters, microbe populations will flourish. The resultant rapid population growth will usually consume hydrocarbons until the "food" supply is exhausted.

### **Do I need to buy microbes or "bugs" to make this process work?**

Generally, you do not need to buy commercially available microbes or "bugs" to successfully complete a bioremediation project. Commercially available "bugs" are either strains which have been isolated or which have been genetically altered to consume a particular hydrocarbon.

Most soils contain "bugs" which are capable of consuming quite a variety of hydrocarbons. "Bugs" which are native to an area may be better able to survive over a wide range of conditions; however they may not be able to reduce the hydrocarbon as effectively or efficiently as an isolated or genetically engineered strain.

In most cases, when dealing with RCRA exempt oily wastes, the native "bugs" are all that is necessary. Commercial strains may provide a head start by breaking down hydrocarbons as much as several weeks before native "bugs". However, with proper environmental conditions, native

“bugs” may actually dominate in short order. Whether native or commercial "bugs" are used, it is critically important to control and optimize the environmental setting. Without this, the bioremediation project is likely to fail. As you become familiar with the bioremediation processes, we suggest you consult with an expert in this field.

## **CHAPTER 1 LEGAL JURISDICTION**

The Ohio Department of Natural Resources, Division of Mineral Resources Management has primary jurisdiction over the storage, transportation, treatment or disposal of wastes associated with crude oil and natural gas production. When crude oil or associated wastes are discharged into the environment, other agencies at the federal, state or local level may have overlapping jurisdiction or sole authority in a given situation. In order to sort out legal jurisdiction, we must first define the types of wastes that are addressed by these guidelines. For the purposes of this bioremediation guideline, wastes will be defined as:

*Crude oil, condensate or RCRA exempt refined petroleum hydrocarbons, that have been spilled on the land surface, without the potential for recovery as a marketable product.*

Crude oil contamination of soils may be the result of events such as blowouts, lightning strikes, accidents, equipment failures, vandalism or human error. These guidelines pertain to remediation of crude oil spills. This guideline does not pertain to discharges of hazardous materials or non-RCRA exempt wastes such as unspent solvents, gasoline, or fuel oil.

When a spill occurs, the responsible party has a number of factors to consider. Typically, first priority is to stop the source of an ongoing spill. The spill must also be contained and recovery operations should be initiated in order to minimize the affected area. The company must decide if the spill requires mandatory reporting and documentation, and if so, which agencies must be contacted. Following is a general discussion regarding spill reporting requirements.

### **Reporting Requirements**

The federal Clean Water Act requires reporting of any discharge of oil in harmful quantities into a navigable water. The reporting requirement is as follows:

Any person in charge of a facility shall, as soon as he or she has knowledge of any discharge of oil in harmful quantities into a navigable water, immediately notify the National Response Center. The National Response Center phone number is **1-800-424-8802**.

This notice satisfies both the United States Environmental Protection Agency (U.S. EPA) and U.S. Coast Guard notification requirements in the event of a reportable spill. The U.S. Coast Guard has jurisdiction over "coastal waters" which includes the Great Lakes and specific ports and harbors of inland rivers. U.S. EPA has jurisdiction over "inland waters."

Regulations adopted by the State Emergency Response Commission (SERC) require the owner to report any release of a "reportable quantity" of oil. The rules differentiate between releases from a facility to a "navigable water," and to "the environment", (everything other than navigable waters) as follows:

1. For release of crude oil, into a navigable water the reportable quantity is any amount which causes a film or sheen upon or discoloration of the surface of the navigable water or causes a sludge or emulsion to be deposited beneath the surface of the water;
2. For releases of crude oil from an oil and gas extraction storage facility to the environment (excluding navigable waters), the reportable quantity is 210 gallons (five barrels) in a twenty-four hour period.

In the event there is a release of crude oil in a reportable quantity from a facility, the owner or operator of the facility must give verbal and written notice of the release. Verbal notice must be given within 30 minutes to:

- Ohio EPA Emergency Response Unit at 1-800-282-9378 or 614-224-0946;
- The Local Emergency Planning Agency (LEPA); and
- The local fire department.

In addition, if the spill is related to a transportation incident, the owner must call 911. If there are wildlife mortalities such as a fish kill, the owner must notify the ODNR, Division of Wildlife (Appendix 1).

Spills in excess of 10 barrels, or smaller spills in sensitive areas on federal lands with federal leases, must be reported to the Bureau of Land Management and the surface managing agency. Spills of 10 barrels or less in non-sensitive areas or on federal land with private leases must be reported to the surface managing agency. Wayne National Forest and Mosquito Creek Reservoir are examples of properties owned by the federal government. Table 1 is a summary of these reporting requirements.

## **Remediation**

Ohio EPA, U.S. EPA or the U.S. Coast Guard have oversight authority for remediation of spills on navigable waters. For all other spills impacting the environment, the ODNR, Division of Mineral Resources Management, will oversee remediation. The method of remediation will vary according to the sensitivity of the environment, public health and safety risks, and the affected area. On-site treatment (bioremediation) as defined in these guidelines, will be a preferred method of remediating contaminated sites when health and safety standards and siting criteria are met.



**TABLE 1**  
**Reporting Requirements for Crude Oil Spills**

Reportable Quantity		Report To						
	Volume	Nat'l Response Center (800) 424-8802	Ohio EPA (800) 282-9378	LEPA Appendix	Local Fire Dept.	Bureau of Land Mgt.	Federal Surface Mng. Agency	ODNR Div. of Wildlife
Impact								
Navigable Water	Sufficient to cause sheen	Yes	Yes	Yes	Yes	No	No	No
Environment (anywhere outside an SPCC dike)	Greater than 210 gal. (5 bbl) in a 24-hr. period	No	Yes	Yes	Yes	No	No	No
On Federal Land	Greater than 10 bbl	No	Yes	Yes	Yes	Yes (if it is federal oil)	Yes (if it is not federal oil)	No
Wildlife Mortality	Non-Applicable	No	No	No	No	No	No	Yes

## CHAPTER 2

### SITE EVALUATION

This section is intended to help you evaluate factors which are important to successfully complete a bioremediation project. By using the **Bioremediation Site Evaluation Report** (Appendix V), you will be able to decide if your project meets the Division's siting criteria. This information will also help in evaluating associated costs. As early as practical, the responsible company should work with the appropriate regulatory agency(s) to develop an environmentally sound and cost effective clean-up plan. The **Bioremediation Site Evaluation Report** also serves as your official request for permission to utilize bioremediation methods to correct site specific problems. Division field personnel will review the information with you while on location. The project will either be denied or receive conditional approval at that time. You may begin your project as soon as you receive conditional approval. Final approval is subject to a review of the registered owner's bond and insurance status.

The following items are listed on the **Bioremediation Site Evaluation Report**. Each item contains a description of the required information.

1) Source of Material Spilled

Briefly describe the source of the material, listing the location or equipment from which the spill originated. This information will be used to categorize the source or cause of significant spills.

2) Type of Material Spilled

A simple description of the material spilled will generally provide the necessary chemical composition information. Material Safety Data Sheets (MSDS) may be used for the chemical description. These are generally required by the Public Utilities Commission of Ohio (PUCO) or U.S. EPA Community Right-to-Know regulations (SARA Title III) and should either be on location or be available through the material supplier, transporter, or manufacturer. The Division will create a library of MSD sheets in order to expedite and simplify the process.

We have also included MSD sheets for common materials in Appendix VI. If more than one material has been spilled, each material should be listed separately.

3) Volume of Material Spilled

Actual spill volumes should be reported when known, but estimated volumes may be submitted if necessary. Volumes may be reported in barrels (42 gal/bbl) or gallons. Please indicate whether reported volumes are estimated or measured.

4) Surface Area Affected

The extent of a spill should be reported by measuring or estimating the size of the affected area. The approximate average length and width of the spill in feet will provide the necessary information.

5) Soil Depth Affected

An estimate of the average depth of the spill in inches should be reported. The depth and area measurements will be used to determine the volume of affected soil. This information is necessary in order to estimate the soil amendment application rates to successfully complete the bioremediation process.

6) Soil Type

A scientific soil description may be reported in the county soil surveys from the United States Department of Agriculture, Soil Conservation Service. If these surveys are not available, a general description of the soil should indicate clayey, silty or sandy soil types. If other soil types, such as loams are affected, this should be recorded.

7) Depth to Ground Water Table (Approximate)

Estimate the seasonal high water table depth in the spill area. The Division will not approve projects in areas where the seasonal high water table is less than four feet from surface. It is also important to determine if the site is in a wetland or in a flood plain area. The Division will not approve remediation projects in such areas due to the potential for contaminating navigable waters.

Very shallow water tables are more susceptible to direct contamination. This information may be available through The Ohio Department of Natural Resources, Division of Water (Appendix II) or by contacting local water well drillers.

8) Slope or Grade of the Affected Land

Estimate the slope of the affected area. Slope may affect soil erosion control measures and/or limit the type of equipment for the bioremediation process, or the restoration that may be used on a specific location. An estimate of the slope of the project site in degrees should be recorded.

### **Cost Analysis Worksheet**

The project **Cost Analysis Worksheet** (Appendix V) is provided to assist you in estimating the material, equipment and labor costs for a bioremediation project and the associated site restoration. Costs may then be compared with other remediation methods, such as landfilling.

The material list represents the material required to complete a typical bioremediation project. The list should be modified for site specific situations. Many factors affect material prices. For example, fertilizer, lime and composted mulch may be less expensive when purchased in bulk.

Equipment prices will vary greatly. Less expensive equipment may lower the cost of a single project, but may not be durable enough for multiple projects. You may also choose to purchase disposable supplies such as "Quantabs," for estimating the chloride concentration.

Renting or leasing certain equipment may also be considered. Sources for sampling and field measurement equipment are listed in Appendix III. Finally, you may choose to hire a contractor to complete a project.

Labor costs may be the most difficult to estimate. Site specific conditions, travel time and crew availability are but a few of the factors affecting labor costs. Remember, you will have labor costs during the initial, intermediate and closure phases of the bioremediation project and also for the site restoration, although most of the labor will be during the initial phase of the project.

Laboratory costs are fairly straight-forward, but shop around; these costs can vary quite a bit from lab to lab. Appendix IV lists a few of the laboratories which may be used for certain analytical tests. Most of the test parameters listed are not required. Only Total Petroleum Hydrocarbons (TPH) and pH (and in some instances metals - TCLP) are required. TPH must be analyzed in a laboratory but pH and most of the other tests may be completed as field tests (with the proper equipment). Laboratory analyses and field tests are listed in Chapter 4 and procedures and methods are explained in detail in Chapter 5.

As you work through the project cost estimates, you may also estimate remediating the site by removing and landfilling the contaminated soil. Remember to factor in costs associated with replacement soil and site restoration.

Long-term environmental liability should also be factored into your decision. When materials are landfilled, they are essentially in-place for the life of the landfill. If environmental problems begin to develop at the landfill, all parties using that facility may be held responsible. With bioremediation, you are essentially correcting environmental problems until the problem no longer exists or until contaminant levels are within an acceptable threshold.

The **Cost Analysis Worksheet** is for company use. Do not forward this worksheet to the Division. The Division will try to assist you with the cost evaluation should you need help. By keeping this worksheet and maintaining a project file, you may discover how to lower future project costs.

## CHAPTER 3

### PROJECT VARIABLES

There are five primary factors which may be controlled to provide an ideal growing environment for the "bugs". These factors include soil moisture, soil temperature, oxygen, pH and available nutrients. Many other factors affect the bioremediation process, but are not considered critical to the process and, therefore, will not be included in this discussion.

#### Soil Moisture

Like us, "bugs" need water to survive. Various articles and studies suggest optimum soil moisture levels should range from 40 to 80 percent. Average annual precipitation in Ohio is in excess of 39 inches per year. In all but the most extreme drought conditions, natural soil moisture levels should be suitable for the successful completion of the bioremediation process. During drought conditions fresh water may need to be applied to the site. Should soil moisture levels fall below 40 percent, the efficiency of the remediation process is greatly reduced.

Soil moisture levels may be monitored through the course of the project. If these values are measured they should be recorded on the **Bioremediation Project Report** (Appendix V). Methods of measurement and equipment requirements are described on page 20.

#### Soil Temperature

"Bugs" have an effective working temperature range from 40° to 90° F. When soil temperatures fall below 40° F, the "bugs" are no longer able to consume hydrocarbons. Soil temperatures above 90° F are generally lethal. In Ohio, the combination of a temperate climate and abundant rainfall keep soil temperatures well below 90° F. Exceptions would only be likely if plastic sheeting was used to cover the project site.

A greenhouse type structure may be used to continue the process year-round. Of course, the economics of such a facility, except perhaps on a commercial scale, may prove cost prohibitive.

On the other extreme, soil temperatures may remain below 40° F for three to as many as five months per year. This lower, near surface soil temperature effectively sets the time-frame in which bioremediation may be used without taking measures to control soil temperature. In Ohio's climate, the bioremediation process essentially ceases from November through March.

If soil temperatures are measured they should be recorded on the **Bioremediation Project Report** (Appendix V). Methods of measurement and equipment requirements for soil temperature readings are described on page 21.

#### Oxygen

"Bugs" that "eat" hydrocarbons in near surface soils require oxygen to survive. Soils may be aerated by plowing or tilling. Tilling generally achieves the best results because this causes soils to have a fine texture with a very high surface area to volume ratio. This allows soils to be more

adequately aerated which accelerates the bioremediation process. Tilling also mixes and more evenly distributes the hydrocarbons, nutrients and soil amendments. With the hydrocarbons and nutrient sources now mixed throughout the soil, bug colonies may populate all of the loosened soil. This in turn causes a rapid growth in the population which speeds the entire remediation process.

Aeration by means of plowing or tilling is very important to successfully complete the bioremediation process. Actual oxygen levels in the soil do not need to be measured. No field measurement or laboratory testing is required. Soil aeration frequency and dates should also be recorded on the **Bioremediation Project Report** (Appendix V).

## Nutrients

As in agricultural practices, nutrients (fertilizer) greatly impact the bioremediation process. Too much fertilizer may adversely affect the process, increase expenses and has the potential to lead to surface or ground water contamination. On the other hand, without enough fertilizer, the "bugs" will not produce the enzymes fast enough to rapidly break down the hydrocarbon.

Ideally, fertilizers should have a Nitrogen:Phosphorus:Potassium ratio of 4:1:1 respectively. Fertilizers with less nitrogen will work, but greater volumes must be applied. Numerous applications of small amounts of nitrogen rich fertilizer are far better than one heavy application. Each application should be thoroughly tilled into the soil.

Fertilizers with ratios such as 10:6:4 or 12:12:12 will work, but there may be some undesirable secondary chemical reactions. One method that may be used to calculate inorganic fertilizer application rates is to use a carbon to nitrogen ratio of 150:1 respectively. To do this, you must use the results from the TPH analysis in the following formulas.

$$\text{Carbon (mg/kg)} = \text{TPH \%} \times 0.78 \times 10,000$$

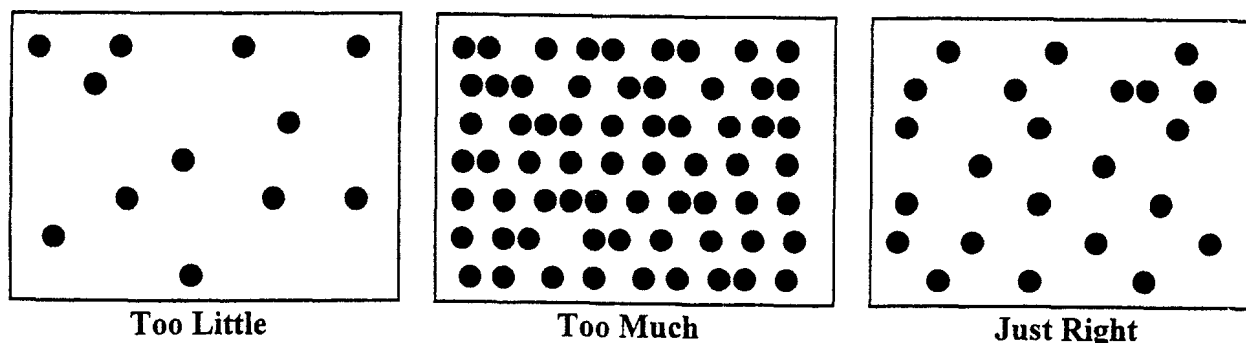
$$\frac{\text{Carbon (mg/kg)}}{150} = \text{Nitrogen (mg/kg)}$$

$$\text{Nitrogen (mg/kg)} \times 2 = \text{Nitrogen (lbs/acre) tilled to a 6 inch depth}$$

TPH must be determined at the beginning and end of the bioremediation process. Initial TPH values are very useful in determining the relative degree of soil contamination. This value also establishes the baseline or "starting point" for the project. As a general rule, inorganic fertilizers should be applied at rates typical for agricultural crops on the same soil. Figure 1 illustrates application rates that are generally adequate for the bioremediation process. Lesser amounts should be used if the project is located on agricultural land that has been recently fertilized.

***Note: Fertilizers must not contain pesticides, fungicides or herbicides. These chemicals would be lethal to the "Bugs" ending the remediation process.***

**Figure 1**  
**Fertilizer Application Rate**  
 Appearance of Fertilizer Granules on Bare Ground Surface



**NOTE:** This is a visual guide to follow if you do not calculate the carbon to nitrogen ratios.

Organic materials such as composted manure, straw, leaves and sawdust may also be used as a nutrient source. These materials may even contain microbes that are beneficial to the process. These materials tend to be acidic, so additional lime may be necessary to properly adjust soil pH. Composted organic materials also tend to improve soil permeability and help retain soil moisture. County Extension Agents, agricultural supply companies and soil laboratories may assist with the determination of fertilizer and mulch application rates. The application rates should be similar to those of agricultural crops with moderate nutrient requirements. Fertilizer and organic mulch application rates should be recorded on the **Bioremediation Project Report** (Appendix V).

## pH

Like plants, microbes react to changes in soil pH. Soil pH is a measure of the relative acidity of the soil. Many articles suggest soil pH be adjusted to approximately 7.0 S.U. Before a bioremediation project is started, initial soil pH should be determined. Crude oil tends to lower pH while brine associated with an oil spill may actually raise pH. Carbonates in brine tend to buffer the soils, which raises soil pH slightly. This does not mean brine may be used as a buffer to raise pH. The salt in formation brines, especially the Sodium ( $\text{Na}^+$ ), actually poison the "bugs," and in clay rich soils, reduces permeability. It is very important to test soils for salt (chloride) content when brine has been spilled with crude oil. Without first purging salts from the soil, the bioremediation process will most likely fail.

Most of the effects of salt on soil may be reversed rather quickly and cost effectively. By adding lime, calcium and magnesium ions replace sodium ions on soil particles and the sodium ions are then washed through the system. This process occurs over a number of weeks or months, depending on rainfall and drainage. Because of this relatively slow release of sodium, there is not likely to be any measurable impact on surface or ground water supplies. The relative concentration of salts in soil may be measured in the field or through a laboratory. These methods are described in detail on page 25.

Soils which do not directly overlie limestone or dolomite may require substantial volumes of powdered lime or other conditioner to properly adjust pH. An agronomy (soil) laboratory, agricultural supply company or county extension service may be able to test soils and recommend application rates.

The pH adjustor (lime) should be thoroughly tilled into the soil. This may be accomplished at the same time other nutrients and soil amendments are applied. Soil pH values and pH adjustor application rates should be recorded on the **Bioremediation Project Report** (Appendix V). Field and laboratory test methods and equipment requirements for pH are described on page 23.



## CHAPTER 4 GETTING STARTED

If you are to this point, you have already evaluated your spill management options and have decided to use bioremediation. You have received permission from the property owner and have had your project approved by the Division of Mineral Resources Management. You are now ready to begin the actual work. Following is a step-by-step procedure that you should generally follow. Some modifications may be necessary for the particular circumstances at your site.

### CRUDE OIL SPILLS (Correcting Problems in Place)

#### STEP 1 (required)

Make sure any pooled crude oil or water (fresh or saline) has been picked-up and properly disposed.

#### STEP 2 (optional)

Measure and record (**Bioremediation Project Report**) soil moisture and soil temperatures at a 4 inch depth. Measurement methods and equipment are described on pages 20 and 21.

#### STEP 3 (optional)

Measure and record (**Bioremediation Project Report**) or collect samples for electrical conductivity (EC). This test is optional unless there has also been a brine spill associated with the oil spill. Methods, equipment and collection information are described on page 24.

#### STEP 4 (required)

Measure and record (**Bioremediation Project Report**) or collect samples for pH. Methods and equipment are described on page 23.

#### STEP 5 (required)

Collect a soil sample for TPH. Sampling methods are described in detail on page 21. Disregard if TPH sample collection Method Two is being used (Step 7).

#### STEP 6 (required)

Spread powdered lime or other pH adjustor as needed. Record the data on the **Bioremediation Project Report**.

STEP 7 (required)

Till the entire project site. Record data on the **Bioremediation Project Report**.

**Note: TPH samples may be collected using TPH collection Method Two at this point. Disregard if TPH sample collection Method One was used in Step 5.**

STEP 8 (required)

Spread fertilizer and organic mulch as needed and record appropriate information on the **Bioremediation Project Report**.

STEP 9 (required)

Till the entire project site a second time. Record data on the **Bioremediation Project Report**.

STEP 10 (required)

Place straw or hay bales or erosion control fencing along the site perimeter as needed.

STEP 11 (required)

Till the site every one to two weeks if possible, but at least one time per month. Record data on the **Bioremediation Project Report**.

STEP 12 (optional)

Although not required, pH and TPH may be checked on one month intervals to evaluate progress. Record data on the **Bioremediation Project Report**.

STEP 13 (required)

Closure samples for TPH should be collected as described on page 21. You may be ready to collect this sample when you can no longer see or smell oil in a handful of soil. When the laboratory analytical report indicates TPH is less than 1 percent or 10,000 ppm you may submit the completed **Bioremediation Project Report** with copies of all lab analyses. This serves as your official request to stop remediation and restore the site. If the project work is officially approved, you will receive a letter stating your site remediation is complete. You will then be asked to restore site to as near the original conditions as possible. Generalized restoration guidelines are described on page 17.

## **CRUDE OIL SPILLS WITH ASSOCIATED BRINE**

### **(Correcting Problems in Place)**

Brine must be purged from the soil before a bioremediation project is started. A generalized step-by-step procedure is outlined below. Site specific modifications may be necessary for the particular circumstances at your site.

#### STEP 1 (required)

Make sure any pooled crude oil or brine has been picked-up and properly disposed.

#### STEP 2 (required)

Directly measure or collect samples for electrical conductivity (EC). Results should be recorded on the **Bioremediation Project Report**. Methods and equipment requirements are described on page 24.

#### STEP 3 (optional)

Measure soil moisture levels and record data. It may be necessary to add fresh water to the site if soil moisture levels drop below 40 percent. Methods and equipment requirements are described on page 20.

#### STEP 4 (required)

Apply powdered (pulverized) agricultural lime or other pH adjustor. Application rates should elevate soil pH to at least 7.0 S.U. and may go as high as 8.5 S.U. Additional applications of lime may be necessary during the project. Record the date and application rate in lbs/yd<sup>2</sup> on the **Bioremediation Project Report**.

#### STEP 5 (required)

Directly measure or collect samples for pH. Methods and equipment are described on page 23. Record data on the **Bioremediation Project Report**.

#### STEP 6 (required)

Till the entire project site. Record data on the **Bioremediation Project Report**. Continue to till every one to two weeks.

When EC values are less than 100 mmhos/cm (ideally less than 50 mmhos/cm), begin the bioremediation project at Step 2 on page 14.

**Note: Poorly drained sites, especially those with very clayey soils, may require the installation of field tile to purge the brines in a timely manner. If this becomes necessary the installation of field tile should be considered. Tile should be buried deeper than the**

anticipated tilling depth. Other factors which may affect the tile installation depth include slope, soil type and depth of brine contamination. The tile should be tied into a water collection point, such as a buried or partially buried plastic saltwater tank. Water with a chloride concentration above 2000 mg/l should be properly disposed. Chloride concentrations may be field tested by using a "Quantab" titrator or samples may be collected and analyzed through a laboratory. These procedures are described on page 25. If chloride concentrations are below 2000 mg/l and there is no visible oil, water collection is not necessary. The water may be discharged as in an agricultural operation.

## **CORRECTING PROBLEMS AT AN OFF-SITE LOCATION**

A number of factors may prevent you from correcting a problem in place. For example, a spill may occur in a wetland or other location which do not meet the Division siting criteria. The spill may occur during winter months when bioremediation simply will not work (although with landowner permission, the soil may be stockpiled and covered until weather conditions improve). A landowner may refuse to give permission for a project on the property.

If you have reviewed your spill clean-up options and would like to use bioremediation but siting criteria or landowner permission are a problem, you may be able to move the soils to another site. If you have a property owner willing to accept the soils and allow the project, you may request Division approval for an offsite or relocated project. This project could even be on company property. In fact, it may be cost-effective to combine contaminated soils from multiple small spills such as those from stuffing box leaks and at load lines for remediation at a centralized location.

This process is very simple. You simply complete the **Bioremediation Site Evaluation Report** (Appendix V) and include a detailed description of the proposed bioremediation site. This request will be reviewed by the Division and you will be contacted within five working days or less. If the project is approved, you will receive an approval letter and **Bioremediation Project Report**. After the affected soils are relocated, the project should be initiated by following an appropriate method as described on pages 14 through 16.

## **RESTORATION GUIDELINES (For Bioremediation Projects)**

Your project site will be ready for closure and site restoration after the Division has approved your request to stop the bioremediation project. You will receive a letter stating the project closure is approved.

### **Grading**

Many sites will not require grading before closure. Your goal is to return the lands surface to a slope and contour that closely approximate conditions before the project was initiated. Care should be taken to fill all ruts and depressions to prevent the ponding of water. The natural flow of surface drainage must not be altered.

Sites having high slopes may necessitate terracing. This should only be done with the property owners informed consent. Terraces should be designed to prevent channelization yet with enough slope to prevent water from ponding. Water breaks or diversions may be necessary, especially along steep banks or lease roads.

### **Seeding**

It is generally necessary to establish some type of vegetation to prevent soil erosion. Exceptions may be in certain agricultural fields or on some lands under development. Again, it is important to keep the property owner informed. Vegetation should be either a perennial or an annual/perennial mix. The vegetative cover should be compatible with the adjacent vegetative cover and should be suitable for the particular soil type.

### **Mulching**

Straw is the most common mulch used in a site restoration. Other suitable materials may also be used. Mulch is used to help retain soil moisture and minimize soil erosion. Care should be taken to apply an adequate amount of mulch, but too much mulch can hinder seed germination and plant growth.

### **Erosion Control**

Some sites will require the use of erosion barriers such as bales of straw or erosion control fencing. Erosion barriers should be placed in a manner that slows surface water drainage enough to allow sediment to settle. Avoid creating a barrier that causes water to pond without drainage. It is important to design erosion control barriers to minimize sediments reaching ditches or waterways.

When the site restoration is complete, you should contact the appropriate Division office (Appendix I) for a restoration inspection. If the restoration is passed, you will receive a letter stating the spill has been corrected according to state guidelines and the site is properly restored. The Division will maintain copies of all files.

## CHAPTER 5

### SAMPLING AND FIELD MEASUREMENT METHODS

This chapter contains information to assist you with sample collection, chain of custody reports and field methods for on-site testing of certain parameters. Equipment requirements are listed for each procedure. Appendix IV lists representative laboratories for chemical analyses and Appendix III lists representative supply companies for materials and equipment.

#### **Soil Sample Containers**

A variety of containers may be used for the collection of soil samples. Some containers are selected for specific chemical testing and others may be used for a wide variety of tests.

Soil sample containers come in many shapes, forms and sizes, but plastic or glass jars, ziplock bags and cotton drawstring bags are the most common. The plastic or glass containers may even be sterilized. If you are working with a consultant, or for some other reason choose to collect a sample for a microbe culture, this may be important. The plastic or glass jars are rather expensive and the cotton drawstring bags may not be suitable for certain tests. Plastic ziplock bags are very inexpensive and versatile. You may purchase the bags through a supply company, discount store or even a grocery store. The pint or quart bags are all that is needed.

Some laboratories supply the sample containers. They may even specify which container they require for a certain analytical test. In many instances, a single soil sample may be used for more than one analytical test. We suggest you contact your laboratory before you collect samples for laboratory analysis.

#### **Sample Container Labeling**

Soil sample containers may be labeled by several means. Glass and plastic containers may be identified with self-adhesive labels. Cotton drawstring bags usually have an attached paper label. Plastic ziplock bags are usually labeled with a permanent marker.

These or other appropriate methods may be used to mark the sample container. The label must not rub or fall off. Do not use a pencil or markers that are not waterproof. It is generally easier to label containers before the sample is collected. The container is dry and there is less chance for confusion if more than one sample is collected. Under no circumstances should you collect samples without labeling the container. Most laboratories will not accept samples without proper labeling.

Regardless of the sample container or labeling method used, all samples should be labeled with the following information:

*Sample collection date; Sample collection time; Name or initials of the person collecting the sample; County; Township; Permit Number (if applicable); Lease Name (if applicable).*

You will also need to instruct the laboratory to complete analyses for specific parameters. Sample collection procedures and instructions for the laboratory are included in this chapter.

### **Chain of Custody**

At times, the storage, handling and integrity of a sample may be questioned. Attorneys very often argue that if the whereabouts and condition of a sample cannot be documented during one's possession, the sample or analytical results should be rejected. For this reason, samples are often accompanied by paperwork which tracks the possession of a sample. This paperwork is referred to as a Chain of Custody.

The person collecting a sample completes the Chain of Custody. While a sample is in that person's possession the person attests the sample has been properly stored and secured so as to prevent tampering. When the sample possession is transferred, the person receiving the sample signs the Chain of Custody. The person transferring the sample signs the form at the same time. Each person also logs the transfer time and date on the form. This transfer procedure may go directly from the sampler to the laboratory or may pass through one or more intermediate persons. A copy of the Chain of Custody form used by the Division has been included in Appendix V. Many laboratories may require the use of their Chain of Custody form. Check with your laboratory before you begin sample collection.

The Division requires the use of a Chain of Custody form for those tests which are required. The required analytical tests are described in Chapter 4. Test requirements vary by procedure. A Chain of Custody form is not required for tests performed in the field.

### **Soil Moisture Measurements**

It is very easy to measure soil moisture with the proper equipment. This test may be performed by a laboratory, but it is generally more timely and cost effective to conduct an on-site field test. The precision of the soil moisture measurement is not critical to the bioremediation process.

### **Equipment Requirements**

- Electronic soil moisture meter; or
- Dielectric soil moisture meter; or
- Plastic soil sampling bags and marker

### **Procedure**

#### **Method One (Field Measurement)**

The use of a meter, either electronic or dielectric, is more than adequate for soil moisture measurement. With either meter, moisture in the soil conducts a very small electric current.

With an electronic meter, an electric current is discharged from one probe and the current travels through the soil and is measured on a second probe. With a dielectric meter, two different metals serve as the probes. A natural electric field develops between the probes and is then measured. When using soil moisture meters, the probe should be pushed into the soil to a 3 to 4 inch depth.

This may vary depending on the specific equipment being used. The soil moisture reading and date should be recorded on the **Bioremediation Project Report**.

### **Method Two (Laboratory Analysis)**

Although we do not suggest the use of a laboratory for this test, you may choose to collect a soil sample and have a laboratory analyze the sample. A few simple steps must be followed. First, properly label a plastic ziplock bag (sample labeling is discussed on page 19). Scrape 3 to 4 inches of soil from the surface of the sample collection site in the project area. Collect about ½ cup of soil and place in the sample bag. Try to squeeze as much air from the bag as possible. The laboratory will dry a specific amount of soil. The weight of the soil before and after the drying process will be converted into the relative percentage of soil moisture. You should receive a laboratory report. Keep a copy of the analytical report.

### **Soil Temperature Measurements**

Soil temperature must be measured in the field. These measurements are only necessary when soil temperatures are around 40° F or if you believe the soil temperature is approaching 90° F. If you try to bioremediate when soil temperatures are too low, you may be wasting both time and money. If soil temperatures are too high, you may cause the process to stop.

In a very general sense, you may begin bioremediation projects in the spring when cold tolerant crops such as peas are planted. Projects may continue into the fall until plants such as grass stop growing.

### **Equipment Requirements**

- Soil thermometer, liquid filled or digital

### **Procedure**

To measure soil temperature, simply push the thermometer to about a 4 inch depth. After the reading has stabilized, record the temperature and date on the **Bioremediation Project Report**.

### **TPH (Total Petroleum Hydrocarbon)**

Total Petroleum Hydrocarbon (TPH) is tested to determine the relative concentration of petroleum hydrocarbons in soil. You may collect this sample, hire an environmental contractor or request Division personnel complete this task. In any case, the analysis must be completed by a



qualified laboratory. A chain of custody should also accompany the sample. TPH samples are chemically undifferentiated hydrocarbons with the total value equaling the sum of all individual component values. The first sample you collect will tell us the relative degree of soil contamination and establishes the baseline or "starting point" for the bioremediation project. Intermediate samples are not required but are useful in determining the efficiency of the project. Simple observations of the soil often allows for a generalized determination of the project effectiveness. The relative strength of the hydrocarbon odor and the degree of discoloration or staining of the soil are often very effective efficiency indicators. A final or closure sample must be collected and analyzed when you believe the remediation project is complete.

### **Equipment Requirements**

- Soil sampling auger or probe
- Sample collection containers (one pint plastic or glass jars with lids or zip lock plastic bags)
- Permanent marker

### **Procedure**

#### **Method One**

Before the site is disturbed by tilling or by the application of lime, fertilizer or mulch, a TPH sample should be collected. This method is used to determine nutrient application rates before disturbing the soil. Using a soil auger or probe, collect a sample in the middle of the affected area. A column of soil should be collected to a depth of 6 inches. The entire column of soil should be placed in the container. Similarly, four additional samples should be collected in the affected area.

The final sample pattern should resemble the five on a dice. All five samples may then be placed in the same or separate sample collection container(s). All containers should be properly labeled.

#### **Method Two**

AFTER the site has been tilled for the first time, collect a sample in the middle of the spill area. It is not necessary to use a soil auger or probe when using this method. Simply scoop approximately  $\frac{1}{2}$  cup of soil after removing 3 - 4 inches of topsoil from each collection point. Repeat this procedure four more times in a pattern resembling the five on a dice. All five samples may then be placed in the same or separate sample collection container(s). All containers should be properly labeled.

### **Laboratory Instructions**

Ask the laboratory to combine all five samples (if not already done), mix or blend the samples thoroughly, and analyze as a single sample for TPH. The laboratory should test using U.S. EPA Method 418.1 or 8015. The laboratory will then mail the results to you. Keep a copy of the analysis.

results. You will need to attach a copy of these results to the **Bioremediation Project Report** when the project is finished.

### **pH Measurements**

This test may be completed in the field or samples may be collected for analysis by a laboratory. You are testing the relative "acidity" of the soil. Soil pH should be adjusted until it is a range from 7.0 to 8.5 S.U. This test is useful and may need to be completed numerous times. Field testing is easy, inexpensive and provides immediate results. We suggest you use field test methods for soil pH.

### **Equipment Requirements**

- Soil pH Test Kit and distilled water; or
- Electronic soil pH meter with calibration (buffer) fluids; or
- Plastic sample bags and a permanent marker.

### **Procedure**

#### **Method One (Field Measurement)**

Use distilled water to mix a soil slurry according to manufacturer specifications. Place the test strip in the slurry. When fully developed, you may then take a direct reading or compare the test strip with a calibration chart for your reading. The date and pH value should be recorded on the **Bioremediation Project Report**.

#### **Method Two (Field Measurement)**

Insert the probe on an electronic soil pH meter to a depth of 4 inches in the project area soil. When the meter reading stabilizes, record the data and pH value on the **Bioremediation Project Report**.

**Note: Follow manufacturer specifications for meter calibration BEFORE using the instrument.**

#### **Method Three (Laboratory Analysis)**

Label a plastic ziplock bag as described on page 19. Scrape 3 or 4 inches of soil from the sample collection point. Collect about ½ cup of soil. Squeeze the air from the sample and seal the bag. The sample is ready for delivery to the laboratory.

### **Laboratory Instructions**

Instruct the laboratory to use test method 9045B as described in the U.S. EPA Solid Waste Preparation Method 846 (SW846). You will receive a report that lists a soil pH value

in Standard Units (S.U.) Attach a copy of the analysis with your completed **Bioremediation Project Report** when the project is complete.

The sample date and soil pH value should be recorded on the **Bioremediation Project Report**. Use the pH value to estimate the lime application rates to properly adjust soil pH. A county extension agent or agricultural supply company may help determine application rates. The advantage of field testing is that you have an immediate reading and may continue to take readings as you apply lime.

### **Electrical Conductivity (EC) Measurement**

Electrical Conductivity may be measured in the field or through a laboratory. Either method is acceptable; however, field methods will not cause a delay in the project.

Portable equipment must be calibrated according to manufacturer specifications. Values are generally reported after being corrected to 25° C. Many instruments are designed to give you a corrected reading.

### **Equipment Requirements**

- Electrical Conductivity Meter and calibration fluid; or
- Plastic soil sampling bags and marker.

### **Procedure**

#### **Method One (Field Measurement)**

Electrical conductivity may be measured in the field by using a properly calibrated portable conductivity meter. The meter probe should be pushed to a depth of about 4 inches. After the reading has stabilized, record the value and date on the **Bioremediation Project Report**.

#### **Method Two (Laboratory Analysis)**

Properly label a plastic ziplock bag as described on page 19. Scrape 3 to 4 inches of soil from the sample collection site. Collect about ½ cup of soil and place in the sample bag. Squeeze as much air as possible from the bag before sealing. A Chain of Custody form should be completed and placed with the sample at this time.

### **Laboratory Instructions**

Ask the laboratory to analyze the sample using method 9050 of the U.S. EPA Solid Waste Preparation Method 846 (SW846). You will receive an analytical report from the laboratory. A copy of this report must be submitted with the completed **Bioremediation Project Report** at the end of the project.

## **Soil Salinity (Chloride) Measurement**

Soil salinity may be measured in place of Electrical Conductivity when a hydrocarbon spill has an associated brine spill. Salts must be purged from the soil before the hydrocarbon may be bioremediated. Brines are relatively easy to purge from soil. A simple process is described on page 16 in Chapter 4.

Soil salinity may be measured directly in the field or samples may be submitted to a laboratory for analysis. Three testing or collection methods are described.

### **Equipment Requirements**

- Electronic Soil Salinity Meter and calibration fluid; or
- "Quantab" titrators, postal scale, fluid measure (ml), filter paper, funnel, and distilled water; or
- Soil sample containers and a permanent marker.

### **Procedure (Field Measurement)**

#### **Method One**

Electronic soil salinity meters may be used to take a direct reading. Record the reading on the **Bioremediation Project Report**.

#### **Method Two (Field Measurement)**

An acceptable method to test for the approximate salt concentration (chloride) in soils is the use of "Quantab" titrators. These are simply strips of plastic coated paper that have been treated with a reagent that reacts with chloride. To use this field test, you must mix 10 grams of soil with 90 ml of boiling distilled water. Mix thoroughly then allow the mixture to cool to room temperature and drain the fluid through filter paper. Place the "Quantab" in the fluid, and when fully developed, compare the reading on the test strip with the enclosed chart. This will give you the chloride concentration in parts per million (ppm).

This test may sound difficult but is actually very easy and inexpensive. There are several different "Quantab" chloride titrator products available. We suggest you use titrator number 1176.

#### **Method Three (Laboratory Analysis)**

Scrape approximately 3 to 4 inches of soil from the sample collection site. Collect about ½ cup of soil. Place the sample in a properly labeled soil container. A Chain of Custody form should be completed and remain with the sample.

## **Laboratory Instructions**

Ask the laboratory to test for chloride using procedure 9251 or 9252 of U.S. EPA Method 325.3. The laboratory will forward an analysis. You must attach a copy of the analysis to the completed **Bioremediation Project Report**.

### **Metals - TCLP**

Crude oil and brine produced within Ohio tend to have very low concentrations of heavy metals. Most of the detectable metals are at or very near the method detection limit. For this reason, very little emphasis has been placed on metals analysis and their potential impacts on health and safety or the environment.

Metals have the potential to accumulate in soils. If a site is used repeatedly for bioremediation without periodic soil removal, there will likely be a small increase in certain metal concentrations. Other metal contaminant sources may also contribute to overall metal concentrations. In particular, lead has become fairly common in soils. The most likely source of lead is from residue from the use of leaded gasoline.

The most common test for heavy metals is the TCLP. This test includes analyses for arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver. The analysis must be completed by a certified laboratory. TCLP testing must be performed when a site is used more than three consecutive times without the removal of soil. You may also use this test on any location to determine heavy metal concentrations. This is particularly useful if a sample is collected outside the affected area. This will allow you to establish background heavy metal concentrations. You will also be able to determine the relative heavy metal impact, if any, as a result of the crude oil spill. These analyses provide valuable information when issues involving heavy metal contamination are reviewed.

### **Equipment Requirement**

- Soil sampling auger or probe; and
- Sample collection containers and a permanent marker

### **Procedure**

Before the soil is tilled, use a soil auger to collect a sample to a depth of 6 inches in the middle of the spill site. The entire sample should be placed in a properly labeled sample container. If a background sample is collected, use the same sampling procedure in an adjacent unaffected area.

## Laboratory Instructions

Ask the laboratory to analyze the sample using U.S. EPA TCLP procedures.

Arsenic (As) - Method 760  
Barium (Ba) - Method 780  
Cadmium (Cd) - Method 7130  
Chromium (Cr) - Method 7190  
Lead (Pb) - Method 7421  
Mercury (Hg) - Method 7470  
Selenium (Se) - Method 7740  
Silver (Ag) - Method 7760

You will receive a copy of the analysis from the laboratory. Attach a copy of the analysis to the **Bioremediation Project Report** when the project is finished.

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U.S. Environmental Protection Agency, Health Effects Assessment Summary Table, April 4, 1991.

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## APPENDIX I

### Agency Contacts for Spill Reporting

#### STATE (County and Local)

1. Ohio Department of Natural Resources  
Division of Mineral Resources Management

Northern Region Office  
3575 Forest Lake Drive  
Suite 150  
Uniontown, OH 44685  
(330) 896-0616 (telephone)  
(330) 896-1849 (fax)

Southern Region Office  
2050 East Wheeling Ave.  
Cambridge, OH 43725-2159  
(740) 439-9079 (telephone)  
(740) 432-7711 (fax)

Western Region Office  
117 East High Street, Suite 144  
Mt. Vernon, OH 43050  
(740) 392-4499 (telephone)  
(740) 392-4499 (fax)

2. Ohio Department of Natural Resources  
Division of Wildlife  
2045 Morse Road, Bldg G  
Columbus, OH 43229-6693  
(614) 265-6300 (telephone)  
(614) 262-1143 (fax)

3. Ohio Environmental Protection Agency  
Emergency Response  
122 South Front Street, 6<sup>th</sup> Floor  
P.O. Box 1049  
Columbus, Ohio 43216  
(800) 282-9378

Central Office Spill Unit  
(614) 224-0946  
(614) 728-3778

Twinsburg Office (Northeast)  
(330) 963-1218

Logan Office (Southeast)  
(614) 385-8501

Bowling Green Office (Northwest)  
(419) 352-8461

Dayton Office (Southwest)  
(513) 285-6357

4. Ohio Department of Commerce  
Division of State Fire Marshall  
8895 E. Main Street  
Reynoldsburg, Ohio 43068-3395  
(614) 752-8200 (telephone)  
(614) 752-7213 (fax)

A listing for every fire department in Ohio is provided in the **Ohio Fire Department Directory**. This publication is available through the State Fire Marshal Office. You may have reporting requirements for certain spills. A complete listing of all Local Emergency Planning Committee (LEPC), Emergency Coordinators is contained in the OOGA Membership Directory.

5. Ohio Secretary of State  
30 E. Broad Street, 14th Floor  
Columbus, Ohio 43266-0418  
(614) 466-0565 (telephone)  
taft@ohio.gov (e-mail)  
<http://www.state.oh.us/sos> (web site)

A listing of all municipal and township officials is available through **The Ohio Municipal, Township, and School Board Roster**. You may have spill reporting requirements within a given township or municipality. Be aware of all township or municipal ordinances as they relate to oil and gas activities and spill response and reporting.

A listing of all county and state officers is available through the State of Ohio; Official Roster: **Federal, State, County Officers and Departmental Information**.

## **FEDERAL**

1. National Response Center  
(800) 424-8802
2. U.S. Department of the Interior  
18th and C Streets N.W.  
Washington, DC 20240  
Bureau of Land Management  
Milwaukee District Office  
3 10 W. Wisconsin Avenue, Suite 450  
Milwaukee, WI 53203  
(414) 297-4400 (telephone)  
(414) 297-4409 (fax)  
  
Roland Adams  
Bureau of Land Management  
Marietta Inspection Office  
c/o Wayne National Forest  
Route 1, Box 132  
Marietta, OH 45750  
(740) 373-9055 (telephone)  
(740) 373-8079 (fax)
3. Fish and Wildlife Services  
National Park Service (Cuyahoga Valley National Recreation Area)
4. U.S. Department of Agriculture  
Wayne-Hoosier National Forest  
Athens District Office  
c/o Wayne National Forest  
Route 1, Box 132  
Marietta, OH 45750  
(740) 373-9055 (telephone)  
(740) 373-8079 (fax)

APPENDIX II  
**Sources of Information**

RCRA EXEMPTIONS

1. EPA "Crude Oil and Natural Gas Exploration and Production Wastes: Exemption from RCRA Subtitle C Regulation, " May 1995, EPA530-K-95-003.  
  
Contact: U.S. Environmental Protection Agency  
Office of Solid Waste  
Oil and Gas Industry Section (5302W)  
401 Main Street, S.W.  
Washington, DC 20460  
1-703-308-8424
2. EPA "Report to Congress: Management of Wastes from the Exploration, Development, and Production of Crude Oil, Natural Gas, and Geothermal Energy," December 1987, NTIS Publication No. PB 88-146212.  
  
Contact: National Technical Information Service (NTIS)  
5285 Port Royal Road  
Springfield, VA 22161  
1-703-487-4650
3. "Regulatory Determination for Oil and Gas and Geothermal Exploration, Development, and Production Wastes," July 6, 1988, *Federal Register* Volume 53, Pages 25446 to 25459.  
  
Contact: RCRA/Superfund Hotline  
Washington, DC  
1-800-424-9346
4. "Clarification of the Regulatory Determination for Wastes from the Exploration, Development, and Production of Crude Oil, Natural Gas and Geothermal Energy," March 22, 1993, *Federal Register* Volume 58, Pages 15284 to 15287.  
  
Contact: RCRA/Superfund Hotline  
Washington, DC  
1-800-424-9346

GEOLOGIC DATA

5. Ohio Division of Geological Survey  
Geologic Records Center  
2045 Morse Road, Bldg. C-1  
Columbus, Ohio 43229-6693  
1-614-265-6576

Source for USGS topographic maps and geologic data (surficial).

#### SOIL DATA

6. Ohio Division of Soil and Water Conservation  
2045 Morse Road, Bldg. B-3  
Columbus, Ohio 43229-6693  
1-614-265-6610

Source for United States Department of Agriculture, Soil Conservation Service;  
Soil surveys for each county in Ohio.

#### WATER DATA

7. Ohio Division of Water  
2045 Morse Road, Bldg. E-1  
Columbus, Ohio 43229-6693  
1-614-265-6728

Source for county water resource maps, water well logs and general aquifer  
information.

## APPENDIX III

### Equipment and Supply Companies

1. **BenMeadows Company**  
3589 Broad Street  
Atlanta, GA 30341  
1-800-241-6401 (telephone)  
1-800-628-2068 (fax)  
mail@benmeadows.com (e-mail)  
http://www.benmeadows.com (web site)

Source for thermometers, pH meters, soil moisture meters, and soil sampling tools.

2. **Cole Parmer Instruments Company**  
625 East Bunker Court  
Vernon Hills, IL 60061-9872  
1-800-323-4340 (telephone)  
1-847-549-1700 (fax)  
export@coleparmer.com (e-mail)  
http://www.coleparmer.com (web site)

Source for thermometers, soil moisture meters, salinity meters, soil pH testers, conductivity (EC) meters and rain gauges.

3. **Davis Instruments**  
4701 Mount Hope Drive  
Baltimore, MD 21215  
1-800-433-9971 (telephone)  
1-410-358-0252 (fax)

Source for thermometers, soil moisture meters, salinity meters, soil pH testers, rain gauges and conductivity (EC) meters.

4. **Environmental Test Systems, Inc.**  
P.O. Box 4659  
Elkhart, IN 46514  
1-800-452-0215 (telephone)  
1-219-262-2060 (fax)

Source of "Quantab" chloride titrator (salt testing).

5. **Forestry Suppliers, Inc.**  
P.O. Box 8397  
Jackson, MS 39284-8397  
1-800-647-5368 (telephone)  
1-800-543-4203 (fax)

Source for soil sampling tools, soil sampling bags, hydrocarbon test kits, pH meters, conductivity (EC) meters, temperature meters; soil pH test kits.

6. **HAZCO Services, Inc.**  
P.O. Box 2635  
Dayton, Ohio 45401  
1-800-332-0435 (telephone) (8-5; M-F)  
1-513-293-9227 (fax)

Source for rental equipment, soil sampling tools, sample containers, pH meters and thermometers.

7. **The Lab Mart**  
J. & H. BERGE, INC.  
4111 S. Clinton Ave.  
S. Plainfield, NJ 07080  
1-800-684-1234 (telephone)  
1-908-561-3002 (fax)

Source for thermometers and pH meters.

The supply companies are listed in alphabetic order. The Division has provided this list as a reference source and does not endorse any company. Many other companies are able to provide similar supplies. You are encouraged to contact many companies to compare products and prices.

Should you have questions about the use of certain equipment at a bioremediation site, the Division will help you review product specifications. We suggest companies either purchase certain test equipment or have sample containers present to collect samples for laboratory analysis. If a company develops a bioremediation project plan before a spill occurs, you will likely save both time and money during a project.

The Division suggests you contact local agricultural supply companies or feed stores to purchase fertilizer, powdered lime, seed and erosion control materials.

**APPENDIX IV**  
**Laboratories**

- |    |  |                |
|----|--|----------------|
| 1. | <b>Coshocton Environmental Testing, Inc.</b><br>1599 Otsego Avenue<br>P.O. Box 723<br>Coshocton, Ohio 43812            | (614) 622-3328 |
|    |  |                |
| 2. | <b>Quanterra, Inc</b><br>4101 Shuffel Drive N.W.<br>North Canton, Ohio 44720   | (330) 497-9396 |
|    |  |                |
| 3. | <b>Environmental Research Group</b><br>John Palmer<br>7777 Exchange Street<br>Cleveland, Ohio 44125                    | (216) 447-0790 |
|    |  |                |
| 4. | <b>Kemron Environmental Services</b><br>Mary Welch, Marketing Coordinator<br>109 Starlite Park<br>Marietta, Ohio 45750 | (614) 373-4071 |
|    |  |                |
| 5. | <b>Stilson Laboratories, Inc.</b><br>170 N. High Street<br>Columbus, Ohio 43215  | (614) 228-4385 |
|    |  |                |
| 6. | <b>Tri-State Laboratories</b><br>2870 Salt Springs Road<br>Youngstown, Ohio 44509                                      | (800) 523-0347 |



The laboratories are listed in alphabetic order. This Division has provided this list as a reference source and does not endorse any laboratory. Many other laboratories are able to provide similar services. You are encouraged to contact many laboratories to compare services and prices. We suggest you make these contacts as part of an overall bioremediation project plan. This will likely save you time and money during a project.

Should you have questions about sampling procedures, analytical test methods or report formats from a laboratory, the Division will help you review these specifications.

## Cost Analysis Worksheet

### Totals

#### Materials

Fertilizer	\$ _____/sack	\$ _____
Lime (or equivalent)	\$ _____/sack	\$ _____
Erosion Control Material (straw, netting & stakes)	\$ _____/bale (roll)	\$ _____
Mulch (composed manures, straw, Bark mulch, peat moss, sawdust)	\$ _____/yard <sup>3</sup>	\$ _____
Fresh Water (if needed)	\$ _____/truck	\$ _____
Microbe Cultures (if need)	\$ _____/unit	\$ _____

#### Equipment

Tiller (plow)	\$ _____/hr	\$ _____
Soil Moisture Meter (if needed)	\$ _____/unit	\$ _____
pH Meter or Disposable Test Strips	\$ _____/unit	\$ _____
Electrical Conductivity (EC) or Salinity Meter (if needed)	\$ _____/unit	\$ _____
Sample Bottles (lab approved)	\$ _____case	\$ _____
Soil Sampling Equipment (if needed)	\$ _____/unit	\$ _____
Fertilizer Spreader	\$ _____/unit	\$ _____
Trucking (if needed)	\$ _____/hr	\$ _____
Backhoe (if needed)	\$ _____/hr	\$ _____
Trachoe (if needed)	\$ _____/hr	\$ _____
Bulldozer (if needed)	\$ _____/hr	\$ _____
Water Truck (if needed)	\$ _____/hr	\$ _____

#### Labor

In House	\$ _____/hr	\$ _____
Contract	\$ _____/hr	\$ _____
Consultant	\$ _____/hr	\$ _____

#### Lab Testing

TPH	\$ _____/test	\$ _____
pH (if needed)	\$ _____/test	\$ _____
Nutrients (if needed)	\$ _____/test	\$ _____
Metals (TCLP) (if needed)	\$ _____/test	\$ _____
EC or Salinity (if needed)	\$ _____/test	\$ _____

#### Restoration

Grading	\$ _____/hr	\$ _____
Seed	\$ _____/sack	\$ _____
Straw	\$ _____/bale	\$ _____

## **Savings Associated with Bioremediation Versus Soil Removal and Landfilling of Crude Oil Contaminated Soils**

- ✓ Assume an average site of 100' X 100', or approximately 1/4 acre. (The actual area affected by crude oil spills is often less than the 1/4 acre average, but the heavy equipment often disturbs an area this large.)
- ✓ Assume 6" depth of soil removal.
- ✓ Soil solidification is necessary in seasonally wet areas.
- ✓ Vacuum trucks may be necessary for either type of remediation. (8 hours may be an average per site at \$75.00/hr., if necessary)
- ✓ Sediment Control may be necessary for either type of remediation. (Sites may require 60 bales of straw at \$3.50/bale)
- ✓ Labor is included with most heavy equipment hourly rates. Additional labor has not been included in either remediation summary. In either project, associated labor costs would be relatively low percentages of the total costs.

### **OPTION: Soil Removal and Replacement**

#### **Earth Moving**

Trac hoe/Backhoe	\$ 75.00 - \$150.00/hr. X 8 hrs.	\$ 600 - \$ 1200
Trucking	\$ 50.00 - \$100.00/hr. X 1 X 8 hrs.	\$ 400 - \$ 800
Soil Solidification	\$ 16.00 - \$ 48.00/cubic yd. X 185 cubic yds.	\$2960 - \$ 8880

#### **Landfill and Associated Fees**

Analytical Testing	\$300.00 - /truckload X 11 loads	\$ 300 - \$ 3300
(Some landfills only require testing of the contents on one truckload)		
Landfill Fees	\$ 50.00/cubic yd. X 185 cubic yds.	\$9250

#### **Soil Replacement**

Topsoil	\$ 10.00 - \$ 15.00/cubic yd. X 185 cubic yds.	\$1850 - \$ 2775
Trucking	\$ 50.00 - \$100.00/hr. X 1 X 8 hrs.	\$ 400 - \$ 800

**Site Restoration**

Grading	\$ 50.00 - \$100.00/hr. X 8 hrs.	\$ 400 - \$ 800
Seeding/Mulching	\$500.00/site (AVG.)	\$500
Erosion Control	\$200.00/site	<u>\$200</u>
Total		\$16,800 - \$25,505

**OPTION: BIOREMEDIATION**

Plowing and Discing/ Tilling	\$ 50.00 - \$ 75.00/hr. X 4 hrs.	\$ 200 - \$ 300
pH Control/Lime, Gypsum, Dolomite	\$ 5.00/bag X 100 bags	\$500
Fertilizer	\$ 8.00/bag X 20 bags	\$160
Analytical Testing	\$100.00 - \$300.00/sample X 2	\$ 200 - \$ 600
Periodic Tilling	\$ 50.00 - \$ 75.00/hr. X 2 hrs. X 4	\$ 400 - \$ 600
Site Restoration		
Grading	\$ 50.00 - \$100.00/hr. X 8 hrs.	\$ 400 - \$ 800
Seeding/Mulching		\$500
Erosion Control	\$200.00	<u>\$200</u>
Total		\$2500 - \$3660

These comparisons are for demonstration purposes only. Actual costs for labor and materials may vary considerably and are probably less than in the example.

**BIOREMEDIATION SITE EVALUATION REPORT**  
**OHIO DEPARTMENT OF NATURAL RESOURCES**  
**Division of Mineral Resources Management**  
**2045 Morse Road, Bldg H-2**  
**Columbus, Ohio 43229-6693**

**Well Owner Information**

Name: \_\_\_\_\_ Lease Name &amp; No.: \_\_\_\_\_

Address: \_\_\_\_\_ SWJW # \_\_\_\_\_

ERP # \_\_\_\_\_

Phone: \_\_\_\_\_ SMP # \_\_\_\_\_

Contact Person: \_\_\_\_\_

Directions to Spill Site: \_\_\_\_\_

Source of Material Spilled: \_\_\_\_\_ Crude Oil; \_\_\_\_\_ Condensate; \_\_\_\_\_ Brine; \_\_\_\_\_ Other

Volume of Material Spilled: \_\_\_\_\_ Bbls. OR \_\_\_\_\_ Gal.; \_\_\_\_\_ Estimated; \_\_\_\_\_ Measured

Surface Area Affected (Approximate): Average Length \_\_\_\_\_ ft.; Average Width \_\_\_\_\_ ft.

Depth of Contaminated Soil: \_\_\_\_\_ inches.

Soil Type: \_\_\_\_\_ Clayey; \_\_\_\_\_ Silty; \_\_\_\_\_ Sandy; \_\_\_\_\_ Other \_\_\_\_\_

Depth to Ground Water Table: Greater than 4 ft.: \_\_\_\_\_ Yes \_\_\_\_\_ No

Slope of the Affected Land (Approximately): \_\_\_\_\_ Degrees

\_\_\_\_\_  
Company Representative Signature\_\_\_\_\_  
Date

Comments: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**For Official Use Only**☐ Approved☐ Denied

Comments/Conditions: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_  
Signature\_\_\_\_\_  
Date

## LANDOWNER INFORMATION

Name: \_\_\_\_\_

Address: \_\_\_\_\_

Phone: (\_\_\_\_) \_\_\_\_\_ (Home) Phone: (\_\_\_\_) \_\_\_\_\_ (Work)

The State of Ohio, Department of Natural Resources, Division of Mineral Resources Management (Division) is the primary state regulatory agency for Ohio's oil and gas industry. This authority is granted and detailed within Chapter 1509. of the Ohio Revised Code and Chapter 1501. of the Ohio Administrative Code. The well owner may ask the State for permission to remediate a crude oil spill at the site on which it occurred. The Division of Mineral Resources Management will evaluate each request for health and safety and environmental considerations. If the project is approved by the state, the well owner will have up to 12 months to complete the remediation and site restoration. Division personnel will oversee the project and will inspect the site periodically. The well owner will be held responsible and liable for remediating the problem and restoring the land. The landowner will NOT be held liable, unless the landowner is also an owner of the well.

A Division of Mineral Resources Management Inspector and District Supervisor will be assigned to this project. Their names, addresses and telephone numbers will be forwarded to the landowner if the project is approved. You will receive a copy of the approved form for your records. You are encouraged to contact the Inspector or Supervisor if you have questions or concerns during the project. Upon completion of the project, you may request a free copy of the project file.

☐ Check this box if you have attached a separate page with comments or concerns regarding this activity.

***By signing this document you attest that you are the landowner or have Power of Attorney to sign on behalf of the landowner. You hereby grant permission to remediate soils affected by crude oil on your property for a period not to exceed 12 months from the date the project receives state approval.***

_____ Landowner (PLEASE PRINT)	_____ Landowner Signature	_____ Date
_____ Power of Attorney (PLEASE PRINT)	_____ Power of Attorney	_____ Date
_____ Witness (PLEASE PRINT)	_____ Witness	_____ Date

## BIOREMEDIATION PROJECT REPORT

Company: _____		Surface Owner: _____	
Contact Person: _____		Telephone No.: (____) _____	
Telephone No.: (____) _____			

<b>pH</b>	(initial) <u>  /  /  </u>	* date <u>      </u>	Results (S.U.)
	<u>      /  /  </u>	<u>      </u>	
	<u>      /  /  </u>	<u>      </u>	
	(closure) <u>  /  /  </u>	* <u>      </u>	
	<u>      /  /  </u>	<u>      </u>	

<b>TPH</b>	(initial) <u>  /  /  </u>	* date <u>      </u>	Results (ppm)
	<u>      /  /  </u>	<u>      </u>	
	(closure) <u>  /  /  </u>	* <u>      </u>	
	<u>      /  /  </u>	<u>      </u>	

<b>EC (25° C)</b>	(initial) <u>  /  /  </u>	**date <u>      </u>	Results
	<u>      /  /  </u>	<u>      </u>	
	(closure) <u>  /  /  </u>	** <u>      </u>	
	<u>      /  /  </u>	<u>      </u>	

<b>Tilling Schedule</b>	<u>  /  /  </u> <u>  /  /  </u> <u>  /  /  </u> <u>  /  /  </u> <u>  /  /  </u> <u>  /  /  </u>	* date <u>      </u> * <u>      </u> * <u>      </u> * <u>      </u> * <u>      </u> * <u>      </u>	<u>      </u> depth (in.) <u>      </u> <u>      </u> <u>      </u> <u>      </u> <u>      </u>	<u>      </u> method <u>      </u> <u>      </u> <u>      </u> <u>      </u> <u>      </u>
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<b>Fertilizer</b>	<u>  /  /  </u> <u>  /  /  </u> <u>  /  /  </u>	* date <u>      </u>	<u>  :  :  </u> ratio <u>  :  :  </u> <u>  :  :  </u>	<u>      </u> rate (lbs/yd2) <u>      </u> <u>      </u>
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<b>Organic Mulch</b>	<u>  /  /  </u> <u>  /  /  </u> <u>  /  /  </u>	date <u>      </u>	<u>  :  :  </u> rate (in/yd2) <u>  :  :  </u> <u>  :  :  </u>	
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<b>Soil Temperature</b>	<u>  /  /  </u> <u>  /  /  </u> <u>  /  /  </u>	date <u>      </u>	Temp. (° F @ 4 in. depth) <u>      </u> <u>      </u>
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<b>Soil Moisture</b>	<u>  /  /  </u> <u>  /  /  </u> <u>  /  /  </u>	date <u>      </u>	% @ 4 in. depth <u>      </u> <u>      </u>
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\* Required date; \*\* Required Data with Associated Brine Spills.

## OHIO DEPARTMENT OF NATURAL RESOURCES - DIVISION OF MINERAL RESOURCES MANAGEMENT

## CHAIN OF CUSTODY FORM 7/01

325 North 7<sup>th</sup> Street  
Cambridge, Ohio 43725

Telephone: (740) 439-5591  
Fax No.: (740) 439-3075

DMRM

Dist. Office: \_\_\_\_\_

DMRM

Sample  
Numbers: \_\_\_\_\_ To \_\_\_\_\_

Location

County or Basin: \_\_\_\_\_

Project Name: \_\_\_\_\_

No. of Containers

Container Type (Glass or Plastic)

Filtered (F) or Non-Filtered (NF)

Preservative Used  
HNO<sub>3</sub>, HCL, H<sub>2</sub>SO<sub>4</sub>, Other

Analysis Requested

Group I

Group II

Group Oil & Gas

FUNDING SOURCE:

AML

AML Set-Aside

Coal Regulatory

Industrial Min.

Oil & Gas

DMRM SAMPLE NO. DATE TIME (Military)

FIELD SAMPLE I.D.

COORDINATES / COMMENTS

LABORATORY:

DMRM Cambridge

Contract Laboratory

Name: \_\_\_\_\_

Address: \_\_\_\_\_

Sampled By: \_\_\_\_\_

Witnessed By: \_\_\_\_\_  
(Optional)

Turned In By:

Transferred By:

Transferred By:

Transferred By:

Date:

Date:

Date:

Date:

Time: (Military)

Time: (Military)

Time: (Military)

Time: (Military)

Received By:

Received By:

Received By:

Received By:

Date:

Date:

Date:

Date:

Time: (Military)

Time: (Military)

Time: (Military)

Time: (Military)



## **SAMPLE PARAMETER CATEGORIZATION**

### **GROUP I**

pH  
Conductivity  
Alkalinity, Total  
Acidity, Hot or Total  
Sulfate  
Total Dissolved Solids  
Total Suspended Solids  
Hardness – Calcium, Magnesium  
Iron (Total)  
Aluminum (Total)  
Manganese (Total)

### **GROUP II**

pH  
Conductivity  
Alkalinity, Total  
Acidity, Hot or Total  
Chloride  
Sulfate  
Total Dissolved Solids  
Total Suspended Solids  
Hardness – Calcium, Magnesium  
Iron (Total)  
Aluminum (Total)  
Manganese (Total)  
Sodium (Total)  
Potassium (Total)

### **GROUP O/G**

Conductivity  
Alkalinity  
Chloride  
Total Dissolved Solids  
Sulfate  
Calcium  
Magnesium  
Sodium  
Potassium  
Barium  
Strontium

# BIOREMEDIATION SITE EVALUATION MATRIX

Material Spilled	Spill Location	Legal Jurisdiction	Site Conditions	Seasonal Considerations
RCRA EXEMPT	WATERWAYS & WETLANDS	SEE APPENDIX 1	STOP	
	U.S. ARMY CORPS OF ENGINEERS DESIGNATED 100 YR. FLOODPLAIN	ODNR DIVISION OF OIL & AS OFF-SITE APPROVAL ONLY	CONTINUE	
	DESIGNATED MUNICIPAL WATER WELL FIELDS	ODNR DIVISION OF OIL & AS OFF-SITE APPROVAL ONLY	CONTINUE	SITE IS TOO WET FOR WORK FREE OIL PICKED-UP POLLUTION CONTROL MEASURES IN PLACE
	PRIVATE LAND	ODNR DIVISION OF OIL & GAS LANDOWNER APPROVAL REQUIRED OR OFF-SITE APPROVAL	CONTINUE	STOCK PILE AND COVER SOILS EROSION CONTROL MEASURES IN PLACE
	STATE LAND COUNTY, TOWNSHIP MUNICIPAL	ODNR DIVISION OF OIL & GAS LANDOWNER APPROVAL REQUIRED OR OFF-SITE APPROVAL	CONTINUE	
	ALL FEDERAL LANDS	CONTACT APPROPRIATE FEDERAL AGENCY SEE APPENDIX 1	STOP	* If all site conditions are met.
RCRA NON-EXEMPT			CONTACT APPROPRIATE STATE AND/OR FEDERAL AGENCY(S)	

# MATERIAL SAFETY DATA SHEET

## Section I

Manufacturer's Name:

Address:

Telephone No. for Information:

Emergency Telephone No.:

Trade Name: Petroleum Crude Oil

Synonyms: Crude

Date Prepared: 10/24/88

CAS Number 8002-05-9

### NFPA Hazard Identification

#### Degree of Hazard

Health: 1

Fire: 3

Reactivity: 0

#### Hazard Ratings

0 - Least

1 - Slight

2 - Moderate

3 - High

4 - Extreme

## Section II - Hazardous Ingredients/Identity Information

Material	CAS #	% WT.	TLV (Units)	OSHA PEL	Hazard
Petroleum Crude Oil	8002-05-9	100	Unknown	Unknown	Fire, Inhalation, Skin

## Section III - Physical/Chemical Characteristics

Boiling Point, 760 mm. Hg: ▶ 90° F

Specific Gravity (H<sub>2</sub>O = 1): ◀ 1

Vapor Density (Air = 1): ▶ 3

Percent Volatiles By Volume ▶ 20

Appearance and Odor: Green to black liquid of varying viscosity. Mild to strong hydrocarbon/aromatic odor.

#### Physical State:

Liquid

Vapor Pressure at 20° C:

4 psi (typical)

Solubility in Water, % by Wt.:

Nil

Evaporation Rate (Butyl Acetate = 1)

◀ 1

Melting Point:

N/A

## Section IV - Fire and Explosion Hazard Data

Flash Point (test method(s)): ◀ 40° (Wide Range)

LEL: N/A

Flammable Limits in Air, % by Volume: 1.0% to 7.0% (Estimated)

UEL: N/A

**Extinguishing Media:** Dry Chemical, carbon dioxide, or chemical foam. Use of water sprays may be ineffective to extinguish fire but should be used to cool tanks, etc. Solid streams of water should be avoided as they may spread fire.

**Special Fire Fighting Procedures:** This product is a dangerous fire and explosion hazard. Do not extinguish pressure fires unless fuel flow can be stopped. Vapors may flow along surfaces, reach distant ignition sources and flash back. Fire fighters should wear self-contained breathing apparatus and full protective clothing.

**Unusual Fire and Explosion Hazards:** Dangerous fire and explosion hazard (OSHA Class IA liquid). Vapors heavier than air. Dense smoke may be generated while burning. Carbon monoxide, carbon dioxide, and other oxides may be generated as products of combustion.

## Section V - Reactivity Data

Stability: Stable

Conditions to Avoid: Storage in hot areas should be avoided.

Incompatibility (Materials to Avoid): Oxidizing agents

Hazardous Combustion or Decomposition Products: Carbon monoxide and partially oxidized hydrocarbons.

Hazardous Polymerization: None

Conditions to Avoid: None

## Section VI - Health Hazard Data

TLV and Source: Unknown

### Acute Effects of Overexposure

Swallowing:

Ingestion may result in loss of consciousness, convulsion, vomiting, vertigo, confusion, cyanosis, fever and death. Ingestion of small quantities is generally non-fatal. Serious aspiration hazard.

Skin Absorption:

Absorption through healthy skin possible, dermatitis caused by prolonged and repeated skin contact or other skin disorders including open wounds can increase the amount of material that may be absorbed through this route.

Inhalation:

Symptoms may include rapid breathing, intoxication, headache, fatigue, nausea, narcosis, loss of consciousness, coma and death.

Skin Contact:

Direct contact may result in skin irritation. Repeated or prolonged exposure may result in drying of skin, dermatitis and dermatologic reactions may occur.

Eye Contact:

Direct contact, as well as exposure to high vapor concentrations, may result in eye irritation (conjunctivitis).

### Chronic Effects of Overexposure

Certain components of this material have been listed in NTP Annual Report on Carcinogens or has been found to be a potential carcinogen in the IARC Monographs or by OSHA.

Includes components which have shown positive results in carcinogenic screening assays and mouse skin carcinogenesis bio-assays.

### Emergency and First Aid Procedures

Swallowing:	Do not induce vomiting. Lay victim down with legs raised, cover with blanket and seek medical attention immediately.
Skin:	Remove contaminated clothing. Wash exposed areas with soap and water. Launder contaminated clothing before rewearing.
Inhalation:	Remove to fresh air. Restore breathing if breathing has stopped. Administer oxygen. Seek medical attention.
Eyes:	Flush with copious amounts of water for 15 minutes and consult a physician.

### Notes to Physician

The composition of crude oil varies from area to area and well to well. Penn Grade crude is typically a paraffinic based crude, low in aromatic and sulfur content. The amount of dissolved natural gas varies with the "aging time" or time stored after being pumped from well.

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## **Section VII - Precautions for Safe Handling and Use**

### Steps to be taken if Material is Released or Spilled:

Remove all sources of heat and ignition. Provide ventilation. Wear proper personal protective equipment. If leak is not ignited, use water spray to disperse vapors. Dike large spills and use absorbent material on small spills. Consult operator's SPCC Plan.

### Waste Disposal Method:

Burn scrap material in an approved incinerator. Follow State and Federal regulations. For large spills, contact licensed waste disposal company.

### Precautions to be Taken in Handling and Storage:

Store in container approved for flammable liquids. Do not transfer or store in unlabeled or mislabeled containers. Store containers in cool, dry, well ventilated storage area, away from sources of ignition and strong oxidizing agents. Storage must meet OSHA Class IA requirements.

### Precautions During Use:

Keep this material away from sparks, non-explosive proof electrical equipment and open flames. No smoking in areas of use. Avoid contact with hot surfaces. Follow electrical bonding and grounding practices to prevent static build up during transfer operations. Use non-sparking tools when working on equipment which has contained straight run gasoline. Avoid inhalation of vapors. Wear clean clothes daily. Follow good personal hygiene practices.

---

## **Section VIII - Control Measures**

### Respiratory Protection:

Use NIOSH-approved respiratory protection as required to prevent overexposure to oil mist, vapor, or fumes and H<sub>2</sub>S. Do not enter storage compartments unless equipped with a NIOSH-approved self-contained breathing apparatus with a full facepiece operated in a positive pressure mode.

### Ventilation:

Adequate ventilation in accordance with good engineering practice must be provided to maintain concentrations below the specific exposure or flammable limits. See also fire protection information in Section IV.

### Protective Gloves:

Impervious protective gloves minimize skin exposure.

### Eye Protection:

Safety glasses and sideshields reduce the possibility of accidental eye contact. Better protection afforded by faceshield or vented goggles where required.

### Protective Gloves and Other Protective Equipment:

Clothing and gloves constructed of Neoprene, Nitrile Rubber, Polyurethane and Polyvinyl Alcohol provide good to excellent protection against gasoline as stated in ACGIH "Guidelines for Selection of Chemical Protective Clothing" and is recommended for protection from crude oil.

### Fire Fighting:

Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.

### Escape:

Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

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

This information is, to the best of the above named manufacturer's knowledge and belief, accurate and reliable. However, no representation, warranty, or guarantee is made to its accuracy, reliability, or completeness. It is the user's responsibility to satisfy himself as to the suitability and completeness of such information for his own particular use.

## MATERIAL SAFETY DATA SHEET

**MATERIAL IDENTITY:** Natural Gas Liquids (Gas Extraction/Process Plant Liquid)  
TSCA Inventory No. 64741-43-6

A complex mixture of naturally occurring hydrocarbons in variable concentrations separated as a liquid from natural gas in a natural gas recycling, extraction or process plant by processes such as refrigeration or absorption. It consists mainly of saturated aliphatic hydrocarbons, having carbon numbers predominantly in the range of C<sub>2</sub> through C<sub>16</sub>.

### SECTION I - MERCHANT'S INFORMATION/STATEMENT

Merchant's Name and Address:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Emergency Telephone Number

( ) \_\_\_\_\_

Information Telephone Number

( ) \_\_\_\_\_

Date MSDS Prepared

February 15, 1991

### SECTION II - HAZARDOUS INGREDIENTS/IDENTITY INFORMATION (See Table A)

### SECTION III - PHYSICAL AND CHEMICAL CHARACTERISTICS (See Table B)

#### Appearance and Odor

Natural gas liquids are generally colorless in their natural state and have a characteristic hydrocarbon odor similar to gasoline.

### SECTION IV - FIRE AND EXPLOSION HAZARD DATA

(See Table C for data on flashpoints, auto ignition temperatures and flammability limits.)

Extinguishing Media - Dry chemical, AFFF foam, halon, CO<sub>2</sub>. Dry chemical preferred; halon and CO<sub>2</sub> gases are only effective for enclosed areas. Water is not effective.

Natural Gas  
Liquids

- 2 -

Special Fire Fighting Procedures - When fighting fires, wear self-contained breathing apparatus with a full face piece operated in pressure demand or other positive pressure mode. Do not pour water into containers of burning liquid.

Unusual Fire and Explosion Hazards - Flammable liquid which vaporizes readily. Vapor is heavier than air. It readily travels downslope along ground to low points. Vapor travel direction is also affected by wind. Ignition sources distant from the vapor source can cause flashback and reignition of source. Liquid expands when heated and may cause closed containers to explode when exposed to fire or heat.

#### SECTION V - REACTIVITY DATA

Stability - Natural gas liquids are stable mixtures.

Incompatibility - High temperatures, sources of ignition, strong oxidizers (e.g. chlorine, bromine and fluorine and their compounds) and liquid oxygen.

Hazardous Decomposition or Byproducts - Carbon monoxide, carbon dioxide and nitrogen dioxide are found in the products of combustion. Improper combustion can result in the release of dangerous concentrations of carbon monoxide and complex hydrocarbon species.

Hazardous Polymerization - Will not occur.

#### SECTION VI - HEALTH HAZARDS DATA

Routes of Entry - Inhalation (X)      Skin (X)      Ingestion (X)

Health Hazard - Asphyxiation and potential skin irritation (dermatitis).

Carcinogenicity - Natural gas liquids are themselves not listed as a carcinogenic product. However, some components in the liquid mixture, such as benzene, are listed, suspected or experimental carcinogens.

#### Signs and Symptoms of Exposure

Inhalation - Rapid respiration and air hunger followed by diminished mental alertness and muscular coordination, followed by faulty judgment and depression of all sensations. Emotional instability often results and fatigue occurs rapidly. As asphyxia progresses, there may be nausea and vomiting, prostration and loss of consciousness. Finally, convulsions, deep coma and complete asphyxiation.

Skin - Prolonged and/or repeated exposure may cause moderate irritation, defatting and/or dermatitis. Eye exposure may result in severe irritation, redness, tearing and/or blurred vision.

Natural Gas  
Liquids

- 3 -

Ingestion - Can cause gastrointestinal irritation, nausea, vomiting and/or diarrhea.

Medical Conditions Generally Aggravated by Exposure - Dermatitis and asthma.

Emergency and First Aid Procedures

Inhalation - Remove victim from contaminated area. Keep victim lying flat, warm and quiet. Remove foreign objects from mouth. If breathing has stopped, use CPR procedures. Keep breathing passages open until medical care is available.

Skin - Wash exposed area with soap and water. If in eyes, flush with large amounts of water, including upper and lower eyelids. Get medical attention.

Ingestion - Do not induce vomiting. Keep warm and quiet and get medical attention.

SECTION VII - PRECAUTIONS FOR SAFE HANDLING AND USE

Steps to be Taken in Case Material is Released or Spilled

Small Spill - Absorb liquid on paper, vermiculite, floor absorbent, or other absorbent material and transfer to DGR-approved containers. Eliminate all sources of ignition such as flares, flames (including pilot lights), and electrical sparks.

Large Spill - Eliminate all ignition sources (flares, flames including pilot lights, electrical sparks). Individuals not wearing protective equipment should be excluded from area of spill until cleanup has been completed. Stop spill at source, dike area of spill to prevent spreading, and pump liquid to salvage tank. Remaining liquid may be taken up with sand, clay, earth, floor absorbent, or other absorbent material and shoveled into containers. Prevent runoff to sewers, streams or other bodies of water. If runoff occurs, notify proper authorities, as required, that a spill has occurred.

Waste Disposal Method - If unusable as a fuel, chemical feedstock, substitute commercial product, or for other use, the liquid must be disposed of in accordance with applicable federal, state, and/or local waste laws.

Precautions to be Taken in Handling and Storage

This product contains hydrocarbon fractions for which OSHA has established workplace standards. Caution should be taken to assure that these OSHA standards are not exceeded. When handling large volumes of this material in confined areas, combustible gas monitoring systems are recommended. Use approved supplied-air breathing equipment and safety lines when working in pits or enclosed areas which may contain natural gas liquid vapors. Follow the National Electric Code Guidelines and local codes for proper installation.

of wiring and equipment. Consult local codes and the National Fire Protection Association Guidelines for recommended fire control systems. For piping system design and operation and maintenance requirements, consult the local authorities. Follow all other applicable electrical, fire and safety codes as required at the local, state and federal levels.

Natural gas liquids in containers should be stored in a dry, well-ventilated area away from corrosive materials and vapors and sources of heat and fire. Proper storage practices are recommended.

Other Precautions - Non-static type clothing, such as cotton, is a recommended precaution.

#### SECTION VIII - CONTROL MEASURES

Respiratory Protection - Personnel not professionally trained in handling natural gas liquids or spills of such liquids must not enter an area containing air mixed with vapors from natural gas liquids or spills of such liquids since a flammable/explosive mixture may be present. Trained personnel should use NIOSH/MSHA-approved supplied-air breathing equipment.

Ventilation - Supply adequate ventilation. If mechanical ventilation is used, the equipment should be certified for explosive vapor service.

Protective Gloves - Impermeable protective gloves are recommended where skin contact is likely.

Eye Protection - Eye protection is recommended.

Other Protective Clothing or Equipment - Equipment suitable to protect against skin contact is recommended.

Work/Hygienic Practices - Normal workplace hygienic practices are recommended.

#### SECTION IX - ADDITIONAL PRECAUTIONS

- Consult appropriate DOT regulations regarding the movement or shipment of this material.
- Odor is not an adequate warning for determining potentially hazardous concentrations of natural gas liquid vapor in air.
- Consult merchant for advice on situations not included on this data sheet.



Natural Gas  
Liquids

- 5 -

SECTION X - MERCHANT'S STATEMENT

DISCLAIMER OF EXPRESSED AND IMPLIED WARRANTIES

The information in this document is believed to be correct as of the date issued. Exact composition, however, will vary from time to time and at different locations.

HOWEVER, NO WARRANTY OF MERCHANTABILITY, FITNESS FOR ANY PARTICULAR PURPOSE, OR ANY OTHER WARRANTY IS EXPRESSED OR IS TO BE IMPLIED REGARDING THE ACCURACY OR COMPLETENESS OF THIS INFORMATION, THE RESULTS TO BE OBTAINED FROM THE USE OF THIS INFORMATION OR THE PRODUCT, THE SAFETY OF THIS PRODUCT, OR THE HAZARDS RELATED TO ITS USE.

This information and product are furnished on the condition that the person receiving them shall make his own determination as to the suitability of the product for his particular purpose and on the condition that he assume the risk of his use thereof.

**TABLE 2**  
**SECTION II - HAZARDOUS INGREDIENTS/IDENTITY INFORMATION**  
(See next page for explanation of abbreviations)

<u>Component</u>	<u>OSHA TWA Transitional Limits (ppm)</u>	<u>OSHA Final Rule Limits (ppm)</u>	<u>ACGIH Levels (ppm)</u>	<u>Other Levels</u>
Alkanes	NL	NL	NL	NIOSH: 350mg/m <sup>3</sup>
Ethane	NL	NL	SA	NL
Propane	1000	1000 (TWA)	SA	NL
n-Butane	NL	800 (TWA)	800 (TWA)	NL
iso-Butane	NL	NL	NL	NL
n-Pentane	1000	600 (TWA) 750 (STEL)	600 (TWA) 750 (STEL)	NL
iso-Pentane	NL	NL	NL	NL
neo-Pentane	NL	NI.		NIOSH: 1800mg/m <sup>3</sup> (CL, 15 min)
n-Hexane	500	50 (TWA)	50 (TWA)	NL
iso-Hexane	NL	500 (TWA) 1000 (STEL)	500 (TWA) 1000 (STEL)	NL
neo-Hexane	NL	500 (TWA) 1000 (STEL)	500 (TWA) 1000 (STEL)	NL
n-Heptane	500	400 (TWA) 500 (STEL)	400 (TWA) 500 (STEL)	NL
iso-Heptane	NL	NL	NL	NL
neo-Heptane	NL	NL	NL	NL
n-Octane	500	300 (TWA) 375 (STEL)	300 (TWA) 375 (STEL)	NL
iso-Octane	NL	NL	NL	NL
Nonane	NL	200 (TWA)	200 (TWA)	NL
Decane	NL	NL	NL	NL
n-Undecane	NL	NL	NL	NL
n-Dodecane	NL	NL	NL	NL
n-Tridecane	NL	NL	NL	NL
n-Tetradecane	NL	NL	NL	NL
n-Pentadecane	NL	NL	NL	NL
n-Hexadecane	NL	NL	NL	NL
Cyclopentane	NL	600 (TWA)	600 (TWA)	NL
Methycyclopentane	NL	NL	NL	NL
Cyclohexane	300	300 (TWA)	300 (TWA)	NL
Methycyclohexane	500	400 (TWA)	400 (TWA)	NL
Benzene*	10 (TWA) 25 (CL) 50 (10 min)	10 (TWA) 25 (CL) 50 (10 min)	10 (TWA) 75 (STEL)	NIOSH: 1 ppm (60 minutes)
Toluene	200 (TWA) 300 (CL) 500 (10 min)	100 (TWA) 150 (STEL)	100 (TWA) 150 (STEL)	NIOSH: 100 ppm (TWA), 200 ppm (CL, 10 min)

\*For general industry. See 29 CFR 1910.1028 for specific industry segment applicability.

Abbreviations for Table A

NL = Not Listed

SA = Simple Asphyxiant

TWA = 8-hour Time-Weighted Average

STEL = Short-Term, 15-minute Exposure Limit

CL = Ceiling Level

mg/m<sup>3</sup> = Milligrams per Cubic Meter

OSHA = Occupational Safety and Health Administration

ACGIH = American Conference of Governmental Industrial Hygienists

NIOSH = National Institute for Occupational Safety and Health

TABLE 8

SECTION III - PHYSICAL AND CHEMICAL CHARACTERISTICS OF  
MAJOR COMPONENTS OF NATURAL GAS LIQUIDS (a, b, c)

Characteristic	Component									
	Ethane	Propane	n-Butane	iso-Butane	n-Pentane	iso-Pentane	n-Hexane	n-Heptane	iso-Heptane	iso-Octane
Chemical Formula .....	C <sub>2</sub> H <sub>6</sub>	C <sub>3</sub> H <sub>8</sub>	C <sub>4</sub> H <sub>10</sub>	C <sub>4</sub> H <sub>10</sub>	C <sub>5</sub> H <sub>12</sub>	C <sub>5</sub> H <sub>12</sub>	C <sub>6</sub> H <sub>14</sub>	C <sub>6</sub> H <sub>14</sub>	C <sub>7</sub> H <sub>16</sub>	C <sub>8</sub> H <sub>18</sub>
Molecular Weight .....	30.08	44.11	58.14	58.14	72.15	72.15	86.20	86.20	100.23	114.26
Chemical Abstracts Service (CAS) No. ....	74-84-0	74-98-6	106-97-8	75-28-5	109-66-0	78-78-4	110-54-3	107-83-5	112-82-6	111-65-9
Boiling Point (°C) ....	-89.6	-42.1	-0.5	-11.7	36.1	27.8	69	60.27	98.52	90.2
Boiling Point (°F) ...	-127.48	-47.78	32.9	10.9	96.98	82.04	156.20	140.49	209.34	258.44
Freezing Or Melting Point (°C) ..	-172	-187.1	-118	-160	-129.8	-160.5	-95.6	-156.63	-98.2	-90.5
Freezing Or Melting Point (°F) ..	-405.08	-304.78	-214.4	-245.06	-201.64	-256.9	-140.08	-244.61	-144.76	-130.76
Vapor Pressure (mmHg) <sup>a</sup> ..	40 <sup>f</sup> (23.6°)	13 <sup>f</sup> (28.9°)	2 <sup>f</sup> (18.3°)	2 <sup>f</sup> (7.5°)	400 (118.5°)	595 (121.1°)	100 (15.8°)	350 (37.78°)	40 (22.3°)	180 (37.78°)
Vapor Density (Air=1) ...	1.04	1.55	2.05	2.01	2.48	2.48	2.97	3.00	3.45	3.93
Specific Gravity (H <sub>2</sub> O=1)	0.45	0.59	0.60	0.56	0.63	0.62	0.65	0.67	0.68	0.69
Solubility in Water ...	Insoluble	Soluble	Soluble	Soluble	Soluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
Appearance .....	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless
Odor .....	Odorless	Odorless	Faint Disagree- able Odor	Odorless	Moderate	Pleasant	Faint	NL	NL	NL
DOT Classification .....	Flammable Gas	Flammable Gas	Flammable Gas	Flammable Gas	Flammable Liquid	Flammable Liquid	Flammable Liquid	Flammable Liquid	Flammable Liquid	Flammable Liquid

a) Sources: M. Irving Sin and Richard J. Lewis, Seventh Edition, Compendious Properties of Industrial Materials, Van Nostrand Reinhold, New York.  
Clayton, G.A. and F.C. Clayton (editors), Third Revised Edition, Patty's Industrial Hygiene and Toxicology, John Wiley and Sons, New York.  
Gas Processors Suppliers Association, Tulsa, OK, Tenth Edition, 1987, Engineering Data Book.

b) Numbers rounded off to nearest hundredth.

c) NL = Not Listed.

d) mm Hg (°C). - (°F = 1.8°C + 32)

e) At 760 mm Hg, 25°C, except for (f) below.

f) At atmospheric pressure.

### SECTION III - PHYSICAL AND CHEMICAL CHARACTERISTICS OF MAJOR COMPONENTS OF NATURAL GAS LIQUIDS (a,b,c)

Characteristic	Component										
	n-Heptane	n-Decane	n-Undecane	n-Dodecane	n-Tridecane	n-Tetradecane	n-Pentadecane	n-Hexadecane	Cyclohexane	Methylcyclohexane	Toluene
Chemical Formula .....	C <sub>7</sub> H <sub>16</sub>	C <sub>10</sub> H <sub>22</sub>	C <sub>11</sub> H <sub>24</sub>	C <sub>12</sub> H <sub>26</sub>	C <sub>13</sub> H <sub>28</sub>	C <sub>14</sub> H <sub>30</sub>	C <sub>15</sub> H <sub>32</sub>	C <sub>16</sub> H <sub>34</sub>	C <sub>7</sub> H <sub>12</sub>	C <sub>7</sub> H <sub>14</sub>	C <sub>6</sub> H <sub>6</sub>
Molecular Weight .....	98.19	142.29	154.27	170.33	186.41	200.44	214.47	228.44	98.19	98.19	92.15
Chemical Abstracts Service (CAS) No. ....	111-84-2	124-18-5	1120-21-4	112-40-3	829-60-8	429-69-1	429-62-3	514-76-3	100-82-7	100-87-2	71-43-2
Boiling Point (°C) .....	35.7	174.1	195.6	216.29	236	253.57	270.5	286.79	90.7	100.3	110.4
Freezing or Melting Point (°C) ..	-94.06	-21.46	-14.15	14.81	20.84	41.9	50	54.71	13.7	112.4	20.72
Vapor Pressure (mmHg) ..	20 (38.0°)	1 (16.5°)	ML	1 (47.0°)	1 (59.4°)	1 (66.4°)	1 (71.6°)	1 (80.3°)	100 (60.8°)	100 (66.1°)	36.7mm (30°)
Vapor Density (Air=1) ..	4.11	4.90	5.4	5.96	ML	6.03	ML	7.8	2.90	3.39	3.14
Specific Gravity (H <sub>2</sub> O=1)	0.72	0.73	0.74	0.75	0.76	0.77	0.77	0.78	0.78	0.77	0.87
Solubility in Water ...	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
Appearance .....	Colorless	ML	Colorless	ML	Colorless	Colorless	Colorless	ML	Colorless	Colorless	Colorless
Odor .....	ML	ML	ML	ML	ML	ML	ML	ML	Pungent or Sweetish	ML	Pleasant Odor
Classification .....	Flammable or Combustible Liquid	Flammable or Combustible Liquid	Flammable or Combustible Liquid	ML	ML	ML	ML	ML	Flammable Liquid	Flammable Liquid	Flammable Liquid

TABLE C  
SECTION IV - FIRE AND EXPLOSION HAZARD DATA

<u>Component</u>	<u>Flashpoint<sup>1</sup></u> <u>(°F)</u>	<u>Flammable Limits,<sup>2</sup></u>		<u>Auto</u> <u>Ignition</u> <u>Temp. (°F)</u>
		<u>LEL</u>	<u>UEL</u>	
Ethane	-202	3.0	12.5	959
Propane	-156	2.3	9.5	842
n-Butane	-76 (CC)	1.9	8.5	761
iso-Butane	-181	1.9	8.5	864
n-Pentane	-56.2	1.5	7.8	588
iso-Pentane	-59.8	1.4	7.6	788
neo-Pentane	20	1.4	8.3	842
n-Hexane	-9.4	1.2	7.5	437
iso-Hexane	20 (CC)	1.0	7.0	583
neo-Hexane	-54	1.2	7.0	797
n-Heptane	25 (CC)	1.05	6.7	433.4
iso-Heptane	-18	1.0	6.0	536
neo-Heptane	NL <sup>2</sup>	NL	NL	NL
n-Octane	56	1.0	4.7	428
iso-Octane	10	1.1	6.0	779
n-Nonane	88 (CC)	0.8	2.9	374
n-Decane	115 (CC)	0.8	5.4	410
n-Undecane	149 (CC)	NL	NL	NL
n-dodecane	165	0.6	NL	399
n-Tridecane	175	NL	NL	NL
n-Tetradecane	212	0.5	NL	NL
n-Hexadecane	275	NL	NL	NL
Cyclopentane	19.4	NL	NL	716
Methylcyclopentane	-20.02	1.2	8.4	NL
Cyclohexane	1.4	1.3	8.4	473
Methylcyclohexane	25	1.2	6.7	482
Benzene	12 (CC)	1.4	8.0	1044
Toluene	40 (CC)	1.27	7.0	996

<sup>1</sup> Method of determining flashpoint given in parentheses when specified.  
CC = Closed Cup, OC = Open Cup

<sup>2</sup> NL = Not Listed

THIS MSDS COMPLIES WITH 29 CFR 1910.1200 (THE HAZARD COMMUNICATION STANDARD)

24-HOUR EMERGENCY TELEPHONE: 1-800-ASHLAND OR 1-800-274-5253

\*\*\*\*\*

PRODUCT NAME: METHANOL

CAS NUMBER:

67-56-1

DATA SHEET NO: 0001447-005.002

PREPARED: 02/10/95

SUPERSEDES: 02/03/95

PRINT DATE: 04/24/95

-----  
SECTION I-PRODUCT IDENTIFICATION  
-----

GENERAL OR GENERIC ID: ALCOHOL

DOT HAZARD CLASSIFICATION: 3 (FLAMMABLE LIQUID)

-----  
SECTION II-COMPONENTS  
-----

IF PRESENT, IARC, NTP AND OSHA CARCINOGENS AND CHEMICALS SUBJECT TO THE REPORTING REQUIREMENTS OF SARA TITLE III SECTION 313 ARE IDENTIFIED IN THIS SECTION.  
SEE DEFINITION PAGE FOR CLARIFICATION

INGREDIENT -----	PERCENT -----	NOTE -----
METHYL ALCOHOL	100	( 1 )
CAS #: 67-56-1	PEL: 200 PPM - SKIN	TLV: 200 PPM - SKIN

( 1 ): SKIN ABSORPTION MAY CONTRIBUTE TO THE OVERALL ABSORPTION OF THIS MATERIAL. APPROPRIATE MEASURES SHOULD BE TAKEN TO PREVENT ABSORPTION SO THAT THE TLV AND/OR PEL ARE NOT INVALIDATED. SEE SECTION V.  
OSHA/ACGIH SHORT TERM EXPOSURE LIMIT (STEL) FOR METHYL ALCOHOL IS 250 PPM. NIOSH RECOMMENDS A LIMIT OF 200 PPM, 8-HOUR TWA; 800 PPM 15-MINUTE CEILING.  
THIS CHEMICAL IS SUBJECT TO THE REPORTING REQUIREMENTS OF SECTION 313 OF SARA TITLE III.

CONTINUED ON PAGE: 2

## SECTION III-PHYSICAL DATA

PROPERTY	REFINEMENT	MEASUREMENT
BOILING POINT	FOR PRODUCT	147.00 DEG F ( 53.88 DEG C) @ 750.00 MMHG
VAPOR PRESSURE	FOR PRODUCT	97.68 MMHG @ 58.00 DEG F ( 20.00 DEG C)
SPECIFIC VAPOR DENSITY	AIR = 1	1.11
SPECIFIC GRAVITY		.793 @ 58.00 DEG F ( 20.00 DEG C)
PERCENT VOLATILES		100.00%
EVAPORATION RATE	(N-BUTYL ACETATE = 1)	5.91
APPEARANCE		CLEAR, APHA COLOR 5 MAX
STATE		LIQUID
FORM		NEAT

## SECTION IV-FIRE AND EXPLOSION INFORMATION

FLASH POINT(TCC ) 54.0 DEG F  
( 12.2 DEG C)

EXPLOSIVE LIMIT (PRODUCT) LOWER - 5.0%

EXTINGUISHING MEDIA: ALCOHOL FOAM OR CARBON DIOXIDE OR DRY CHEMICAL

HAZARDOUS DECOMPOSITION PRODUCTS: MAY FORM:, CARBON DIOXIDE AND CARBON MONOXIDE, ETC.

FIREFIGHTING PROCEDURES: WEAR A SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE OPERATED IN THE POSITIVE PRESSURE DEMAND MODE WITH APPROPRIATE TURN-OUT GEAR AND CHEMICAL RESISTANT PERSONAL PROTECTIVE EQUIPMENT. REFER TO THE PERSONAL PROTECTIVE EQUIPMENT SECTION OF THIS MSDS. WATER MAY BE INEFFECTIVE.

WATER MAY BE USED TO KEEP FIRE-EXPOSED CONTAINERS COOL UNTIL FIRE IS OUT.

SPECIAL FIRE & EXPLOSION HAZARDS: NEVER USE WELDING OR CUTTING TORCH ON OR NEAR DRUM (EVEN EMPTY) BECAUSE PRODUCT (EVEN JUST RESIDUE) CAN IGNITE EXPLOSIVELY.

CONTINUED ON PAGE: 3



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SECTION IV-FIRE AND EXPLOSION INFORMATION (CONTINUED)

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ALL FIVE GALLON PAILS AND LARGER METAL CONTAINERS INCLUDING TANK CARS AND TANK TRUCKS SHOULD BE GROUNDED AND/OR BONDED WHEN MATERIAL IS TRANSFERRED. VAPORS ARE HEAVIER THAN AIR AND MAY TRAVEL ALONG THE GROUND OR MAY BE MOVED BY VENTILATION AND IGNITED BY PILOT LIGHTS, OTHER FLAMES, SPARKS, HEATERS, SMOKING, ELECTRIC MOTORS, STATIC DISCHARGE, OR OTHER IGNITION SOURCES AT LOCATIONS DISTANT FROM MATERIAL HANDLING POINT.

NFPA CODES:       HEALTH- 1       FLAMMABILITY- 3       REACTIVITY- 0

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SECTION V-HEALTH HAZARD DATA

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PERMISSIBLE EXPOSURE LIMIT   200 PPM - SKIN  
THRESHOLD LIMIT VALUE       200 PPM - SKIN  
NOT ESTABLISHED FOR PRODUCT. SEE SECTION II.

EFFECTS OF ACUTE OVEREXPOSURE:

---

EYES - EXPOSURE MAY CAUSE MILD EYE IRRITATION. SYMPTOMS MAY INCLUDE STINGING, TEARING, AND REDNESS.

SKIN - EXPOSURE MAY CAUSE MILD SKIN IRRITATION. PROLONGED OR REPEATED EXPOSURE MAY DRY THE SKIN. SYMPTOMS MAY INCLUDE REDNESS, BURNING, DRYING AND CRACKING, AND SKIN BURNS. PRE-EXISTING SKIN DISORDERS MAY BE AGGRAVATED BY EXPOSURE TO THIS MATERIAL.

SKIN ABSORPTION IS POSSIBLE, AND MAY CONTRIBUTE TO SYMPTOMS OF TOXICITY FROM OTHER ROUTES OF EXPOSURE.

BREATHING - EXPOSURE TO VAPOR OR MIST IS POSSIBLE.

SHORT-TERM INHALATION TOXICITY IS LOW. BREATHING SMALL AMOUNTS DURING NORMAL HANDLING IS NOT LIKELY TO CAUSE HARMFUL EFFECTS; BREATHING LARGE AMOUNTS MAY BE HARMFUL.

SYMPTOMS ARE MORE TYPICALLY SEEN AT AIR CONCENTRATIONS EXCEEDING THE RECOMMENDED EXPOSURE LIMITS. SYMPTOMS OF EXPOSURE MAY INCLUDE:  
-IRRITATION (NOSE, THROAT, RESPIRATORY TRACT)- PRE-EXISTING LUNG DISORDERS, E.G. ASTHMA-LIKE CONDITIONS, MAY BE AGGRAVATED BY EXPOSURE TO THIS MATERIAL.

-ABDOMINAL AND LOW BACK PAIN-

-LEG CRAMPS-

-GASTROINTESTINAL IRRITATION (NAUSEA, VOMITING, DIARRHEA)-

-SHORTNESS OF BREATH-

-CENTRAL NERVOUS SYSTEM DEPRESSION (DIZZINESS, DROWSINESS, WEAKNESS, FATIGUE, NAUSEA, HEADACHE, UNCONSCIOUSNESS)-

-BLURRED VISION-

-VISUAL IMPAIRMENT (INCLUDING BLINDNESS)-

-CYANOSIS (CHARACTERIZED BY BLUISH DISCOLORATION OF THE SKIN AND NAILS)-THIS MAY AGGRAVATE ANY PRE-EXISTING CONDITION SENSITIVE TO A DECREASE IN AVAILABLE OXYGEN, SUCH AS CHRONIC LUNG DISEASE, CORONARY

-ARTERY DISEASE OR ANEMIAS-

-COMA-

SWALLOWING - SINGLE DOSE ORAL TOXICITY IS MODERATE. SWALLOWING MAY BE HARMFUL.

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SECTION V-HEALTH HAZARD DATA (CONTINUED)

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## SYMPTOMS MAY INCLUDE:

- ABDOMINAL AND LOW BACK PAIN-
- LEG CRAMPS-
- GASTROINTESTINAL IRRITATION (NAUSEA, VOMITING, DIARRHEA)-
- SHORTNESS OF BREATH-
- CENTRAL NERVOUS SYSTEM DEPRESSION (DIZZINESS, DROWSINESS, WEAKNESS, FATIGUE, NAUSEA, HEADACHE, UNCONSCIOUSNESS)-
- BLURRED VISION-
- VISUAL IMPAIRMENT (INCLUDING BLINDNESS)-
- CYANOSIS (CHARACTERIZED BY BLUISH DISCOLORATION OF THE SKIN AND NAILS)-THIS MAY AGGRAVATE ANY PRE-EXISTING CONDITION SENSITIVE TO A DECREASE IN AVAILABLE OXYGEN, SUCH AS CHRONIC LUNG DISEASE, CORONARY ARTERY DISEASE OR ANEMIAS-
- COMA-
- AND DEATH

## FIRST AID:

- 
- IF ON SKIN: REMOVE CONTAMINATED CLOTHING. WASH EXPOSED AREA WITH SOAP AND WATER. IF SYMPTOMS PERSIST, SEEK MEDICAL ATTENTION. LAUNDER CLOTHING BEFORE REUSE.
- IF IN EYES: IF SYMPTOMS DEVELOP, MOVE INDIVIDUAL AWAY FROM EXPOSURE AND INTO FRESH AIR. FLUSH EYES GENTLY WITH WATER WHILE HOLDING EYELIDS APART. IF SYMPTOMS PERSIST OR THERE IS ANY VISUAL DIFFICULTY, SEEK MEDICAL ATTENTION.
- IF SWALLOWED: IF SWALLOWED, SEEK MEDICAL ATTENTION. IF INDIVIDUAL IS DROWSY OR UNCONSCIOUS, DO NOT GIVE ANYTHING BY MOUTH; PLACE INDIVIDUAL ON THE LEFT SIDE WITH THE HEAD DOWN. IF INDIVIDUAL IS CONSCIOUS AND ALERT, INDUCE VOMITING BY GIVING SYRUP OF IPECAC OR BY GENTLY PLACING TWO FINGERS AT THE BACK OF THE THROAT. IF POSSIBLE, DO NOT LEAVE INDIVIDUAL UNATTENDED.
- IF BREATHED: IF SYMPTOMS DEVELOP, MOVE INDIVIDUAL AWAY FROM EXPOSURE AND INTO FRESH AIR. IF SYMPTOMS PERSIST, SEEK MEDICAL ATTENTION. IF BREATHING IS DIFFICULT, ADMINISTER OXYGEN. KEEP PERSON WARM AND QUIET; SEEK IMMEDIATE MEDICAL ATTENTION.

## NOTE TO PHYSICIAN:

THIS PRODUCT CONTAINS METHANOL WHICH CAN CAUSE INTOXICATION AND CENTRAL NERVOUS SYSTEM DEPRESSION. METHANOL IS METABOLIZED TO FORMIC ACID AND FORMALDEHYDE. THESE METABOLITES CAN CAUSE METABOLIC ACIDOSIS, VISUAL DISTURBANCES AND BLINDNESS. SINCE METABOLISM IS REQUIRED FOR THESE TOXIC SYMPTOMS, THEIR ONSET MAY BE DELAYED FROM 5 TO 30 HOURS FOLLOWING INGESTION. ETHANOL COMPETES FOR THE SAME METABOLIC PATHWAY AND HAS BEEN USED TO PREVENT METHANOL METABOLISM. ETHANOL ADMINISTRATION IS INDICATED IN SYMPTOMATIC PATIENTS OR AT BLOOD METHANOL CONCENTRATIONS ABOVE 20 UG/DL. METHANOL IS EFFECTIVELY REMOVED BY HEMODIALYSIS.

## PRIMARY ROUTE(S) OF ENTRY:

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INHALATION, SKIN ABSORPTION, SKIN CONTACT, EYE CONTACT

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### SECTION V-HEALTH HAZARD DATA (CONTINUED)

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#### EFFECTS OF CHRONIC OVEREXPOSURE:

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EXPOSURE TO LETHAL CONCENTRATIONS OF METHANOL HAS BEEN SHOWN TO CAUSE DAMAGE TO ORGANS INCLUDING LIVER, KIDNEYS, PANCREAS, HEART, LUNGS AND BRAIN. ALTHOUGH THIS RARELY OCCURS, SURVIVORS OF SEVERE INTOXICATION MAY SUFFER FROM PERMANENT NEUROLOGICAL DAMAGE.

WHILE THERE IS SUFFICIENT EVIDENCE THAT METHANOL CAUSES BIRTH DEFECTS IN EXPERIMENTAL ANIMALS, THE RELEVANCE OF THESE FINDINGS TO HUMANS IS UNCERTAIN BECAUSE OF DIFFERENCES IN METABOLISM AND TOXICITY OF METHANOL BETWEEN HUMANS AND NON-PRIMATES.

OVEREXPOSURE TO THIS MATERIAL (OR ITS COMPONENTS) HAS BEEN SUGGESTED AS A CAUSE OF THE FOLLOWING EFFECTS IN LABORATORY ANIMALS, AND MAY AGGRAVATE PRE-EXISTING DISORDERS OF THESE ORGANS IN HUMANS:, CENTRAL NERVOUS SYSTEM DAMAGE

OVEREXPOSURE TO THIS MATERIAL (OR ITS COMPONENTS) HAS BEEN SUGGESTED AS A CAUSE OF THE FOLLOWING EFFECTS IN HUMANS, AND MAY AGGRAVATE PRE-EXISTING DISORDERS OF THESE ORGANS:, VISUAL IMPAIRMENT

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### SECTION VI-REACTIVITY DATA

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HAZARDOUS POLYMERIZATION: CANNOT OCCUR

STABILITY: STABLE

INCOMPATIBILITY: AVOID CONTACT WITH:, STRONG OXIDIZING AGENTS, STRONG ACIDS, REACTIVE METALS SUCH AS ALUMINUM AND MAGNESIUM

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### SECTION VII-SPILL OR LEAK PROCEDURES

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#### STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:

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SMALL SPILL: ABSORB LIQUID ON VERMICULITE, FLOOR ABSORBENT OR OTHER ABSORBENT MATERIAL.

LARGE SPILL: ELIMINATE ALL IGNITION SOURCES (FLARES, FLAMES INCLUDING PILOT LIGHTS, ELECTRICAL SPARKS). PERSONS NOT WEARING PROTECTIVE EQUIPMENT SHOULD BE EXCLUDED FROM AREA OF SPILL UNTIL CLEAN-UP HAS BEEN COMPLETED. STOP SPILL AT SOURCE. PREVENT FROM ENTERING DRAINS, SEWERS, STREAMS OR OTHER BODIES OF WATER. PREVENT FROM SPREADING. IF RUNOFF OCCURS, NOTIFY AUTHORITIES AS REQUIRED. PUMP OR VACUUM TRANSFER SPILLED PRODUCT TO CLEAN CONTAINERS FOR RECOVERY. ABSORB UNRECOVERABLE PRODUCT. TRANSFER CONTAMINATED ABSORBENT, SOIL AND OTHER MATERIALS TO CONTAINERS FOR DISPOSAL.

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**SECTION VII-SPILL OR LEAK PROCEDURES (CONTINUED)**

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PREVENT RUN-OFF TO SEWERS, STREAMS OR OTHER BODIES OF WATER. IF RUN-OFF OCCURS, NOTIFY PROPER AUTHORITIES AS REQUIRED, THAT A SPILL HAS OCCURED.

**WASTE DISPOSAL METHOD:**

SMALL SPILL: DISPOSE OF IN ACCORDANCE WITH ALL LOCAL, STATE AND FEDERAL REGULATIONS.

LARGE SPILL: DISPOSE OF IN ACCORDANCE WITH ALL APPLICABLE LOCAL, STATE AND FEDERAL REGULATIONS.

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**SECTION VIII-PROTECTIVE EQUIPMENT TO BE USED**

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RESPIRATORY PROTECTION: IF WORKPLACE EXPOSURE LIMIT(S) OF PRODUCT OR ANY COMPONENT IS EXCEEDED (SEE SECTION II), A NIOSH/MSHA APPROVED AIR SUPPLIED RESPIRATOR IS ADVISED IN ABSENCE OF PROPER ENVIRONMENTAL CONTROL. OSHA REGULATIONS ALSO PERMIT OTHER NIOSH/MSHA RESPIRATORS (NEGATIVE PRESSURE TYPE) UNDER SPECIFIED CONDITIONS (SEE YOUR INDUSTRIAL HYGIENIST). ENGINEERING OR ADMINISTRATIVE CONTROLS SHOULD BE IMPLEMENTED TO REDUCE EXPOSURE.

VENTILATION: PROVIDE SUFFICIENT MECHANICAL (GENERAL AND/OR LOCAL EXHAUST) VENTILATION TO MAINTAIN EXPOSURE BELOW TLV(S).

PROTECTIVE GLOVES: WEAR RESISTANT GLOVES (CONSULT YOUR SAFETY EQUIPMENT SUPPLIER).

EYE PROTECTION: CHEMICAL SPLASH GOGGLES IN COMPLIANCE WITH OSHA REGULATIONS ARE ADVISED; HOWEVER, OSHA REGULATIONS ALSO PERMIT OTHER TYPE SAFETY GLASSES. CONSULT YOUR SAFETY REPRESENTATIVE.

OTHER PROTECTIVE EQUIPMENT: TO PREVENT REPEATED OR PROLONGED SKIN CONTACT, WEAR IMPERVIOUS CLOTHING AND BOOTS.

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**SECTION IX-SPECIAL PRECAUTIONS OR OTHER COMMENTS**

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CONTAINERS OF THIS MATERIAL MAY BE HAZARDOUS WHEN EMPTIED. SINCE EMPTIED CONTAINERS RETAIN PRODUCT RESIDUES (VAPOR, LIQUID, AND/OR SOLID), ALL HAZARD PRECAUTIONS GIVEN IN THE DATA SHEET MUST BE OBSERVED.

WARNING!!! SUDDEN RELEASE OF HOT ORGANIC CHEMICAL VAPORS OR MISTS FROM PROCESS EQUIPMENT OPERATING AT ELEVATED TEMPERATURE AND PRESSURE, OR SUDDEN INGRESS OF AIR INTO VACUUM EQUIPMENT, MAY RESULT IN IGNITIONS WITHOUT THE PRESENCE OF OBVIOUS IGNITION SOURCES. PUBLISHED "AUTOIGNITION" OR "IGNITION" TEMPERATURE VALUES CANNOT BE TREATED AS SAFE OPERATING TEMPERATURES IN CHEMICAL PROCESSES WITHOUT ANALYSIS OF THE ACTUAL PROCESS CONDITIONS. ANY USE OF THIS PRODUCT IN ELEVATED TEMPERATURE PROCESSES SHOULD BE THOROUGHLY EVALUATED TO ESTABLISH AND MAINTAIN SAFE OPERATING CONDITIONS.

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SECTION IX-SPECIAL PRECAUTIONS OR OTHER COMMENTS (CONTINUED)

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THE INFORMATION ACCUMULATED HEREIN IS BELIEVED TO BE ACCURATE BUT IS NOT WARRANTED TO BE WHETHER ORIGINATING WITH THE COMPANY OR NOT. RECIPIENTS ARE ADVISED TO CONFIRM IN ADVANCE OF NEED THAT THE INFORMATION IS CURRENT, APPLICABLE, AND SUITABLE TO THEIR CIRCUMSTANCES.