Environmental Guidance Document: Waste Management in Exploration and Production Operations

API E5
SECOND EDITION, FEBRUARY 1997

STEP
Strategies for Today's Environmental Partnership

American Petroleum Institute

CONTENTS

Waste Management in Exploration and Production Operations

1 Pollution Prevention

1.1 INTRODUCTION

Pollution prevention is the practice of reducing or eliminating pollutant discharges to air, water, or land. It includes the development of more environmentally acceptable products, changes in processes and practices, source reduction, beneficial use, environmentally sound recycling, waste minimization, proper waste handling, waste treatment, and proper disposal practices. This section presents an overview of media, operational impacts, and waste minimization methods, including the EPA hierarchy of waste management. These basic concepts are critical in achieving pollution prevention goals.

Pollution prevention requires continuous improvement in operating practices. Industry should review its use of materials, processes, practices, and products in order to identify ways to reduce or eliminate pollution. A practical approach encourages the use or production of environmentally acceptable products while working toward source reduction on the following waste management hierarchy:

source reduction	(most preferred) ↑
recycling/reuse	
treatment, and/or	
land disposal	↓ (least preferred)

Details are presented in 1.3.2.

The API Pollution Prevention Management Practices for API's Strategies for Today's Environmental Partnerships (STEP) program embody the petroleum industry's practical commitment to pollution prevention. They provide specific guidelines for compliance with these Guiding Environmental Principles, which are as follows:

a. To recognize and to respond to community concerns about our raw materials, products, and operations.
b. To operate our plants and facilities, and to handle our raw materials and products in a manner that protects the environment and the safety and health of our employees and the public.
c. To make safety, health, and environmental considerations a priority in our planning, use, and development of new products and processes.
d. To advise promptly appropriate officials, employees, customers, and the public of information on significant industry-related safety, health, and environmental hazards and to recommend protective measures.
e. To counsel customers, transporters, and others in the safe use, transportation, and disposal of our raw materials, products, and waste materials.
f. To develop and produce natural resources economically and to conserve those resources by using energy efficiently.
g. To extend knowledge by conducting or supporting research on the safety, health, and environmental effects of our raw materials, products, processes, and waste materials.
h. To commit to reduce overall emissions and waste generation.
i. To work with others to resolve problems created by handling and disposal of hazardous substances from our operations.
j. To participate with government and others in creating responsible laws, regulations, and standards to safeguard the community, workplace, and environment.
k. To promote these principles and practices by sharing experiences and offering assistance to others who produce, handle, use, transport, or dispose of similar raw materials, petroleum products, and wastes.

1.2 API'S MANAGEMENT PRACTICE FOR POLLUTION PREVENTION

Both management commitment and comprehensive planning are critical to a successful pollution prevention program. Steps to consider in developing and operating such a program include the following:

a. Providing management support for ongoing pollution prevention activities through appropriate policies, actions, communications, and resource commitments.
b. Developing and implementing a program to improve prevention and early detection and reduce impacts of spills of crude oil and petroleum products and other accidental releases from operations.
c. Developing an inventory of significant releases to air, water, and land; identifying their sources; and evaluating their impact on human health and the environment.
d. Periodically reviewing and identifying pollution prevention options and opportunities, developing approaches for reducing releases, and setting goals and schedules for reducing releases and measuring progress; consider the issues of community concerns, technology and economics, and impact on human health and the environment.
e. Including pollution prevention objectives in research efforts and in the design of new or modified operations, processes, and products.
f. Supporting an outreach program to promote pollution prevention opportunities within the industry, including sharing of industry experiences and accomplishments.

1.3 MEDIA

Proper management of wastes is important to the protection of human health and the environment. Waste can be transported via three natural carriers—water, soil, and air.

All three media may provide pathways by which potentially polluting materials can migrate from their original source. Thus, materials used and wastes generated in exploration and production operations should be managed by considering risk to human health and the environment via media pathways (see Figure 1).

1.3.1 Water

Fresh water for human consumption, domestic needs, recreation, stock water, irrigation of crops, and industry comes from underground aquifers, lakes, streams, and reservoirs.

Most fresh water is stored in underground reservoirs called aquifers. Aquifers are part of a large water-recycling system as illustrated in Figure 1. These porous formations or sediments can store and transport groundwater from rain, leakage of stream beds, and other sources.

Materials from spills or improper waste disposal may contaminate aquifers. Of major concern are those aquifers that contain water suitable for drinking. Also important are aquifers used for agricultural purposes. Pollutants found in water are measured in concentrations of parts per billion (ppb); some of these pollutants may cause that water to fail drinking water standards.

The quality of aquifer waters can be degraded by pollutants to such a degree that it is not practical to restore the aquifer to drinking water standards.

1.3.2 Soil

Spills can adversely affect the capacity of soil to support agricultural, industrial, human, and recreational uses. Soil acts to retain spilled, improperly stored, or disposed materials; however, once in the soil, pollutants can migrate to air and water and be picked up by plants and animals. Contam-

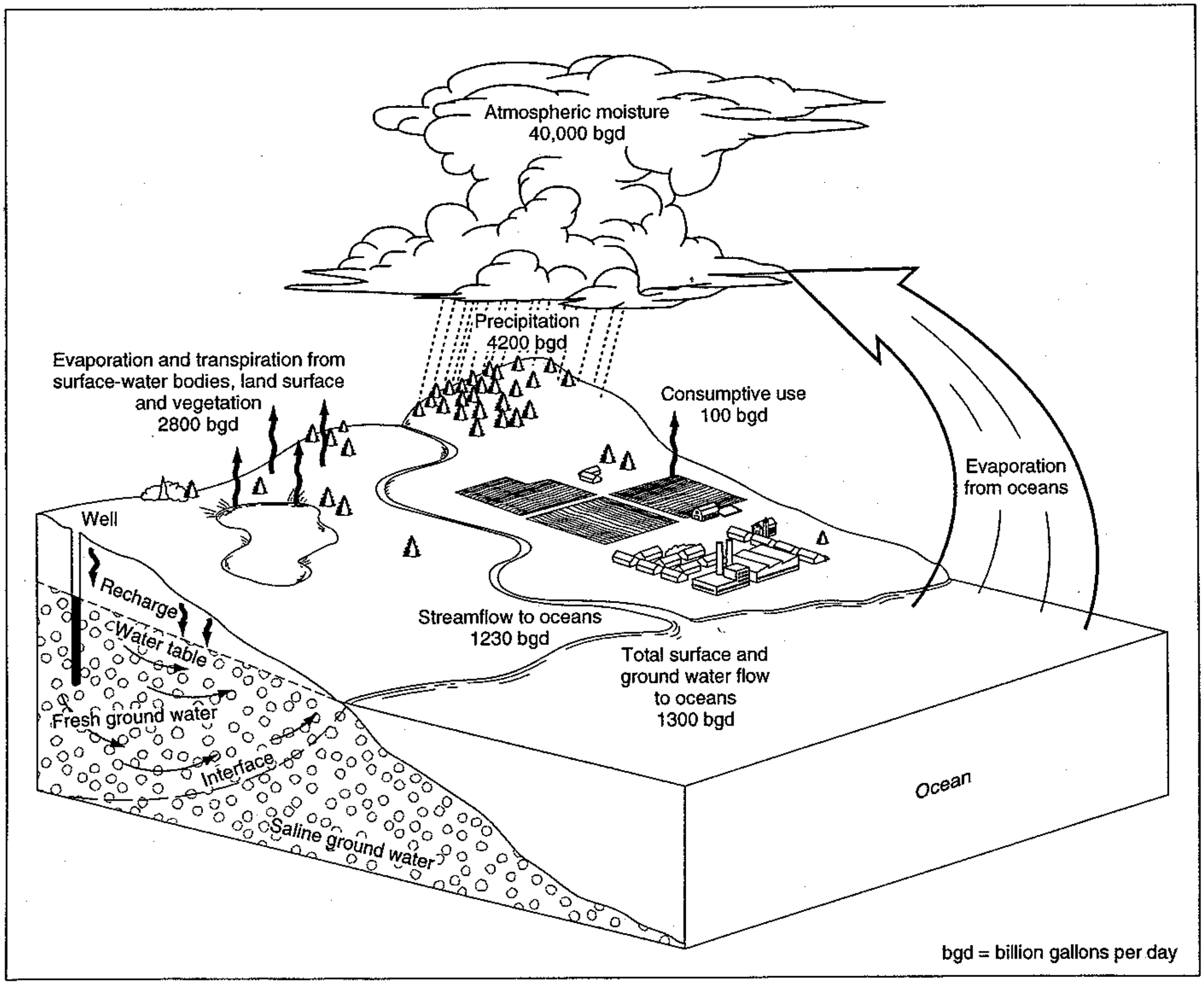

Figure 1—Basic Media of Soil, Air, and Water Can Transport Pollutants Away From Their Original Source

inants can evaporate into the atmosphere, be carried by rainwater to a lake, creek, or other surface water, and be leached downward into groundwater.

1.3.3 Air

Gaseous waste released to the air can potentially affect humans, animals, and plant life through inhalation or dermal contact. Indirectly, gaseous wastes may alter the chemical balance in the atmosphere. Acid rain is a known result of altering the chemical makeup of the atmosphere. Ozone depletion and global warming are thought by some to be the result of human impact on the atmosphere.

1.3.4 Summary

A properly implemented pollution prevention program can reduce or eliminate pollutant discharges to air, water, or land. API supports cooperative efforts to research and develop scientifically based standards and promotes technical advancements for the evaluation and implementation of measures to address environmental impacts.

1.4 UNDERSTANDING OPERATIONAL IMPACTS

Because exploration and production (E&P) operations can affect all environmental media, API suggests the use of sound science to identify adverse impacts and the means to mitigate, reduce, or eliminate them. Science is also critical to developing cost-effective strategies that address environmental risks. Science provides the foundation for identifying methods to prevent or reduce pollution, for expanding waste management options to reduce risk, and for developing and improving pollution control technologies.

Sound science is the key to determining which environmental problems pose the greatest risk to human health, ecosystems, and the economy. Without sound scientific information, high profile but low risk problems may possibly be targeted, while more significant threats remain ignored.

A sound scientific understanding of environmental risks to populations and ecosystems will help create a more effective allocation of resources—resources which can be targeted towards hazards that pose the greatest environmental risk.

1.5 POLLUTION PREVENTION AND WASTE MINIMIZATION

Waste minimization is a major component of pollution prevention. The goals of a waste minimization plan are to reduce the total volume or quantity of waste generated and to reduce the toxicity of waste.

Hydrocarbon recovery, an extractive procedure, inherently generates wastes. Some of these wastes are similar to those generated by the general public and can be managed similarly. Most of the waste generated by the oil and gas industry consists of naturally occurring materials brought to the surface in association with extracted oil and gas.

Due to large increases in costs of waste management, increasing complexity of waste management regulations, and efforts to reduce potential environmental liabilities, many API member companies have implemented in-house waste minimization programs.

These programs go beyond traditional approaches to waste management and incorporate pollution prevention concepts.

1.5.1 Solid Waste Definition

According to federal regulations, a solid waste is any material that is discarded or intended to be discarded. Solid wastes may be either solid, semi-solid, liquid, or contained gaseous material. Point source water discharges, subject to federal permits under the Clean Water Act, are not considered solid wastes.

1.5.2 EPA Hierarchy of Methods

EPA has developed the following hierarchy of waste management methods to guide generations toward waste minimization. The four waste management hierarchy steps, in decreasing order of preference are as follows:

a. Source Reduction—reduce the amount of waste at the source through the following:

- material elimination
- inventory control and management
- material substitution
- process modification
- improved housekeeping
- return of unused material to supplier

b. Recycling/Reuse—reuse and recycle material for the original or some other purpose, such as materials recovery or energy production; this may occur onsite or offsite, through the following methods:

- reuse
- reprocess
- reclaim
- use as fuel
- underground injection for enhanced recovery
- roadspreading

c. Treatment—destroy, detoxify, and neutralize wastes into less harmful substances through the following methods:

- filtration
- chemical treatment
- biological treatment
- thermal treatment
- extraction

- chemical stabilization
- incineration
- landfarming
- landspreading

d. Disposal—dispose of wastes through the following methods:

- landfills
- NPDES discharge
- solidification
- burial
- underground injection for disposal

1.5.3 Summary

By incorporating waste minimization practices into the waste management program, the generator may further efforts to

a. Protect public health and worker health and safety.
b. Protect the environment.
c. Meet company, state, and/or national waste minimization goals.
d. Save money by reducing waste treatment and disposal costs and other operating costs.
e. Reduce potential environmental liabilities.

2 Waste Management System

2.1 INTRODUCTION

In order to achieve pollution prevention and waste minimization goals, waste management needs to be viewed as an integrated system. A good waste management system should include the following key elements:

a. A system for maintaining knowledge of pertinent laws and regulations.
b. A system for pollution prevention/waste minimization.
c. A health and safety program.
d. An incident response preparedness program.
e. A training program.
f. A system for proper waste identification.
g. A transportation program.
h. A proper waste storage and disposal program.
i. A system for waste tracking, inventories, and recordkeeping.
j. A waste management auditing program.

This section introduces the concept of a waste management plan—the tool for implementing these key elements at the field level, where actual waste management decisions should be made.

The key elements of training, waste tracking, and auditing are also discussed.

2.2 SUMMARY OF A TEN-STEP PLAN FOR WASTE MANAGEMENT

A waste management plan should

a. Offer a solid waste plan that is area-specific.
b. Provide proper management guidance for each waste generated in E&P operations.
c. Be written for field operations.
d. Be used to ensure regulatory compliance and environmentally sound management of wastes.
e. Form a basis for training, evaluation, monitoring, and pollution prevention programs.
f. Be periodically reviewed and updated as new practices and options are discovered.

API suggests the ten-step waste management plan shown in Table 1 for integrating the waste management system into operations. This plan is described in detail in Appendix A. It has proven successful for a number of member companies. Appendix B includes planning aids to help in preparing the waste management plan.

Both technology and regulatory requirements in the environmental field are changing constantly. For these reasons, open communication among field operations personnel, environmental and legal specialists, and management is crucial to conducting environmentally sound operations.

2.3 TRAINING

Training in the proper identification and handling of waste material is vital in any exploration or production operation. Field personnel and management should be trained in environmentally sound and safe waste management practices. Instruction in waste management should include the following:

a. General environmental awareness.
b. Health and safety concerns related to waste handling.
c. Benefits of proper waste management, including risk reduction for future liabilities.
d. Review of internal environmental policies and other documentation of management support.
e. Environmental laws and regulations.
f. Legal liability, both corporate and personal, associated with improper handling of waste.
g. The applicable facility waste management program.

In addition, a company may consider scheduling periodic training to cover updates of procedures, review of incidents, and feedback from field personnel.

Federal agencies also mandate personnel training as follows:

a. The U.S. Occupational Safety and Health Administration (OSHA) requires specific, detailed training for certain operations that may be associated with waste management.
b. Emergency response to a release of hazardous chemicals

transportation is defined by the duties or tasks he is required to perform. These tasks include classifying the material or waste; selecting the packaging; marking and labeling the package; preparing the shipping paper; certifying that the shipment is in accordance with the DOT requirements; providing emergency response information; and providing placards when required.

Transfer of ownership has little bearing on the shipper responsibilities under the DOT regulations. Ownership of the hazardous material offered or accepted for transportation is only one of many factors that determine which party or parties perform, or has a duty to perform, any of the functions of the shipper.

4.9.6.2 Transporter Responsibilities

The DOT regulations also apply to each carrier who transports a hazardous material by air, highway, rail, or water. In general, the carrier or transporter is defined as the person engaged in the transportation of passengers or property by land, water, or as a common, contract, or private carrier. In certain instances, the operator may also be considered the carrier or transporter if the hazardous materials are transported on company owned or leased vehicles or vessels.

Transporter tasks include incident reporting, training, shipping paper or dangerous cargo manifest requirements, marking or placarding the vehicle, loading and unloading requirements, segregating materials, and emergency response for accidents.

4.10 OTHER REGULATIONS AND AGREEMENTS

All states have regulations to protect public health and the environment. E&P wastes and practices are subject to regulation by state agencies responsible for environmental protection. When more than one agency is involved, typically a Memorandum of Understanding (MOU) delineates the specific areas of authority for the agencies involved (for example, oil and gas agency and environmental agency).

Oil and gas E&P takes place in states with widely diverse geological and environmental conditions. The resulting state regulations exhibit a variety of approaches to environmental protection because they have evolved relatively independently.

All oil and gas producing state statutes, rules, and regulations provide regulatory agencies the right of access to inspect producing properties for regulatory compliance and to investigate complaints associated with environmental or other problems. Pending the outcome of an investigation, states have the authority to:

a. Issue cease and desist orders.
b. Assess or seek administrative, civil, or criminal penalties.
c. Order cleanups.
d. Ban further operations and sever an operator's pipeline connection.

4.10.1 Naturally Occurring Radioactive Materials (NORM)

There are currently no federal statutes or regulations specifically covering generation, storage, or disposal of oilfield NORM, other than regulations that apply generally to other radioactive materials. States are developing or have developed rules for the regulation of NORM.

4.10.2 Oil and Gas Lease Agreements

Lease agreements may impose obligations with respect to waste treatment, disposal, or reclamation and may be different or more stringent than regulatory requirements.

5 Waste Management Methods

5.1 INTRODUCTION

This section describes waste management practices for E&P wastes and their potential environmental impacts. When these practices are implemented onsite, they should be conducted in accordance with lease and landowner obligations and local, state, and federal regulations. Although special circumstances may warrant regulatory approval of other specific practices, the following criteria have been shown to be effective in the management of wastes.

Users are cautioned, however, that the information in this document is not all-inclusive and may not apply in all situations. State and local requirements vary and may be more stringent. Federal, state, and local regulations are constantly evolving; they should be reviewed to determine whether information in this document is consistent with current laws and regulations. Finally, the chemical nature of a particular waste and its impact on its surroundings may dictate taking a more lenient or more stringent approach to waste management.

Sound practices should be employed in all aspects of waste management. These sound practices not only serve to protect human health and the environment, they can help protect an operator from the long term liabilities of waste disposal. An overview of waste management methods and applications is presented in this section and summarized in Table 2. To encourage pollution prevention, Table 2 arranges available waste management options in a hierarchy.

5.2 SOURCE REDUCTION

Source reduction means eliminating or decreasing, to the extent practical, the volume or relative toxicity of wastes that are generated.

Opportunities to achieve significant volume reductions for some E&P wastes may not be practical and are limited by

Table 2–Overview of Waste Management Methods

Method	Applications
Source reduction—eliminate or reduce the quantity or relative toxicity of waste generated.	Product substitution 100% product use (inventory control) Process modification Improved process controls Good housekeeping
Recycling—reuse or reclaim valuable material from the waste generated.	Reprocessing Burning for energy recovery Reuse in same process Reuse in a different process Return of unused product
Treatment—employ techniques to reduce volume, relative toxicity, or other characteristics of waste.	Filtration Centrifugation Chemical precipitation Chemical flocculation Thermal treatment Extraction Biodegradation (landfarming)
Proper disposal—utilize environmentally-sound methods to dispose of generated waste to minimize its impact, if any, and to protect human health.	Landspreading Roadspreading or road surfacing Burial or landfilling Onsite pits Annular injection Underground injection wells Discharges to surface water Open burning and incineration Offsite commercial facilities

Note: Check appropriate regulations prior to selecting waste management options.

the age or state of depletion of a producing property. For example, the volume of produced water typically increases as the field is depleted.

The volume of drilling muds generated is generally linked to the number of wells drilled and their depths. Nevertheless, cost-effective opportunities for source reduction exist and should be considered. Suggestions include the following:

a. Product and process substitution to reduce the volume and toxicity of the waste generated.
b. Complete use of all commercial chemical products or return of unused commercial chemicals to vendors. First in/first out inventory control should be practiced to ensure that chemicals do not exceed their expiration date. The number of chemicals used should be minimized to simplify tracking and recordkeeping.
c. Process modification through more effective use of mechanical means. Improved drilling techniques, such as the use of more effective drill bits rather than chemical additions, can minimize waste.
d. Improved controls to minimize mud changes, engine oil changes, or solvent usage.
e. Good housekeeping to prevent spills to soils, accumulations of oily materials, or releases to waterways.

5.3 RECYCLING AND RECLAIMING

After reviewing all reduction options, the operator should consider recycling or reclaiming the waste material, either in process, onsite, or with outside contractors. Suggestions include the following:

a. Reprocessing into products; burning for energy recovery, where permissible; reuse in different processes; returning unused materials; and recovery for reuse in other industries.
b. Use of chemical clearinghouses to find a customer for waste materials.
c. Recycling hydrocarbons. Used oils, hydraulic fluids, and oily sump waters may be managed according to 6.7. Recovery of hydrocarbons from tank bottoms and separator sludges can be accomplished at onsite production facilities or offsite commercial facilities.
d. Return of oil-based drilling mud to the vendor for reprocessing, where practical. State and local regulations should be consulted to ensure that any notification or recordkeeping and reporting requirements are met.

5.4 TREATMENT

After examining source reduction and recycling opportunities, potentially cost-effective treatment steps to minimize waste volume, toxicity, or other characteristics should be considered. Examples include the following:

a. Filtration, centrifugation, chemical precipitation/flocculation, thermal treatment (evaporation), and extraction may be used to reduce the volume of a waste. This volume reduction may produce lower disposal space requirements, or it may concentrate a constituent to a level where recovery is feasible.
b. Chemical treatment, such as hydrogen peroxide oxidation of phenol to carbon dioxide and water, may be used to reduce or eliminate the toxicity of a chemical waste.
c. Biodegradation of organic material may result in transformation to less toxic compounds or in complete degradation.
d. Thermal treatment can result in recovery or destruction of toxic organics.
e. Chemical stabilization of toxic inorganic compounds may be used to reduce toxicity and mobility.
f. Elementary neutralization may be applicable to the treatment of corrosives.

All treatment must be performed in accordance with applicable state or federal regulations as described in Section 4.

5.5 DISPOSAL

5.5.1 Evaluation Factors

Disposal is the final waste management alternative to be considered after incorporating all practical source reduction, recycling, and treatment options. The following factors should be considered when evaluating both onsite and offsite disposal facilities.

5.5.1.1 General Site Conditions

Area-wide topographical, hydrological, and geological features, as well as sources of usable water, should be reviewed. Also, current and probable future activities around the disposal site should be evaluated.

5.5.1.2 Hydrological Conditions

A hydrological review should identify the location, size, and direction of flow for existing surface water bodies and aquifers characterized as an Underground Source of Drinking Water (USDW).

5.5.1.3 Area Rainfall or Net Precipitation Conditions

Historical rainfall and distribution data should be evaluated to establish soil loading conditions for landspreading, speed of reserve pit drying, net evaporation rates, and pH overtopping potential.

5.5.1.4 Soil Conditions and Loading Considerations

Soil conditions should be checked since they will affect decisions on loading for landspreading and liners for pits. For example, in high clay content and permafrost areas, liners may be unnecessary for reserve pits. In other areas, liners may be appropriate.

5.5.1.5 Drainage Areas

Natural or existing drainage pattern should be determined. Drainage devices needed to control water flow into, onto, or from facility systems should be identified.

5.5.1.6 Presence of Special Conditions

Environmentally-sensitive conditions such as wetlands, historical or archaeological sites, protected habitants, or the presence of endangered species should be identified. Proximity to urban areas also affects disposal decisions.

5.5.1.7 Air Quality

The potential air quality impact of solid waste management facilities should be considered.

5.5.2 Landspreading

Landspreading is a method of treatment and disposal for RCRA Subtitle C-exempt, low-toxicity wastes. It promotes reduction of organic and inorganic constituents by natural processes. Landspreading, a process of applying a waste to the upper soil zone, minimizes impacts to current and future land use. Characteristics and levels of the wastes are such that contamination of soil, groundwater, and runoff should not occur if landspreading is executed in a prescribed manner.

While initial loadings are designed to be protective, further reduction of organic and inorganic constituents generally occur by natural processes such as dilution, absorption, and biodegradation.

Landspreading should be practiced in accordance with local, state, and federal regulations and consistent with lease obligations.

Wastes are applied in a one-time loading as determined by the absolute salt concentration, hydrocarbon concentration, metals concentration, and/or pH level after mixing with the soil. This one-time loading is what differentiates landspreading from landfarming. Landfarming is a permitted biological treatment process consisting of multiple applications of waste to an area with managed additions of moisture and nutrients and repetitive disking.

5.5.2.1 Loading Limits

Based on soil and waste analysis, one constituent will be found to be controlling—that is, it will limit the amount of waste that can be applied to soil. Loading criteria for salts, hydrocarbons, and metals are discussed below. An example of the application of this procedure is given in Appendix F.

5.5.2.2 Salts

Studies have shown that landspreading, which results in waste/soil mixtures with soluble salt levels (that is, electrical conductivity) of less than 4 mmho/cm, exchangeable sodium percentage less than 15, and a sodium adsorption ratio less than 12, will not harm most agricultural crops or soil (based on one-time application). Higher values may be appropriate for some sites depending on (a) land use, (b) salt tolerance of native vegetation, and (c) background soil salinity. For a detailed description of these guidance values and their application, see API Publication 4527, *Evaluation of Limiting Constituents Suggested for Land Disposal of E&P Operations*, August, 1993.

5.5.2.3 Hydrocarbons

API Publication 4527 also supports and describes the landspreading of wastes that contain hydrocarbons. A waste/soil mix containing oil and grease (O&G) or total petroleum hydrocarbon (TPH) concentrations of up to 1 percent by weight has been found to be generally protective of water, plants, and soil microbes. Site specific conditions may accommodate initial waste/soil mixtures with higher

TPH if they contain low levels of water soluble organic compounds. Enhanced techniques, such as repetitive disking and nutrient addition, may be used to increase the rate of biodegradation.

5.5.2.4 pH

According to the API Publication 4595, *Criteria for pH in Onshore Solid Waste Management in Exploration and Production Operations*, the pH of the waste/soil mixture is best maintained between 6 and 8 for upland landspreading but may be expanded to between 6 and 9 for wetland landspreading. This document describes methods for determining and controlling pH in the field.

5.5.2.5 Metals

Concentration of metals in the waste/soil mixture must also be controlled. The API document, *Metals Criteria for Land Management of Explanation and Production Wastes,* should be consulted. Table 3 presents API-recommended guidance values for metals in land disposed soil/waste mixtures.

5.5.2.6 Example Land Loading Calculations for Oil and Grease and TDS

Problem:

An operator has 1,500 yd^3 of waste with 12,000 ppm TDS, 10 percent oil (100,000 ppm), and a density of 93.6 lb/ft^3. The operator wishes to landspread the waste such that the maximum oil loading in the soil is 2 percent and the TDS content of the soil/waste mixture is not above 3,000 ppm.

Detailed below is the solution calculation for the land requirements for landspreading this waste based on (a) the oil content of the waste and (b) the TDS content.

It is assumed that the soil will be tilled to a depth of 6 in. and that 1 acre of soil 6 in. deep (1 acre-6 in.) weighs 2×10^6 lbs.

Solution:

a. Calculate the land requirement based on the oil content of the waste and a 2 percent O&G maximum loading (assume soil with no previous O&G exposure).

Convert the 2 percent O&G maximum loading into pounds of O&G per acre-6 in.:

$$\text{Maximum lbs oil/acre-6 in.} = 0.02\ \frac{\text{lbs oil}}{\text{lbs soil}} \times 2 \times 10^6 \text{ lbs soil/acre-6 in.}$$
$$= 40{,}000 \text{ lbs oil/acre-6 in.}$$

From the oil concentration in the waste, calculate the corresponding maximum pounds of waste that can be tilled in:

$$\text{Maximum waste-to-soil} = 40{,}000\left(\frac{\text{lb oil}}{\text{acre-6"}}\right)\left(\frac{1}{\text{Oil concentration}}\right)$$
$$= 40{,}000\left(\frac{\text{lb oil}}{\text{acre-6"}}\right)\left(\frac{1 \text{ lb waste}}{0.1 \text{ lb oil}}\right)$$
$$= 4 \times 10^5\ \frac{\text{lb waste}}{\text{acre-6"}}$$

Convert pounds of waste to volume:

$$\text{Maximum waste volume loading} = \left(4 \times 10^5\ \frac{\text{lb waste}}{\text{acre-6"}}\right)\left(\frac{1 \text{ ft}^3 \text{ waste}}{93.6 \text{ lb waste}}\right)$$
$$= 4{,}274\ \frac{\text{ft}^3 \text{ waste}}{\text{acre-6"}}$$

Determine the land required to spread 1,500 yd^3 of waste:

$$(1{,}500 \text{ yd}^3)\left(\frac{27 \text{ ft}^3}{1 \text{ yd}^3}\right)\left(\frac{\text{acre-6"}}{4{,}274 \text{ ft}^3 \text{ waste}}\right) = 9.5 \text{ acres}$$

b. Calculate the land requirement based on the TDS content of the waste and a maximum loading of 3,000 ppm TDS (including TDS in the native soil). Assume the native soil has 100 ppm TDS.

Convert maximum ppm TDS loading to lbs TDS/acre-6 in.:

$$\text{Maximum lbs TDS / acre-6"} = \left(3{,}000\ \frac{\text{mg TDS}}{\text{kg soil}}\right)\left(\frac{1 \text{ g TDS}}{1{,}000 \text{ mg TDS}}\right)$$
$$\left(\frac{1 \text{ kg soil}}{1{,}000 \text{ g soil}}\right)\left(\frac{1 \text{ lb TDS}}{454 \text{ g TDS}}\right)\left(\frac{454 \text{ g soil}}{1 \text{ lb soil}}\right)\left(\frac{2\times10^6 \text{lbs soil}}{\text{acre-6"}}\right)$$
$$= 6000\ \frac{\text{lb TDS}}{\text{acre-6"}}$$

Note that the pounds of TDS per acre-6 in. (6,000) is twice the loading of TDS in ppm (3,000).

Calculate lbs TDS/acre-6 in. in the receiving soil:

$$\text{lbs TDS / acre-6" in receiving soil} = \left(\frac{100 \text{ lbs TDS}}{1\times10^6 \text{ lbs soil}}\right)\left(\frac{2\times10^6 \text{ lbs soil}}{\text{acre-6"}}\right)$$
$$= 200 \text{ lbs TDS / acre-6"}$$

Calculate the maximum pounds TDS to be applied:

$$\text{Maximum TDS to apply} = (\text{Maximum lb TDS/acre-6"}) - \text{lb TDS/acre-6" in receiving soil})$$
$$= (6000 \text{ lb TDS/acre-6"}) - (200 \text{ lb TDS/acre-6"})$$
$$= 5{,}800 \text{ lb TDS/acre-6"}$$

Convert pounds TDS to volume of waste:

$$\text{Maximum waste loading} = (\text{Maximum lbs TDS / acre-6"})\left(\frac{\text{lb waste}}{\text{lb TDS}}\right)\left(\frac{1 \text{ ft}^3 \text{ waste}}{\text{lb waste}}\right)$$
$$= (5{,}800 \text{ lb TDS / acre-6"})\left(\frac{1\times10^6 \text{ lbs waste}}{12{,}000 \text{ lb TDS}}\right)\left(\frac{1 \text{ ft}^3 \text{ waste}}{93.6 \text{ lb waste}}\right)$$
$$= 5{,}164\ \frac{\text{ft}^3 \text{ waste}}{\text{acre-6"}}$$

Determine the land required to spread 1,500 yd^3 of waste:

$$(1{,}500\text{yd}^3)\left(\frac{27 \text{ ft}^3}{1 \text{ yd}^3}\right)\left(\frac{\text{acre-6"}}{5{,}164 \text{ ft}^3 \text{ waste}}\right) = 7.8 \text{ acres}$$

Since the land requirement for oil loading is greater than for TDS loading, oil is the limiting constituent and 9.5 acres would be required to landspread this waste to achieve the desired loadings.

Wastes that do not meet the above guidelines may be safely landspread if additional management controls have been developed and proper approvals obtained.

5.5.3 Roadspreading

5.5.3.1 Oil Wastes

Exempt oily wastes such as tank bottoms, emulsions, heavy hydrocarbons, and crude oil-contaminated soil may be used for road oil, road mix, or asphalt. These wastes should be analyzed to ensure they are not ignitable (that is, flash point above 140°F), and that they have a mixed density and metals content consistent with approved road oils or mixes.

Application of oily wastes to private or public roads should be at loading rates that minimize the possibility of surface runoff.

Roadspreading should have the approval of landowners and should meet appropriate state and local regulatory requirements.

5.5.3.2 Produced Waters

It is generally recommended that produced waters used for roadspreading or dust suppression be within a pH range of 6 to 9 and below electrical conductivity 4 mmho/cm. Produced waters with higher electrical conductivity may be used in lieu of road salting with state and local regulatory agency approval.

5.5.4 Burial or Landfill

It is suggested that operators limit burial or landfilling without a protective liner primarily to solid or semi-solid, low-salt and low-hydrocarbon content inert materials (for example, fresh water-based drilling muds, spent iron sponge, pipe scale, gas plant catalyst, and molecular sieve). Furthermore, these techniques should be used only in areas where soil and hydrological conditions would preclude or minimize any threat of groundwater contamination. Also, special waste characteristics such as naturally occurring radioactive material (NORM) should be considered.

Recommended criteria for buried or landfilled wastes include the following:

a. Less than 4 mmho/cm electrical conductivity.
b. Less than 1 percent O&G by weight.
c. Free oil should not be buried.

Burial may reduce the rate or amount of natural biodegradation that occurs.

As described in 5.5.2, the presence of heavy metals should also be considered. When the waste exceeds the suggested criteria (see Table 4), a liner or encapsulation should be used, unless it can be shown that groundwater is either not present or is naturally protected from any significant threat of contamination.

Solidification, stabilization, and encapsulation are methods used to modify adverse properties of wastes to make them suitable for burial.

Operators should maintain complete records of analytical data, sites used, and types and quantities of waste disposed.

Table 3—API Metals Guidance: Maximum Soil Concentrations

Metal	Extraction Method	Maximum Soil Concentration (mg/kg)
Arsenic	EPA Method 3050[a]	41
Barium	LDNR True Total Barium[b]	180,000
Boron	Hot Water Soluble (Carter, 1993)[c]	2 mg/L[d]
Cadmium	EPA Method 3050	26
Chromium	EPA Method 3050	1,500
Copper	EPA Method 3050	750
Lead	EPA Method 3050	300
Mercury	EPA Method 3050	17
Molybdenum	EPA Method 3050	See Note 1
Nickel	EPA Method 3050	210
Selenium	EPA Method 3050	See Note 2
Zinc	EPA Method 3050	1,400

[a]EPA, *Testing Methods for Evaluating Solid Waste*, SW-846, Third Edition, 1986.

[b]Louisiana Department of Natural Resources, *Laboratory Procedures for Analysis of Oilfield Waste*, Statewide Order No. 29-B, 1989.

[c]Carter, *Soil Sampling and Methods of Analysis*, Lewis Publishers, Boca Raton, pp. 91-93, 1993.

[d]Guidance for boron is based on the soluble concentration with units of mg/L rather than the total concentration (mg/kg).

Notes:

1. Molybdenum: On February 25, 1994 (59 FR 9050), EPA rescinded the risk-based maximum soil concentration for Mo of 9 mg/kg due to technical errors and established a nonrisk-based interim ceiling limit of 37 mg/kg. Under certain conditions this interim level may not be protective of grazing livestock. These conditions are alkaline soils under arid and semi-arid conditions with deficient levels of copper in the soil (see Discussion of Limiting Exposure Pathways).

2. Selenium: The limiting pathway concentration of 100 mg/kg was generated by EPA using the risk-based multipathway analysis (see Table 3). However, the potential for plant uptake of Se may be high in alkaline soils under arid and semi-arid conditions. Plants that accumulate Se in these soils may pose a threat to grazing animals. Therefore, if elevated levels of Se are found in the waste, the operator should consider site conditions that control its availability (see Discussion of Limiting Exposure Pathways).