Appendix A

Glossary of Process Options

Aerobic Biotreatment – see Bioremediation.

Air Stripping is a cost-effective and reliable method of removing volatile organics from contaminated water. Air stripping is accomplished in a tower in which water cascades down through a packing material while air is forced up through the packing by means of a blower.

Bioremediation relies on microorganisms to transform hazardous compounds into innocuous materials. Almost all organic compounds and some inorganic compounds can be degraded biologically if given the proper physical and chemical conditions and sufficient time. In situ bioremediation is achieved via bioventing while ex situ treatment is achieved in a land farming/treatment unit.

Bioventing stimulates natural in situ biodegradation of any aerobically degradable compounds in soil by providing oxygen to existing soil microorganisms. In contrast to soil vapor vacuum extraction, bioventing uses low air flow rates to provide only enough oxygen to sustain microbial activity. Oxygen is most commonly supplied through direct air injection into residual contamination in soil. In addition to degradation of adsorbed fuel residuals, volatile compounds are biodegraded as vapors move slowly through biologically active soil.

Block Displacement places an impermeable barrier around and beneath the contaminated zone. The ground is physically displaced upward by pumping slurry, usually a soil bentonite and water mixture, into a series of notched injection holes. A perimeter barrier is constructed in conjunction with the bottom barrier.

Clay/Synthetic Membrane is a type of cap that involves placing clay or a synthetic liner over the top of the site to contain contaminants and prevent contact. This action often reduces the amount of leachate formed by precipitation and helps prevent exposure through the surface.

Carbon Adsorption removes contaminants from aqueous wastes by contacting the stream with a solid, activated carbon adsorbent in the granular or powdered form. Organic compounds, and some inorganic species, become bound to the surface of the carbon particles and are subsequently removed along with the adsorbent. Carbon adsorption is primarily used to remove organic compounds with low solubilities in water.

Chemical Reaction involves the addition of a chemical, such as hydrogen peroxide, that will react with the constituents in the groundwater or soil such that the products of the reaction are nonhazardous or more amenable to other forms of treatment (i.e., biological treatment).

Cryogenic Barrier is a technique that involves creating a frozen barrier using an underground refrigeration system to control groundwater flow. The frozen zone acts as a barrier that prevents the material from migrating into surrounding soils, groundwater, or nearby aquifers.

Chemical Dechlorination/Dehalogenation is a chemical process to remove *halogens* (usually chlorine) from a chemical contaminant, rendering it less hazardous. This process, which is typically preformed ex situ, involves heating and physically mixing

contaminated soils with chemical reagents to chemically convert them to less toxic materials.

Dual-Phase Extraction is a technology to simultaneously remove liquid and gas from low permeability or heterogeneous formations. The vacuum extraction well includes a screened section in the zone of contaminated soils and ground water to remove organic contaminants from above and below the water table.

Electrical Resistance Heating (ERH) uses an electrical current to heat less permeable soils above and below the water table so that water and contaminants trapped in these relatively conductive regions are vaporized and ready for vacuum extraction. Six-phase soil heating (SPSH) is a typical electrical resistance heating which uses low-frequency electricity delivered to six electrodes in a circular array to heat soils. With SPSH, the temperature of the soil and contaminant is increased, thereby increasing the contaminant's vapor pressure and its removal rate.

Electrokinetic Separation process removes metals and organic contaminants from low permeability soils or sludges. This process option uses electrochemical and electrokinetic processes to desorb, and then remove, metals and polar organics. This in situ soil processing technology is primarily a separation and removal technique for extracting contaminants from soils.

Evaporation is used to allow water to evaporate into the atmosphere. It is accomplished through ponds, or by spraying the water into large areas of soil to facilitate the evaporation process.

Excavation is accomplished by digging up waste or contaminated soil typically with a backhoe or loader.

Extraction Wells are used to remove groundwater for treatment, subsequent discharge or both. A well system uses one or more pumps to draw groundwater to the surface forming a cone depression in the groundwater table, the extent and slope of which is dependent on pumping rates and duration as well as local groundwater and soil factors. Groundwater pumping can be used to lower the water table and to contain a plume. It can also be utilized in conjunction with other groundwater controls to maximize their efficiency.

Extraction Trenches may be used to collect leachate or shallow groundwater by excavating trenches that are either equipped with pumps or use gravity to collect contaminated water.

Fencing is an institutional control that restricts access to a site by creating a physical barrier to entry. Fencing prevents persons from coming in contact with contaminated surface media at the site but does nothing to treat contamination.

Fixation – see Stabilization.

Grading is a method for altering the surface landscape to prevent contact with contaminated surface media and/or change the surface water run-on/run-off pathway to control contamination migration.

Groundwater Pumping techniques involve the active manipulation and management of groundwater in order to contain or remove a plume or to adjust groundwater levels in order to prevent formation of a plume. Groundwater pumping uses a series of wells to remove groundwater for treatment, subsequent discharge or both. A well system uses one or more pumps to draw groundwater to the surface forming a cone of depression in the groundwater table, the extent and slope of which is dependent on pumping rates and duration as well as local groundwater and soil factors. Groundwater pumping can be used to lower the water table and to contain a plume. It can also be utilized in conjunction with other groundwater controls to maximize their efficiency.

Grout Injection creates fixed underground barriers formed by injecting grout, either particulate (such as portland cement) or chemical (such as sodium silicate), into the ground through well points. By installing injections equidistant along a line, a barrier wall is formed.

Horizontal Wells have distinct accessibility and waste removal advantages over conventional vertical wells. They can be used to detect, to monitor, to contain, and to extract subsurface contaminants.

Hot Air or Steam Injection includes the injection of hot air or stream below the contaminated zone to heat up contaminated soil. The heating enhances the release of contaminants form soil matrix. Some VOCs and SVOCs are stripped from contaminated zone and brought to the surface through soil vapor extraction.

Hydrolysis is the process of transforming a chemical to another species by breaking a bond in a molecule so that it will react with water. Hydrolysis can be achieved by the addition of chemicals, by irradiation, or biologically.

Incineration combusts or oxidizes organic material at very high temperatures. Emission control equipment is needed for particulates and products of incomplete oxidation to control emissions of regulated air pollutants.

Infiltration is a method that allows water to percolate through soils by introducing the water into the ground through a series of wells or a network of underground-perforated piping.

Injection Wells may be used to create groundwater barriers to change both the direction of plume and the speed of plume migration. By creating an area with a higher hydraulic head, the plume can be forced to change direction.

Inorganic Stabilization – see Stabilization.

Interceptor Trenches are excavated and designed to prevent surface water from either entering or escaping from the surface of a site. This helps prevent additional leachate

being formed by infiltration of surface water. It also limits pathways for migrating contaminants.

Ion Exchange is a reversible interchange of ions between an insoluble salt or resin, in contact with wastes containing ionic species. In the process, unwanted ionic species, principally inorganics, are replaced (exchanged) with innocuous ions on the resin. The ion exchange process is used to treat metal wastes including cations and anions. It is based on the use of specifically formulated resins having an exchangeable ion bound to the resin with a weak ionic bond.

Lagoon Buttress is a system for treating or containing surface liquids or sludges using a holding pond (lagoon) and retaining wall and buttress system.

Land Treatment/Farming is an ex situ process whereby contaminated soil is excavated, applied into lined beds, and periodically turned over or tilled to aerate the waste. Biological activity is stimulated and contaminants are encouraged to biodegrade.

Land Use Restrictions are designed to prevent access/exposure to groundwater or soil by limiting what can be done at the site. They can be accomplished administratively via deed or zone classification. For example, a deed restriction may include limitations on the future development of a property for anything other than industrial use.

Low-Temperature Thermal Desorption (LTTD), also known as low-temperature thermal volatilization, thermal stripping, and soil roasting, is an ex-situ remedial technology that uses heat to physically separate petroleum hydrocarbons from excavated soils. Thermal desorbers are designed to heat soils to temperatures sufficient to cause constituents to volatilize and desorb (physically separate) from the soil.

Microbial Degradation – see Bioremediation.

Monitoring is the process of collecting and analyzing groundwater samples and hydraulic data to define the toxicity, mobility, and volume of contamination. Monitoring can be used as supporting documentation of the either the persistence of contamination, its migration, or its natural attenuation. Natural attenuation is defined as the biodegradation, dispersion, dilution, sorption, volatilization, and/or chemical stabilization of contaminants to reduce the toxicity, mobility, or volume to levels that are protective of human health and the ecosystem.

Multimedia Pavement involves placing a material such as concrete, asphalt, rubber, or combination thereof over the top of the site. This action reduces the amount of percolation through the soil from precipitation and helps prevent exposure through the surface.

Neutralization is a process used to adjust the pH of a waste stream to an acceptable level for discharge, usually between 6.0 and 9.0 pH units. Adjustments of the pH is done by adding acidic reagents or acidic wastes to alkaline streams and vice versa.

No Action is an alternative whereby no remedial technology or associated process option would be used for soil or groundwater remediation at the project site. No action

may be an appropriate response in cases where remediation is unwarranted, based on screening criteria and remediation goals.

Oil/Water Separation can be used to separate two (or more) immiscible liquids having sufficiently different densities, such as oil and water. Liquid/liquid separation occurs when the liquid mix is allowed to settle. Thus, flow velocities must be kept low. This treatment is applicable to the insoluble phase only. Another treatment must be used to treat the dissolved phase.

Oxidation reactions are utilized to change the chemical form of a hazardous material in order to render it less toxic or to change its solubility, stability, separability, or otherwise change it for handling and disposal purposes. Oxidation can be an effective way of pretreating wastes prior to biological treatment; compounds that are refractory to biological treatment can be partially oxidized making them more amenable to biological oxidation. Oxidation rates can sometimes be catalyzed by ultraviolet light.

A *Permeable Reactive Barrier* (PRB) is a zone of reactive material placed in the subsurface so that contaminated groundwater flows through and contamination is either contained or destroyed in the process.

Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment. The mechanisms of phytoremediation include enhanced rhizosphere biodegradation, phyto-extraction (also called phyto-accumulation), phyto-degradation, and phyto-stabilization. Phytoremediati0on is best suited for sites with low concentrations of contaminants over large cleanup areas and at shallow depths.

Precipitation is a widely used, relatively low cost physical chemical technique in which the equilibria of chemical constituents of a waste are changed to reduce the solubility of the undesired components. These components precipitate out of solution and are removed by one or more solids removal techniques. Precipitation is most commonly used to treat wastes containing heavy metals.

Pumping Wells – See Groundwater pumping.

Radio Frequency Heating consists of heating a subsurface zone with electromagnetic energy of varying frequencies to thermally decompose or vaporize hazardous components. The energy is transmitted to the soil via electrodes placed horizontally above the contaminated area.

RCRA Subtitle C Landfills are used for the disposal of hazardous wastes.

RCRA Subtitle D Landfills are used for the disposal of sanitary wastes.

Reduction involves addition of a reducing agent, which lowers the oxidation state of a substance in order to reduce toxicity or solubility or to transform it to a form that can be more easily handled. Most reduction reactions for organic chemicals are done under very dry conditions because reducing agents often react with water.

Revegetation is the establishment of annual and perennial plant material for temporary and long-term soil stabilization. Prior to revegetation, soil amendments such as top soil or fertilizers and mechanical treatments such as aeration and drainage may be necessary to create a suitable growing environment.

Soil Aeration introduces air into the soil through mechanical means allowing for a greater air to constituent surface area. This process increases volatilization but vaporized contaminants must be withdrawn from the soil in order for this technology to be effective.

Soil Cover/Vegetation involves emplacement of a layer of soil, typically one-foot or greater in thickness, and establishing vegetative growth to stabilize the soil as described above in "revegetation." The soil cover acts as containment and a barrier to direct contact with underlying contaminants in soil.

Soil Flushing refers to applying a liquid flushing agent to contaminated soil to physically or chemically remove contaminants. The flushing agent is allowed to percolate into the soil and enhance the transport of contaminants to groundwater extraction wells for recovery. This technology is most applicable for soluble organics and metals at a low-to-medium concentration that are distributed over a wide area.

Soil Reclamation/Recycling is the practice of reusing contaminated soil in processes such as asphalt production or as landfill cover soil, where contaminants are reduced or immobilized so that they pose no risk to human health and/or the ecosystem.

Soil Vapor Extraction (SVE) has been used to augment groundwater extraction and treatment. A vacuum is applied to subsurface soils in the unsaturated zone and in dewatered portions of the saturated zone. The extracted vapor or soil gas contains volatile contaminants that can be either vented directly to the atmosphere or collected in a vapor-phase carbon adsorption system. The system may consist of s a single extraction well screened in the contaminated zone, or it may include inlet wells that direct airflow through a particular interval.

Soil Washing is a technology that cleanses the soils of contaminants that are readily removed by the "solvent" used. Oftentimes, the solvent used is water, but a different solvent, or additives, can improved the removal efficiency.

Solvent Extraction uses solvents to remove constituents from the groundwater or soil. The solvent is later recovered, recycled, and reused. Often the extracted soil or groundwater must be treated further because candidate solvents are environmentally significant materials like petroleum solvents and chlorinated solvents.

Solidification/Stabilization (S/S) reduces the mobility of hazardous substances and contaminants in soil through both chemical and physical treatment. Soil is typically mixed with a binding agent to hold contaminants in a solid matrix, thereby immobilizing them. This process may be performed in situ or ex situ and its effectiveness is confirmed via follow-up leachability testing.

Thermal Desorption involves heating materials to drive off volatile organics. Thermal desorption is similar to incineration except it usually operates at a lower temperature and retains the option of recovering the volatilized chemicals. This process removes volatile

organics from soil by heating the soil in a rotating device while passing a noncombustible vapor through the equipment. The equipment is often heated indirectly to avoid contact between the combustion gases and the contaminated soil. Gas produced by the process is usually treated by condensation, scrubbing, or secondary combustion.

Vitrification is thermal treatment process that converts the contaminated area into a chemically inert, stable glass and crystalline product. Electrodes are inserted into the area to be treated, and a conductive mixture of flaked graphite and glass frit is placed among the electrodes to act as the starter path. An electric potential is applied to the electrodes, establishing an electric current in the starter path. The resultant power heats the starter path and surrounding material above the fusion temperature of soil. The graphite starter pad is consumed by oxidation, and the current is transformed to the molten soil.