

**Summary**

The technologies discussed in this Section are those that may be effective at achieving the treatment goals and that have the potential to be implemented under site conditions. Other treatment technologies may be considered on a case-by-case basis and will need to consider effectiveness and ability to be conducted at the individual sites where the waste is located.

Before treatment is conducted on a specific waste, a site specific treatment plan should be prepared and the site *Environmental Representative* should be involved in the analysis and plan preparation along with site personnel. The plan should consider such issues as type and quantity of waste to be treated, the hazardous constituents/characteristics to be treated, the target cleanup levels, the types of treatment that can be used to achieve the objectives, and the time, space and cost to conduct the treatment.

Whether a treatment or disposal option is suitable for a particular waste stream will depend on many factors. The following pages summarize some of the factors to consider when determining whether a technology is applicable. Items discussed for each option include:

- The locations (onshore or offshore) where a technology may be considered;
- The types of wastes or waste components for which a technology offers a reduction of the waste stream's potential for undesired environmental or human health impact, or for which the disposal option is feasible; and
- General descriptions of each treatment or disposal option. Limitations of the method are indicated along with discussion of possible environmental impact considerations that accompany use of the method (e.g., from the waste, or from operation of the treatment process), or disposal of the treated waste streams.

This information should be useful for screening options, for a particular waste, when it is uncertain whether the preferred management method provided in Section 2.1 is applicable at a given location. The site *Environmental Representative* should be consulted if additional information on these technologies and guidance with regard to their application and implementation is needed or if other technologies need to be considered.

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Disposal Technologies

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A number of wastewater treatment technologies are addressed in Volume 2 (Biophysical/Socioeconomic/Health Technical Requirements and Specifications).

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<b>Section 6.1</b> Candidate Treatment Technologies	<b>Topic 6.1.1</b> Composting
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**Locations**

- Onshore

**Applicable Wastes**

- Composting may be appropriate for certain waste streams that are contaminated by (lighter) petroleum hydrocarbons. Composting may be applicable to contaminated soil, drilling mud, tank bottom sludges, and other “granular” solids and sludges.

**Technology Description**

Composting is a type of biodegradation process in which the hydrocarbons are broken down into shorter-chain hydrocarbons, some of which can volatilize. Typically, the hydrocarbon-contaminated material is mixed with fertilizer and moisture. The mixture can be covered to keep the temperatures in the mix higher and accelerate the breakdown of the hydrocarbon molecules. The final material may be able to be used as a fertilizer or soil amendment.

**Feasibility/Limitations**

- Composting can be conducted using simple mixing equipment or manual labor and does not require “equipment” or “power/energy”. Consequently, even remote locations may be able to have small compost piles to treat hydrocarbon-contaminated wastes.
- Because composting may involve mixing the waste with relatively large quantities of non-waste material (e.g., fertilizer or plant matter), it may not be practical where large volumes of waste need to be treated either due to lack of mixing material, or space.
- Because composting is a biodegradation process, it may take a relatively long time for highly contaminated soils to be treated to acceptably low levels of contamination.
- Composting is not expected to be useful for “non-granular” wastes such as oily scrap metal or oily wastewater nor on heavy hydrocarbons such as polynuclear aromatic hydrocarbons. Composting is not effective on non-hydrocarbons (e.g., metals, inorganic salts, etc.) and composting would only provide “dilution” due to the mixture with other materials.

**Environmental Issues**

- Although composting may be conducted inside roll-off bins or other containers, it is often conducted in piles on bare earth or a bottom liner. As such, steps should be taken, as appropriate, to limit the potential that contaminants will migrate into the soil, be washed away by stormwater, or be blown away by the wind. There is potential that volatile hydrocarbons will be generated and emitted to the air. Compost piles may also be podorous.

**Additional Comments**

**Locations**

- Onshore or offshore

**Applicable Wastes**

- Paper, wood, kitchen wastes and items that will burn.
- Hydrocarbons and hydrocarbon containing wastes.

**Technology Description**

As a technology, incineration may be used to:

- Reduce the volume of waste such as occurs with the burning of trash.
- Combust undesired organic constituents (e.g., oil, solvents, etc.) into “innocuous” ash, water vapor and carbon dioxide.
- Destroy infectious/pathogenic agents (as is the case in the burning of medical waste).

An incinerator needs to be designed and operated at a high enough temperature to burn (incinerate) the undesired features of the waste and different types of waste may require higher temperatures than others depending on the constituents of concern. Incinerators often consume significant amounts of energy to achieve the high temperature. Some of the energy may come from the waste being burned, but the majority is typically provided by burning a fuel such as natural gas, liquid petroleum products or crude.

Depending on its design, an incinerator may be able to burn waste in a batch or continuous mode. The waste to be incinerated is fed into an incineration chamber (or kiln) and combustion consumes/destroys the organic component. The process generates a solid (ash) and a vapor (combustion gases consisting of air and the products of combustion from the waste).

In order to help alleviate the energy requirements for incineration of a waste stream with low overall energy content, the vapor phase from the incinerator may be used to preheat the combustion air and/or the incoming waste stream.

**Feasibility/Limitations**

- Incinerators may be highly technical pieces of equipment, but in general they do not require a lot of space or manpower to operate. The majority of the space is used to store the waste before incineration and to manage the ash after incineration. Often, the majority of manpower needed is used to move the waste into the incinerator and the ash out of the incinerator. An appropriate and adequate fuel source is needed. Depending on the design and operating temperatures, water may be needed to cool incinerator parts or to cool the ash or off gases. Consequently, a water source and cooling water system may be needed.
- Typically, incineration is more appropriate for waste streams that contain relatively high concentrations of the constituents of concern (i.e., a high ratio of the constituent to be “destroyed” relative to the total waste volume) because the entire waste stream needs to be heated to the incineration temperature.
- Typically, incineration is not preferred when the majority of waste will not burn (e.g., metal or concrete coated with a thin layer of oil, etc.) or has a low heat content (e.g., soil, oily wastewater, etc.). In addition, some constituents may “burn” to undesired by-products (e.g., dioxins and furans from certain plastics, metal oxides from certain metal containing wastes, acid gases from waste or combustion air, etc.).
- One factor to consider for both the air and solid waste streams is that combustion conditions may alter the chemical state of salts and metals from that of the feed stream. Also, particulates may be emitted in the air stream.
- Temperatures in the incinerator will typically be between 1,400° and 1,800°F (760°-982°C). Medical wastes may require temperatures in the range 1,800° to 2,100°F (982°-1,150°C). Materials handling issues need to consider the type of waste and preferred method of incineration. Due to the temperatures involved, safety considerations will also need to be addressed.

**Environmental Issues**

- Incinerators have the potential to emit undesirable air pollutants; however, technologies are available to reduce these emissions to acceptable levels.
- If air pollutant emissions of concern are generated, then monitoring and/or testing of the emissions before and/or after the control systems, if installed, may be appropriate.
- Depending on the wastes burned, the ash may contain metals, inorganic salts or other constituents of concern. Depending on the final disposal location for the ash and other factors, the ash may need to be treated (e.g., stabilization) prior to placement in a landfill. In other cases, such as the burning of hydrocarbon contaminated soil, the “ash” may be “clean” soil that no longer needs to be managed as a waste.

**Additional Comments**

- The residence time (i.e., the length of time the waste needs to be inside the incinerator to burn/destroy the constituents of concern) may range from a few seconds to a few minutes depending on the design and operation of the incinerator and the characteristics of the waste. Incinerators need to be sized correctly which involves consideration of many factors.
- If a waste type has not been incinerated previously, it may be appropriate to conduct a small scale test to evaluate the combustion characteristics of the waste to identify if there may be constituents of concern in the exhaust gases or ash that may warrant additional or special requirements.

<b>Section 6.1</b> Candidate Treatment Technologies	<b>Topic 6.1.3</b> Landspreading and Landtreatment
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**Locations**

- Onshore

**Applicable Wastes**

- Hydrocarbon containing wastes

**Technology Description**

The terms Landspreading and Landtreatment refer to a general category of treatment technologies that involve a common feature: the treatment is conducted with the waste being spread out over an area of land (as opposed to being conducted in a piece of equipment such as an incinerator). The treatment involves the use of microorganisms to biologically degrade hydrocarbons. In addition to biodegradation, some hydrocarbon constituents may volatilize into the air. In general, light hydrocarbons will degrade faster than heavy hydrocarbons.

Within the treatment category, there are different technologies that incorporate features to: 1) help speed up the biodegradation process; 2) target specific types of hydrocarbons; or 3) otherwise impact the timeliness, effectiveness, and cost of the treatment.

In its simplest form, the waste is spread over an area of land and left to allow indigenous microorganisms to degrade the hydrocarbons. This is often referred to as “passive bioremediation” because nothing is done other than the spreading of the waste. However, the biodegradation can be enhanced by maintaining an appropriate amount of moisture, nutrients and oxygen in the waste and adding additional microorganisms to the waste.

As it is commonly employed, landtreatment involves spreading the hydrocarbon contaminated waste over the treatment area and then disking the waste into the soil using common farming type equipment. Disking is typically to a depth of 30 to 45 centimeters (12 to 18 inches) and is conducted to help homogenize the distribution of waste, moisture, microorganisms, nutrients, oxygen etc. As desired, additional water and nutrients can be added periodically and the area redisked. Disking also helps to break up the waste allowing the microorganisms better access to the contamination.

**Feasibility/Limitations**

- Depending on the quantity of waste, landtreatment may require a relatively large area of land.
- Landspreading can be conducted with minimum resources because the only real requirements are space (land) and time. More “sophisticated” systems may involve the need for disking equipment and systems to add water and nutrients. Depending on the methods used, the type and concentration of hydrocarbons present and the desired reduction goals and other factors, bioremediation may take from several months to several years to achieve the desired results.
- If water will be added or if the unit is located in an area that gets significant rain, then control systems (e.g., a bottom liner to reduce the potential for waste constituents to migrate downward or stormwater runoff control systems) may need to be provided.
- Typically, bioremediation is not effective (other than dilution) on the treatment of metals, inorganic salts or very heavy hydrocarbons such as polynuclear aromatic hydrocarbons. The presence of some metals, salts or halogenated compounds may impede biodegradation, as these constituents may be lethal to the microorganisms. In addition, high, low or quickly fluctuating temperature may impede bioremediation.
- If light hydrocarbons are present, then volatilization may be high and could result in odors. The presence of sulfur-bearing compounds in the waste could also lead to odorous emissions. Consequently, the potential for air emissions should be considered when evaluating the appropriateness of this technology.
- When deciding whether to use a landtreatment technology, it should be considered whether it is desired or acceptable to leave the treated waste in place or whether the treated waste will be excavated and moved to another location. This consideration may influence whether to use this technology and/or the design of the treatment unit.

**Environmental Issues**

- Typically, landtreatment areas should not be located in watercourses, flood plains or other areas where the waste could be washed away during storms.
- Typically, large vegetated areas should not be cleared for the purpose of installing a landtreatment unit. Before the start of landspreading or landtreatment, site revegetation after treatment is complete should be addressed.
- Repeated use of the same area may have the potential to result in concentrated levels of metals, inorganic salts or other constituents in the waste that were not bioremediated.

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**Additional Comments**

- Landtreatment units should be designed and operated based on consideration of multiple factors.
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**Locations**

- Onshore
- Offshore (if space/equipment allows)

**Applicable Wastes**

- Aqueous wastes containing free water (i.e., water that can be separated by gravity or pressure) or which contain too much moisture to be managed as desired)
- Hydrocarbon, salt, and metals containing wastes may be treated if conditions are met

**Technology Description**

Solidification and stabilization often use similar principals and have comparable results; however, the intent is different as described below.

Solidification

The goal of solidification is to “solidify” (i.e., make solid) a waste stream that contains too much water. In its simplest form, solidification may absorb liquid (e.g., adding more dirt to mud). In its purest form, the goal of solidification is to chemically bind the water or liquid so that it cannot be readily separated from the waste by gravity or pressure (e.g., adding cement to a waste where the cement reacts with the water). Therefore, in general, solidification is the addition of hydrophilic polymers, sawdust, soil, cement or other water absorbent materials to water based liquid wastes to bind up the water and solidify the waste. Solidification does not necessarily “stabilize” waste constituents.

Stabilization

Stabilization involves a chemical process to react the constituents of concern (typically metals) from a more soluble form to a less soluble form. For example, the reaction of a silica material with lead carbonate (higher lead solubility) to form lead silicate (lower lead solubility).

Stabilization of wastes can be done in batch or continuous mode. In an ex-situ system, the waste to be treated may be loaded into a hopper from which it is conveyed into a processing unit that mixes the waste with cement or a comparable pozzolan (e.g., fly ash). Silica-based cement-like reactions change the waste material from wet sludge to stable powder. If the initial waste was dry, water may have to be added to complete the cement-like reaction. The constituents of concern are physically and/or chemically bound into a cement-like matrix reducing their ability to leach from the waste mixture. Stabilization is one of the few methods available for treatment of wastes with leachable metals.

**Feasibility/Limitations**

- The ability to solidify or stabilize a particular waste stream and the effectiveness of the treatment is dependant on waste-specific factors and treatment reagent specific factors. Typically, representative samples of the waste will need to be tested in a laboratory using different processes, formulations, etc. Bench-scale testing may then lead to larger scale pilot tests before actual field implementation.
- Typically, testing of the treated material may be appropriate to verify that the desired treatment (stabilization-immobilization) has been achieved and that it will be maintained under the conditions of disposal.
- Solidification and stabilization often require the use of specialized equipment (e.g., mixers, reagent storage and pumping, etc.) and chemical reagents. The processes involve significant material handling upstream and downstream of the mixing unit and may be labor intensive.
- Some waste streams may contain contaminants that inhibit the solidification/stabilization processes. For example, the presence of elevated concentrations of hydrocarbons, salts or certain metals may interfere with the formation of a stable matrix. General rules for effective stabilization indicate that the salts must be less than 4 percent of the waste by weight, while the oil content must be below 25 percent by weight. When attempting to apply stabilization technology to wastes with high salt or oil content, it is important to test the effectiveness of the stabilization to determine whether adjustments need to be made.
- Solidification/stabilization is typically not conducted on aqueous waste streams that have low solids content due to the large quantity of reagents needed.
- Typically, salts (e.g., NaCl) will not be stabilized within the matrix and will leach from the treated material.

**Environmental Issues**

- Steps should be taken to ensure that the solidifying or stabilizing agent added does not act as a source of undesirable compounds (e.g., some fly ashes may contain leachable heavy metals).
- These processes typically increase the volume of material to be managed (due to the addition of reagents). Depending on the characteristics of the treated waste, the site location, and other factors, the final disposition of the treated material may vary. Stabilization may generate a powdery solid that is hydrophobic which could adversely impact its ability to be further treated (e.g., landspread for biodegradation of oils).
- Oily drill cuttings that have been stabilized are generally buried in a lined pit and sealed in plastic to isolate the solids from the environment. For some sites, if the burial pit was not lined, or the liner failed, pit contents or their leachates could migrate from the site and potentially impact soil or water sources.

**Additional Comments**

- Note that solidification and stabilization generally increase the volume of the waste.
- There is only a solid phase generated by the stabilization process.
- Commercial units are available that will process 50 cubic yards (38 cubic meters) of waste material per hour. These units are portable and can be set up at a waste site.
- Time for processing may be affected by the consistency of the waste and additional mixing steps that may be required.

**Locations**

- Onshore

**Applicable Wastes**

- Non-hazardous solid wastes (no Hazardous Waste may be placed in a Burial Pit – refer to Section 2.1)

**Technology Description**

The use of onsite burial pits is acceptable for some types of non-hazardous waste; however, the use of such pits typically should be limited to those locations where there is not a threat to surface or groundwater. Similarly, the use of burial pits typically should be limited to those times when other disposal options are not available (e.g., early in the construction phase). Burial pits are excavations in which the waste is placed and which are covered with soil when no longer needed. [Note – a Non-Hazardous Waste Burial Form should be completed – see Topic 4.0.2].

**Feasibility/Limitations**

- The use of burial pits may be feasible in many locations. Areas to avoid include areas with nearby surface water, shallow groundwater or other locations where 1) the waste may inadvertently be unearthed, or 2) where contaminants in the waste have the potential to migrate out of the waste into surface or groundwater or significant gas emissions may escape to the atmosphere.
- The materials disposed should not have the potential to react with each other, react with the soil or degrade the pit liner, if installed. Typically, the wastes should not be disposed in a manner that would allow them to react with, or generate leachate containing constituents of concern if there is, infiltration of rainwater into the waste.

**Environmental Issues**

- By itself, burial does not destroy contaminants of concerns and such constituents may have the potential to migrate subsurface to nearby surface or groundwater sources.. Buried waste may undergo biodegradation over time.
- If hydrocarbon-containing wastes are buried, there is the potential for the formation of methane or other gaseous products through natural degradation and/or chemical reactions. Air emissions and/or odors may be a concern.
- Wastes with high oil, salt, or metals content could be of concern if opportunity for subsurface migration of waste constituents exists (e.g., no natural or synthetic barriers, high precipitation area facilitating percolation, etc.).

**Additional Comments**

- The aerial extent of a burial pit, or system of multiple pits, may be limited by the availability of open space at the site. Typically, land should not be cleared for the construction of a burial pit. In general, the best locations for burial pits are those that are in arid regions, that are distant from surface and groundwater resources, and that are located in low permeability soils.
  - Because the constituents of concern are not typically destroyed, consideration should be given to the long-term compatibility of the wastes with each other and with the pit construction materials.
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**Locations**

- Onshore or offshore

**Applicable Wastes**

- Oil and water based liquid wastes

**Technology Description**

The concept of injection involves pumping liquids under pressure into an injection well where they are forced into the subsurface at the bottom of the well. As part of oilfield operations, aqueous wastes such as produced water are injected into wells that terminate in the oil-bearing zone (injection wells or waterflood wells) or in non-oil-bearing zones (disposal wells). Prior to injection, the waste may be filtered to remove solids, trace amount of oil, or other contaminants if these have the potential to clog the well, the receiving formation or react with the well construction materials or subsurface soils.

**Feasibility/Limitations**

- Injection requires the presence of a subsurface zone to receive the fluid and to have geological barriers to confine propagated fractures.
- The waste must be pumpable and be sufficiently free of solids or other undesirable constituents. Treatment facilities may be required.
- Increased injection well pressure may lead to fracturing of the formation rock. Additionally, injection into a limited formation could lead to over-pressuring, requiring increased mud weight for new wells drilled into the same enclosed formation.

**Environmental Issues**

- Failure of injection system (tubing, casing, cement, formation capacity exceedence, unwanted fracturing) could threaten ground water.
- Typically, hazardous wastes should not be injected.

**Additional Comments**

- Maximum pump pressure should be specified and safety valves should be installed.
- Pressures at adjacent wells and annuli may need to be monitored. Logs may need to be run to detect flow behind casing.
- Modeling hydraulic fracturing before injection may be desirable, depending on the circumstances.

**Locations**

- Onshore

**Applicable Wastes**

- Wastes with high solids content (typically, no free liquids)

**Technology Description**

Landfills are engineered facilities for the burial of wastes. Many landfills are constructed specifically for the disposal of certain types of wastes.

Typically, landfills should be designed and operated to limit the potential for waste constituents and leachate from migrating out of the landfill. At a minimum, landfills are typically constructed with a compacted soil bottom. Landfills may also be constructed with a leachate collection system and/or a leak detection/collection system and/or one or more synthetic liners in addition to the (base) soil liner. Project landfills will be engineered to the technical requirements and specifications provided in Volume 2 of the Environmental Management Plan.

The landfills should be operated to maintain the integrity of the liners and the leachate/leak detection systems.

**Feasibility/Limitations**

- Landfills can be designed to accept a wide variety of waste streams. A key concern is to take steps to reduce the likelihood that waste constituents will react with each other or with the landfill's construction materials in a manner that results in the waste and/or leachate from degrading the liners or leachate/leak detection systems.
- Because the constituents of concern are not typically destroyed, consideration should be given to the long term compatibility of the wastes with each other and with the landfill construction materials

**Environmental Issues**

- Wastes with high oil, salt, or metals content could be of concern if potential for subsurface migration exists and there are nearby surface or groundwater sources.
- If hydrocarbon-containing wastes are buried, there is the potential for the formation of methane or other gaseous products through natural degradation and/or chemical reactions. Air emissions and/or odors may be a concern.

**Additional Comments**

- Typically, landfills are constructed in phases or cells because this allows different types of wastes to be segregated and also limits the amount of waste that is “exposed” to rainfall at a given time which may result in less leachate. Typically, when a cell is full, a soil and/or synthetic liner cap is put over the top to “protect” the waste from rainwater infiltration
- Steps should be taken to segregate the disposal of hazardous wastes from non-hazardous wastes.

**Locations**

- Onshore or offshore

**Applicable Wastes**

- Water-based wastes

**Technology Description**

Direct disposal of treated or untreated aqueous wastes into the environment (e.g., onto soil or into surface watercourse).

**Feasibility/Limitations**

- Surface discharge may be acceptable for certain types of wastewater (e.g., clean, raw water from flushing a firewater system or non-contaminated hydrotest water).
- Typically, drilling wastes should not be discharged into surface water courses or drainage ways, including dry or flowing creeks.
- Surface discharges may not contain constituents of concern above allowable concentrations for the receiving land or water.

**Environmental Issues**

- Wastewater should be discharged in a manner the limits the potential for erosion.
- Wastewater containing constituents of concern should not be discharged in a manner that allows the constituents to accumulate: ideally, the discharge should facilitate the dilution of these constituents (e.g., into flowing water).
- Because the wastes are discharged directly into the environment, their impacts will be based on the constituents of concern discharged and the sensitivity of the environment.
- Oil and heavy metal concentrations in discharged wastes may be of concern if they are high enough to impact plants and animals. Salt levels may be of concern for surface discharges.

**Additional Comments**

- For surface discharges, total suspended solids, oxygen demand, oil and grease, heavy metals, chloride, pH, and other properties may be a concern.
- Offshore discharges of treated wastewater must meet the International Convention for Prevention of Pollution from Ships criteria.