

TABLE 2
Ongoing SITE Demonstration Program Projects as of September 2002

Developer	Technology	Technology Contact	EPA Project Manager	Applicable Media	Applicable Waste	
					Inorganic	Organic
Earth-Tech Roanoke, VA (HSA)	In-Situ Enhanced Bioremediation of Groundwater	Brian B. Looney 808-725-7673 Rosann Kryczkowski 540-362-7326	Vince Gallardo 513-569-7679	Groundwater	Not Applicable	VOCs
Electro-Petroleum, Inc. Wayne, PA	Electro-Kinetically Aided Remediation (EKAR)	Dr. J. Kenneth Whittle 610-687-9070	Randy A. Parker 513-569-7271	Soil	Various radionuclides, arsenic, cadmium, lead, nickel, mercury	Acetone, BTEX, PAHs, TCE
Geokinetics International, Inc. Palo Alto, CA	Electrokinetic Remediation Process	Steven Schwartzkopf 415-424-3176	Thomas Holdsworth 513-569-7679	Clay, Silty Clay, Shale Beds, Gravel Deposits, etc.	Not Applicable	Feul Oil, Diesel, Kerosene, PAHs, Coal Tar, Hydraulic Fluid, TCE
Harding ESE A MacTec Company (formerly ABB Environmental Services, Inc.) Wakefield, MA.	Two-Zone, Plume Interception, In Situ Treatment Strategy	Willard Murray 781-245-6606	Randy Parker 513-569-7271	Groundwater, Soil	Inorganic Chloride	Chlorinated and Nonchlorinated Organic Compounds
Integrated Water Resources, Inc Santa Barbara, CA.	Dynamic Underground Stripping & Hydrous Pyrolysis Oxidation	Roger Aines 925-423-7184 Robin Newmark 925-423-3644 Norman Brown 805-966-7757	Thomas Holdsworth 513-569-7679	Groundwater, Soil	Not Applicable	Chlorinated solvents, fuels, creosote
Lewis Environmental Services, Inc./ Hickson Corporation Etna, PA	Chromated Copper Arsenate Soil Leaching Process	Tom Lewis III 412-799-0959	Randy Parker 513-569-7571	Leachate, liquid, Soil, Wastewater	Mteals, Nonspecific Inorganics	Nonspecific Organics
Lockheed Martin Missiles and Space Co., and Geokinetics International, Inc. Palo Alto, Ca	Electrokinetic Remediation Process	Steven Schwartzkopf 415-424-3176	Tom Holdsworth 513-569-7679	Soil, Sludges, Sediment	Heavy Metals	Polar Organics
Matrix Photocatalytic Inc., London, Ontario, Canada	Photocatalytic Air Treatment	Bob Henderson 519-660-8669	Paul de Percin 513-569-7797	Air	Not Applicable	VOCs, SVOCs
Process Technologies, Inc. Boise, ID	Photolytic Destruction of Vapor-Phase Halogens	Not Available	Paul dePercin 513-569-7797	Air, Gases	Not Applicable	VOCs, CFCs, HCFCs
Recycling Sciences International, Inc. Chicago, IL	Desorption and Vapor Extraction System	William Meenan 312-663-4269	Richard Eilers 513-569-7809	Soil, Sediment, Sludge	Volatile Inorganics	VOCs, SVOCs, PCBs, PAHs, PCP, Pesticides
RKK, Ltd. Arlington, WA	CRYOCELL®	Ronald Krieg 360-653-4844	Steven Rock 513-569-7149	Soil	Nonspecific Inorganics	Nonspecific Organics
Selentec Environmental Technologies, Inc. Atlanta, GA	Selentec MAG*SEP SM Technology	Steve Weldon 770-640-7059	Randy Parker 513-569-7271	Water, Wastewater	Heavy Metals, Radionuclides	Not Applicable
SIVE Services Dixon, CA	Steam Injection and Vacuum Extraction	Douglas Dieter 707-678-8358	Michelle Simon 513-569-7469	Soil	Not Applicable	VOCs, SVOCs

* Solicitation Number

** An additional demonstration is planned for this technology. Refer to the profile in the Demonstration Program section (completed projects) for more information.

*** From Emerging Technology Program

TABLE 2 (Continued)
Ongoing SITE Demonstration Program Projects as of September 2002

Developer	Technology	Technology Contact	EPA Project Manager	Applicable Media	Applicable Waste	
					Inorganic	Organic
Vortec Corporation*** Collegeville, PA	Vitrification Process	James Hnat 610-489-2255	Teri Richardson 513-569-7949	Soil, Sludge, Sediment	Metals, Other Nonspecific Inorganics	Nonspecific Organics
Western Research Institute Laramie, WY	Contained Recovery of Oily Wastes	Lyle Johnson 307-721-2281	Eugene Harris 513-569-7862	Soil, Groundwater	Not Applicable	Coal Tars, Petroleum By-Products, PCP, Chlorinated Solvents
Wheelabrator Technologies Inc. Hampton, NH	WES-PHix® Stabilization Process	Mark Lyons 603-929-3403	Teri Richardson 513-569-7949	Soil, Sludge	Metals	Not Applicable

* Solicitation Number
 ** An additional demonstration is planned for this technology. Refer to the profile in the Demonstration Program section (completed projects) for more information.
 *** From Emerging Technology Program

EARTH TECH, INC.
(formerly ITT Night Vision)
(In Situ Enhanced Bioremediation of Groundwater)

TECHNOLOGY DESCRIPTION:

ITT Night Vision is conducting in situ enhanced aerobic bioremediation of contaminated groundwater in fractured bedrock utilizing technologies developed at the U.S. Department of Energy Savannah River Site. The site demonstration involved remediation of groundwater in the vicinity of one contaminant source area as a pilot-scale operation, with the possibility of applying the technology elsewhere on site. Contaminants of concern in on-site groundwater included chlorinated solvents and their products, plus acetone and isopropanol. To accelerate the intrinsic (natural) biodegradation observed at the site, the selected remedy involves the subsurface injection of air, gaseous-phase nutrients (triethyl phosphate and nitrous oxide), and methane. The amendments were added to stimulate existing microbial populations (particularly methanotrophs) so that they could more aggressively break down the contaminants of concern. Amendment delivery to the surface was accomplished through an injection well, and the injection zone of influence was confirmed using surrounding groundwater monitoring wells and soil vapor monitoring points.

The patented PHOSter™ process for injection of triethyl phosphate in a gaseous phase was licensed for use at this site as an integral element of the enhanced bioremediation operation. This technology maximizes the subsurface zone of influence of nutrient injection as compared to technologies injecting nutrients in liquid or slurry form. Monitoring of contaminant (and breakdown product) concentrations in groundwater and soil vapor, measurement of microbiological population density and diversity, and monitoring of nutrient concentrations and groundwater geochemical parameters provides feedback on system effectiveness. This in turn allows adjustments to be made in the sequencing and rate of delivery of air, nutrients, and methane in response to changing subsurface conditions.

WASTE APPLICABILITY:

The Enhanced In-Situ Bioremediation process is applicable for creating volatile organic compounds (VOCs) in groundwater that can be naturally biodegraded, including some hard to degrade chlorinated VOCs. The mixture of air and gaseous phase nutrients that is injected into the subsurface provides an aerobic environment for contaminant degradation. Toxic products resulting from anaerobic degradation of chlorinated solvents (e.g., vinyl chloride) may be broken down completely in this aerobic environment. The in-situ process is especially applicable for hydrogeologically complex sites where injected nutrient flow patterns are uncertain (i.e., in fractured bedrock gaseous phase nutrient injection is more likely to affect a larger area than liquid nutrient injection). The process is also applicable in situations where subsurface utilities limit or preclude the use of technologies requiring excavation.

The enhanced bioremediation system, currently being used in the ongoing RCRA corrective action interim measure at the ITT Night Vision facility, was accepted into the SITE program in 1997, (the demonstration was conducted March 1998 to August 1999) with system start up occurring in March of 1998. The technology had previously been approved by EPA Region 3 as an Interim Measure part of the facility's ongoing RCRA Corrective Action program.

Due to the positive performance of the technology during the SITE Demonstration project, the remediation system was expanded to address the entire contamination plume at the site.

Demonstration results are shown in Table 1. Results were based on 28 baseline and 28 final samples for the four critical analytes are presented in Table 1. VOC concentrations were determined by EPA SW-846 Method 8260. The results indicate that the targeted 75 percent reduction was achieved or exceeded for two of the four critical compounds, from baseline to final events.

Target Compound	Contaminant Concentration (µg/L)		Average Percent Reduction	Statistically Significance Present Reduction
	Baseline	Final		
CA	256	210	36	4
1,1-DCA	960	190	80	71
<i>cis</i> -1,2-DCE	1,100	90	97	55
VC	1,100	45	96	52

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ELECTRO-PETROLEUM, INC. **(Electro-Kinetically Aided Remediation [EKAR])**

TECHNOLOGY DESCRIPTION:

Electrokinetics is a general term describing a variety of physical changes, electrochemical reactions and coupled flows, which can occur when electrical current flows through soils containing one or more phases of fluids. Electrokinetically-Aided Remediation (EKAR), which utilizes electric fields to drive fluids and charged particles through a porous medium, is being developed for in-situ soil remediation. In this process, an electrical current or potential difference is applied across electrodes placed into soil in the treatment area. The applied electrical current effectively enlarges the throat diameter of soil pores, compared to Darcy flow, and changes the capillary forces allowing NAPL to pass through. Dissolved organic and non-aqueous phase liquids (NAPLs) will also accompany the increased electroosmotic water flux toward the cathode. Hydrolyzed ionic species and charged colloidal particles will drift toward the electrode of opposite polarity.

A typical electrokinetic field deployment is set up as follows: A seven-spot pattern consisting of six anode wells surrounding a central cathode extraction well is used to remediate a volume of subsurface material. NAPL concentrations are extracted at the electrode wells for further treatment or disposal. The mobility of the ions and pore fluids decontaminates the soil mass. EKAR can supplement or replace conventional pump and treat technologies.

WASTE APPLICABILITY:

Electrokinetically aided remediation has particular applicability to both organic and inorganic contaminants in low permeability soils. Electrokinetic mechanisms increase fluid flow through fine grained porous media. This mechanism increases the removal of mobile non-aqueous phase liquid, its residual, and its aqueous phases. It is equally effective with both LNAPL and DNAPL. Because of the electrokinetically imposed electric field's ability to drive charged particles through a fluid, the technology can be used to increase particulate contaminant flux through soil and transport microbes to contaminated zones for bioremediation. Electrochemical treatment may be engineered to extract soluble species of cations and anions without the need for water flushing and secondary treatments.

STATUS:

Bench laboratory studies investigating the metals, organics, and radionuclides, have been completed. Organics investigated included acetone, BTEX, and PAHs. Metals removal investigations focused on arsenic, cadmium, chromium, lead, nickel and mercury.

Radionuclides investigated included cesium, cobalt, technicium, strontium, and uranium. Bench scale treatability tests have shown significant removal of TCE from core samples.

The technology is scheduled to be demonstrated at Offut Air Force Base, Nebraska in 2003, and evaluated for its ability to remediate TCE contaminated soils.

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GEOKINETICS INTERNATIONAL, INC.
(Electrokinetic Remediation Process)

TECHNOLOGY DESCRIPTION:

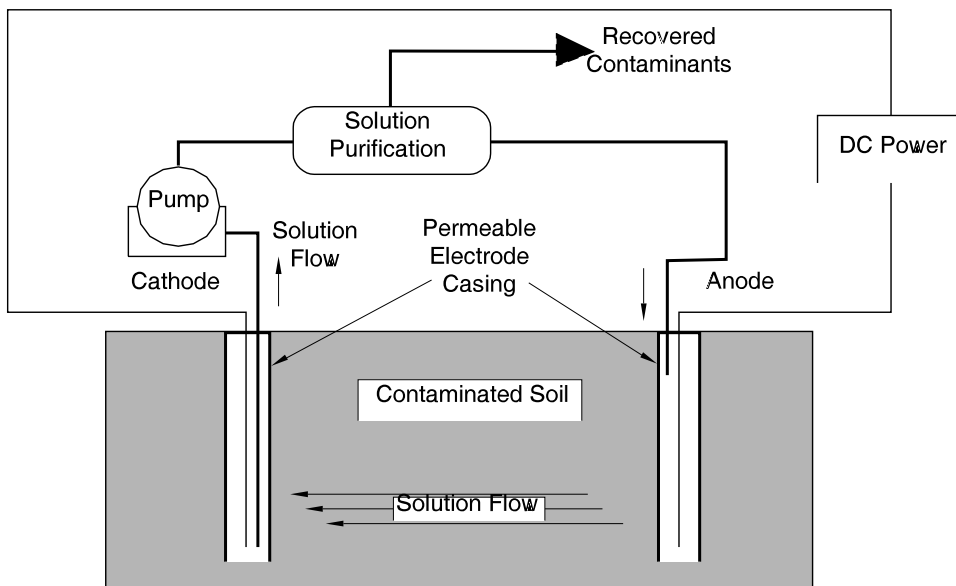
The Electrokinetic Remediation (ER) process removes metals and organic contaminants from soil, mud, sludge, and marine dredgings. ER uses electrochemical and electrokinetic processes to desorb and remove metals and polar organics. The technology may be applied in situ or in the batch mode.

The figure below is a flow diagram of the batch reactor. Waste material is placed into the batch reactor, between Ebonex® ceramic electrodes that are divided into a cathode array and an anode array. A direct current is then applied, causing ions and water to move toward the electrodes. Metal ions, ammonium ions, and positively charged organic compounds move toward the cathode. Anions such as chloride, cyanide, fluoride, nitrate, and negatively charged organic compounds move toward the anode. Two primary mechanisms transport contaminants through the soil: electromigration and electroosmosis. In electromigration, charged particles are transported through the substrate. In contrast, electroosmosis is the movement of a liquid

containing ions relative to a stationary charged surface. Of the two, electromigration is much faster and it is the principle mechanism for the ER process.

The electrodes are positioned inside permeable casings that are inserted into the waste material. After the annulus of each casing is filled with water, the current is turned on. The water passes from the anode casing into the waste and toward the cathode. This procedure (1) supports electrokinetic movement of the contaminants through the soil; (2) helps maintain soil moisture, thereby sustaining the electric field; and (3) enables various chemicals that enhance contaminant removal to be added as required.

As the water accumulates in the annulus of the cathode casing, it is pumped out for processing. Processing involves removal of contaminants by electrochemical means, producing a concentrated contaminant brine that can be either further processed or disposed of as hazardous waste. The water is then returned to the annulus of the anode casing.



Flow Diagram of the Electrokinetic Remediation Process

WASTE APPLICABILITY:

ER is designed to remove heavy metals, anions, and polar organics from soil, mud, sludge, and dredgings. Treatable concentrations range from a few parts per million (ppm) to tens of thousands ppm. The batch technology is most appropriate for sites with contaminated estuarine and river muds and dredgings, sewage processing sludges, and fines remaining after soil washing. The process can be used with virtually any substrate. ER's effectiveness is sharply reduced for wastes with a moisture content of less than 10 percent.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1994. A demonstration of the process will be conducted at the Alameda Naval Air Station in California.

The ER process has been used successfully at several European sites on soils contaminated with metals.

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HARDING ESE, A MACTEC COMPANY
(formerly ABB Environmental Services, Inc.)
(Two-Zone, Plume Interception, In Situ Treatment Strategy)

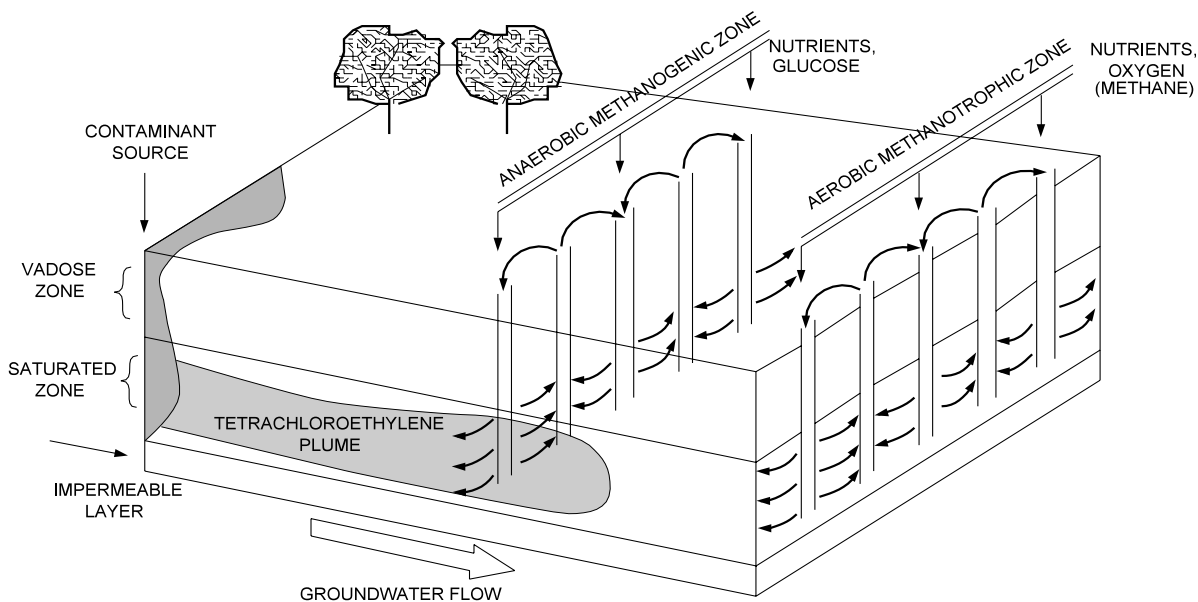
TECHNOLOGY DESCRIPTION:

The two-zone, plume interception, in situ treatment strategy is designed to treat chlorinated and nonchlorinated organic compounds in saturated soils and groundwater using a sequence of anaerobic and aerobic conditions (see figure below). The in situ anaerobic and aerobic system constitutes a treatment train that biodegrades a wide assortment of chlorinated and nonchlorinated compounds.

When applying this technology, anaerobic and aerobic conditions are produced in two distinct, hydraulically controlled, saturated soil zones. Groundwater passes through each zone as it is recirculated through the treatment area. The first zone, the anaerobic zone, is designed to partially dechlorinate highly chlorinated solvents such as tetrachloroethene (PCE), trichloroethene (TCE), and 1,1,1-trichloroethane with natural biological processes. The second zone, the aerobic zone, is designed to biologically oxidize the partially dechlorinated products from the first zone, as well as other compounds that were not susceptible to the anaerobic treatment phase.

Anaerobic conditions are produced or enhanced in the first treatment zone by introducing a primary carbon source, such as lactic acid, and mineral nutrients, such as nitrogen and phosphorus. When proper anaerobic conditions are attained, the target contaminants are reduced. For example, PCE is dechlorinated to TCE, and TCE is dechlorinated to dichloroethene (DCE) and vinyl chloride. Under favorable conditions, this process can completely dechlorinate the organics to ethene and ethane.

Aerobic conditions are produced or enhanced in the second treatment zone by introducing oxygen, mineral nutrients such as nitrogen and phosphorus, and possibly an additional carbon source, such as methane (if an insufficient supply of methane results from the upstream, anaerobic zone). When proper aerobic conditions are attained in this zone, partially dechlorinated products and other target compounds from the first zone are oxidized. For example, less-chlorinated ethenes such as DCE and vinyl chloride are cometabolized during the aerobic microbiological degradation of methane.



Two-Zone, Plume Interception, In Situ Treatment Strategy

The treatment strategy is designed to biologically remediate subsoils by enhancing indigenous microorganism activity. If indigenous bacterial populations do not provide the adequate anaerobic or aerobic results, specially adapted cultures can be introduced to the aquifer. These cultures are introduced using media-filled trenches that can support added microbial growth.

WASTE APPLICABILITY:

The two-zone, plume interception, in situ treatment strategy is designed to treat groundwater and saturated soils containing chlorinated and nonchlorinated organic compounds.

STATUS:

The two-zone, plume interception, in situ treatment strategy was accepted into the SITE Emerging Technology Program in July 1989. Optimal treatment parameters for field testing were investigated in bench-scale soil aquifer simulators. The objectives of bench-scale testing were to (1) determine factors affecting the development of each zone, (2) evaluate indigenous bacterial communities, (3) demonstrate treatment of chlorinated and nonchlorinated solvent mixtures, and (4) develop a model for the field remediation design. The Emerging Technology Bulletin (EPA/540/F-95/510), which details the bench-scale testing results, is available from EPA.

A pilot-scale field demonstration system was installed at an industrial facility in Massachusetts. Pilot-scale testing began in September 1996. Results from this testing indicate the following:

- The reductive dechlorination of PCE and TCE to DCE, VC, and ethene has been accomplished primarily by sulfate-reducing bacteria.

- A time lag of about 4 months was required before significant reductive dechlorination occurred. This corresponded to the time and lactic acid dosing required to reduce the redox to about -100 throughout the treatment cell.
- Sequential anaerobic-aerobic (Two-Zone) biodegradation of PCE and its degradation products appear to be a viable and cost-effective treatment technology for the enhancement of natural reductive dechlorination processes.

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**INTEGRATED WATER RESOURCES, INC.
(Dynamic Underground Stripping & Hydrous Pyrolysis Oxidation)**

TECHNOLOGY DESCRIPTION:

Dynamic Underground Stripping and Hydrous Pyrolysis Oxidation are components of a toolbox of remediation techniques that mobilize and remove as well as destroy, *in situ*, a variety of organic contaminants including chlorinated solvents (TCE and PCE), fuels and creosote. Steam is injected through stainless steel wells, creating a steam-front that volatilizes the contaminants as it moves towards groundwater and vapor extraction wells where contaminants are brought to the surface for *ex situ* treatment. When the site reaches the target temperature, and for the period afterward while the target zone remains hot, a portion of the contaminants will be destroyed *in situ* by Hydrous Pyrolysis/Oxidation, producing the byproducts carbon dioxide, water and, for chlorinated compounds, a chloride ion.

Toolbox Technologies Defined:

Dynamic Underground Stripping (DUS): Subsurface heating by steam injection and/or electrical heating, to volatilize and mobilize contaminants for removal through vacuum extraction wells.

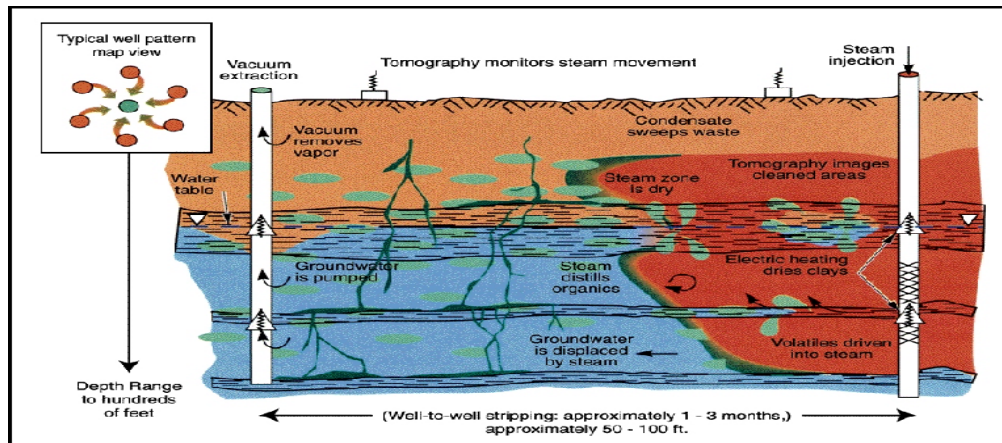
Hydrous Pyrolysis/Oxidation (HPO): *In situ* physical/chemical destruction process for organic contaminants involving oxidation. Contaminants are destroyed in the aquifer during pulsed steam injection. HPO processes will continue after steam injection is ceased.

Electrical Resistance Tomography (ERT): Provides nearly real-time tomographic imaging of thermal distribution within the subsurface during heating, allowing modification and fine-tuning of steam injection and vacuum extraction parameters for process control and performance review.

In contrast to many existing remediation technologies, DUS/HPO toolbox technologies work quickly and efficiently, with site closure in months to years as opposed to decades. In addition to free product removal, the technology can provide treatment of contaminated aquifers to drinking water standards. DUS/HPO technology is also less expensive than many traditional pump and treat processes, in part due to the dramatically reduced treatment time. Data from pilot and full scale projects indicate that full treatment costs range between \$35 and \$50 per cubic yard of contaminated volume.

WASTE APPLICABILITY:

DUS/HPO technology is effective at sites contaminated by chlorinated solvents (including TCE, PCE and CC14), fuels, and creosote. Former Energy Secretary Richardson stated that these technologies are applicable to one quarter of the nation's Superfund Sites.



The technologies are well-suited to application in a variety of geological environments, including heterogeneous aquifers which are typically problematic for pump-and-treat and related techniques. DUS/HPO works above and below the water table and has no practical depth constraint. DUS/HPO toolbox technologies may have special advantages in hydrogeological environments where existing technologies are known to be inapplicable or largely ineffectual.

At the project currently underway at Cape Canaveral Launch Complex 34, in addition to remediation of both sands and fine-grained silty clay layers, IWR's system will remove TCE trapped in sediments beneath a large building.

STATUS:

The technologies, developed at Lawrence Livermore National Laboratory and UC-Berkeley, were nationally licensed to IWR in 1998. Since that time, several large-scale DUS/HPO projects have been successfully realized, including one nearing completion for the U.S. DOE at the Savannah River Site in Aiken, South Carolina. Contaminants at this former solvent storage tank site were removed from as deep as 165' below ground surface, the deepest deployment of this technology to date. Over 55,000 pounds of PCE and 2,000 pounds of TCE were removed from the subsurface during eight months of active operation, more than twice the maximum estimated contaminant mass prior to DUS/HPO deployment.

This technology was accepted into the Superfund Innovative Technology Program (SITE) late 1999. The Interagency DNAPL Consortium, combining the interests of NASA, the Departments of Defense and Energy, and the US EPA, selected IWR to design a system for removal of TCE from a contaminated aquifer at Cape Canaveral Launch Complex 34. The design has since been approved and construction is currently underway. Commencement of active steaming began in July 2001.

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**LEWIS ENVIRONMENTAL SERVICES, INC.
HICKSON CORPORATION
(Chromated Copper Arsenate Soil Leaching Process)**

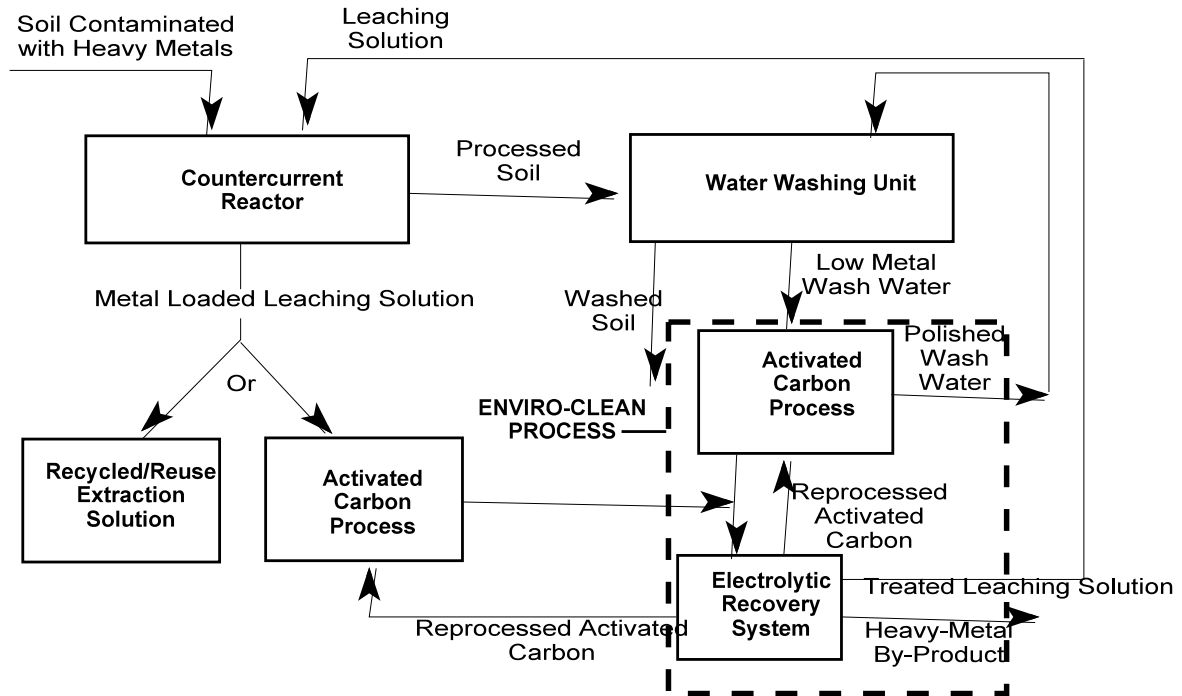
TECHNOLOGY DESCRIPTION:

Lewis Environmental Services, Inc. (Lewis), has developed a soil leaching process to remediate soils contaminated with inorganics and heavy metals including chromium, copper, cadmium, mercury, arsenic, and lead.

The soil leaching process consists of leaching contaminated soil in a countercurrent stirred reactor system (see figure below). A screw feeder delivers the soil into the reactor, where it is leached with sulfuric acid for 30 to 60 minutes. The sulfuric acid solubilizes the inorganics and heavy metals into the leaching solution. Any organic contaminants are separated and decanted from the leaching solution, using strong acid leachate, space separation, and skimming. The processed soil is then washed with water and air-dried.

The wash water is then treated with Lewis' ENVIRO-CLEAN PROCESS, which consists of a granulated activated carbon system followed by an electrolytic recovery system. The ENVIRO-CLEAN PROCESS recovers the heavy metals from the leaching solution and wash water and produces an effluent that meets EPA discharge limits for heavy metals. The treated wash water can then be reused in the soil washing step. The leaching solution can be returned directly to the stirred reactor system, depending on its metals concentration.

Contaminated soil must be properly sized and screened to facilitate leaching in the stirred reactor system. Large pieces of debris such as rocks, wood, and bricks must be removed before treatment. Standard screening and classification equipment, such as that used in municipal waste treatment plants, is suitable for this purpose.



Chromated Copper Arsenate Soil Leaching Process

The soil leaching process does not generate appreciable quantities of treatment by-products or waste streams containing heavy metals. The treated soil meets toxicity characteristic leaching procedure (TCLP) criteria and can be either returned to the site or disposed of at a nonhazardous landfill. The granular activated carbon requires disposal after about 20 to 30 treatment cycles and should also meet TCLP criteria. Heavy metals recovered by the ENVIRO-CLEAN process can be reused by industry.

WASTE APPLICABILITY:

The soil leaching process can treat wastes generated by the wood preserving and metal plating industries, battery waste sites, and urban lead sites.

STATUS:

The soil leaching process was accepted into the Emerging Technology Program in 1993. Laboratory-scale tests have shown that the process successfully treats soil contaminated with chromated copper arsenate (CCA). The evaluation of the technology under the SITE Program was completed in September 1996. Results from the evaluation will be available in 1997.

In 1992, Lewis treated a 5-gallon sample of CCA-contaminated soil from Hickson Corporation (Hickson), a major CCA chemical manufacturer. The treated soil met TCLP criteria, with chromium and arsenic, the two main leaching solution constituents, averaging 0.8 milligram per kilogram (mg/kg) and 0.9 mg/kg, respectively.

Analysis also revealed 3,330 milligrams per liter (mg/L) of chromium, 13,300 mg/L of copper, and 22,990 mg/L of iron in the leaching solution. In addition, analysis indicated 41.4 mg/L of chromium, 94.8 mg/L of copper, and 3.0 mg/L of arsenic present in the wash water. After treatment, the wash water contained metals levels below 0.01 mg/L for copper and chromium and 0.3 mg/L for arsenic.

Lewis plans further laboratory-scale testing at its Pittsburgh, Pennsylvania facility, followed by bench- or pilot-scale testing at Hickson's facility in Conley, Georgia.

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LOCKHEED MARTIN MISSILES AND SPACE CO. and GEOKINETICS INTERNATIONAL, INC. (Electrokinetic Remediation Process)

TECHNOLOGY DESCRIPTION:

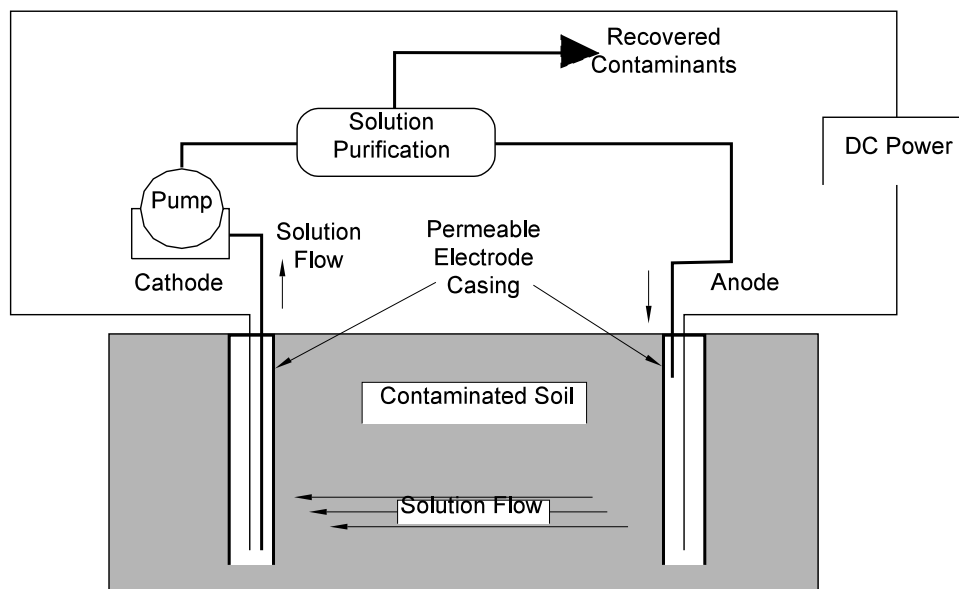
The Electrokinetic Remediation (ER) process removes metals and organic contaminants from soil, mud, sludge, and marine dredgings. ER uses electrochemical and electrokinetic processes to desorb and remove metals and polar organics. The technology may be applied in situ or in the batch mode.

The figure below is a flow diagram of the batch reactor. Waste material is placed into the batch reactor, between Ebonex® ceramic electrodes that are divided into a cathode array and an anode array. A direct current is then applied, causing ions and water to move toward the electrodes. Metal ions, ammonium ions, and positively charged organic compounds move toward the cathode. Anions such as chloride, cyanide, fluoride, nitrate, and negatively charged organic compounds move toward the anode. Two primary mechanisms transport contaminants through the soil: electromigration and electroosmosis. In electromigration, charged particles are transported through the substrate. In contrast, electroosmosis is the movement of a liquid containing ions relative to a stationary

charged surface. Of the two, electromigration is much faster and it is the principle mechanism for the ER process.

The electrodes are positioned inside permeable casings that are inserted into the waste material. After the annulus of each casing is filled with water, the current is turned on. The water passes from the anode casing into the waste and toward the cathode. This procedure (1) supports electrokinetic movement of the contaminants through the soil; (2) helps maintain soil moisture, thereby sustaining the electric field; and (3) enables various chemicals that enhance contaminant removal to be added as required.

As the water accumulates in the annulus of the cathode casing, it is pumped out for processing. Processing involves removal of contaminants by electrochemical means, producing a concentrated contaminant brine that can be either further processed or disposed of as hazardous waste. The water is then returned to the annulus of the anode casing.



Flow Diagram of the Electrokinetic Remediation Process

WASTE APPLICABILITY:

ER is designed to remove heavy metals, anions, and polar organics from soil, mud, sludge, and dredgings. Treatable concentrations range from a few parts per million (ppm) to tens of thousands ppm. The batch technology is most appropriate for sites with contaminated estuarine and river muds and dredgings, sewage processing sludges, and fines remaining after soil washing. The process can be used with virtually any substrate. ER's effectiveness is sharply reduced for wastes with a moisture content of less than 10 percent.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1994. A demonstration of the process will be conducted at the Alameda Naval Air Station in California.

The ER process has been used successfully at several European sites (see table below) on soils contaminated with metals.

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MATRIX PHOTOCATALYTIC INC. **(Photocatalytic Air Treatment)**

TECHNOLOGY DESCRIPTION:

Matrix Photocatalytic Inc. is developing a titanium dioxide (TiO₂) photocatalytic air treatment technology that destroys volatile organic compounds (VOC) and semivolatile organic compounds in air streams. During treatment, contaminated air at ambient temperatures flows through a fixed TiO₂ catalyst bed activated by ultraviolet (UV) light. Typically, organic contaminants are destroyed in fractions of a second.

Technology advantages include the following:

- Robust equipment
- No residual toxins
- No ignition source
- Unattended operation
- Low direct treatment cost

The technology has been tested on benzene, toluene, ethylbenzene, and xylene; trichloroethene; tetrachloroethane; isopropyl alcohol; acetone; chloroform; methanol; and methyl ethyl ketone. A field-scale system is shown in the photograph on the next page.

WASTE APPLICABILITY:

The TiO₂ photocatalytic air treatment technology can effectively treat dry or moist air. The technology has been demonstrated to purify contaminant steam directly, thus eliminating the need to condense. Systems of 100 cubic feet per minute have been successfully tested on vapor extraction operations, air stripper emissions, steam from desorption processes, and VOC emissions from manufacturing facilities. Other potential applications include odor removal, stack gas treatment, soil venting, and manufacturing ultra-

pure air for residential, automotive, instrument, and medical needs. Systems of up to about 1,000 cubic feet per minute can be cost- competitive with thermal destruction systems.

STATUS:

The TiO₂ photocatalytic air treatment technology was accepted into SITE Emerging Technology Program (ETP) in October 1992; the evaluation was completed in 1993. Based on results from the ETP, this technology was invited to participate in the SITE Demonstration Program. For further information about the evaluation under the ETP, refer to the journal article (EPA/600/A-93/282), which is available from EPA. A suitable demonstration site is being sought.

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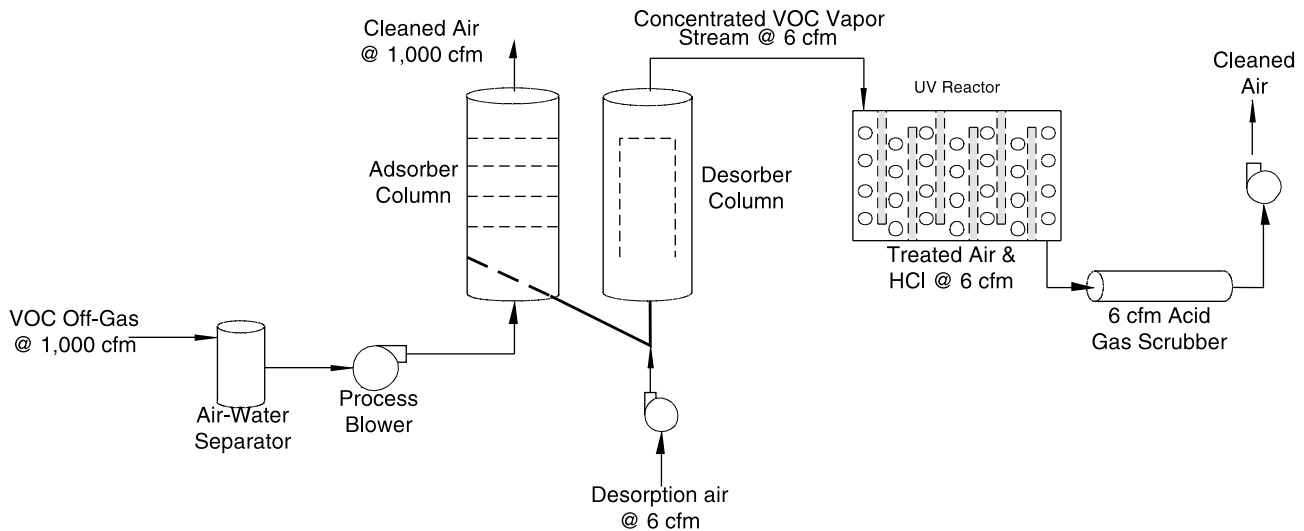
PROCESS TECHNOLOGIES INCORPORATED (Photolytic Destruction of Vapor-Phase Halogens)

The proprietary, nonthermal technology developed by Process Technologies Incorporated (PTI), is a method of photochemically oxidizing gaseous organic compounds within a reaction chamber. PTI's Photolytic Destruction Technology (PDT) uses low-pressure ultraviolet (UV) lamps, with UV emissions primarily at wavelengths in the 185 to 254 nanometer range, located within the reaction chamber. Photons emitted from these lamps break apart the chemical bonds making up the volatile organic compound (VOC) molecule. The process is capable of destroying mixtures of chlorinated and nonchlorinated VOCs.

The PDT system is designed and fabricated in 3- to 12-cubic-foot-per-minute (cfm) modules. The size of the module applied is dependent on the gas flow rate and VOC concentrations in the gas stream. PTI implements a fluid bed concentrator to allow for the treatment of high flow gas streams, or those with rates greater than 1,000 cfm. Significant cost savings can be realized if the gas flow can be reduced, and concentration increased prior to destruction.

PTI uses a proprietary reagent that forms a liner within the process chamber. The reagent reacts chemically with the gaseous degradation products formed during the photolytic destruction of halocarbon molecules to form solid, stable reaction products.

Reagent lifetime depends on flow rate, influent concentrations, and specific chemical composition of destruction targets. PTI has performed tests on spent reagent to determine whether the material would be classified as a hazardous waste under federal regulations. Those tests indicated that the spent reagent is likely nontoxic. The spent reagent is also not reactive, corrosive, or flammable, and thus PTI is confident that it is not a hazardous waste under federal law. PTI accordingly believes that the spent reagent material can be disposed of as ordinary solid waste or used as a feedstock for cement manufacturing. The PTI process is simple in design and easy to operate. The system is designed to run continuously, 24-hours per day.



Simplified Process Flow Diagram
of Photolytic Destruction

WASTE APPLICABILITY:

The technology was developed to destroy a number of groups of compounds, including chlorinated solvents, chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and halons. Example sources of process off-gas that contains chlorinated and nonchlorinated VOCs, CFCs, and HCFCs include steam vapor extraction, tank vents, air strippers, steam strippers, and building vent systems.

The process is capable of destroying as high as 50,000 parts per million by volume VOC streams. The system is capable of achieving greater than 90 percent on-line availability, inclusive of scheduled maintenance activities.

STATUS:

The PTI technology was accepted into the SITE Demonstration Program in summer 1994. The demonstration began in September 1994 at McClellan Air Force Base (AFB) in Sacramento, California. The SITE demonstration was postponed shortly thereafter. Activities under the SITE Program were rescheduled in 1997. Additional tests incorporating an improved design for treating soil vapor extraction off-gas were successfully completed at the AFB in January 1996.

PTI completed a four month demonstration of the combined fluid bed concentrator and PDT system at the U.S. Navy's North Island Site 9 in February, 1998. This demonstration was performed to evaluate the effectiveness and cost to remove and destroy VOC vapor from an existing SVE system. The results of the demonstration at the Navy's North Island Site 9 showed the PTI System was capable of achieving greater than 95 percent destruction and removal efficiency of VOCs in the soil vapor at a 250 standard cfm flow rate. Furthermore, the Navy determined that the PTI System provided a 45 percent cost savings over activated carbon or flameless thermal oxidation.

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RECYCLING SCIENCES INTERNATIONAL, INC. (Desorption and Vapor Extraction System)

TECHNOLOGY DESCRIPTION:

The mobile desorption and vapor extraction system (DAVES) uses a low-temperature fluidized bed to remove organic and volatile inorganic compounds from soils, sediments, and sludges. This system can treat materials with 85 percent solids at a rate of 10.5 tons per hour.

Contaminated materials are fed into a co-current, fluidized bed dryer, where they are mixed with hot air (about 1,000 to 1,400°F) from a gas-fired heater. Direct contact between the waste material and the hot air forces water and contaminants from the waste into the gas stream at a relatively low fluidized-bed temperature (about 320°F). The heated air, vaporized water and organics, and entrained particles flow out of the dryer to a gas treatment system.

The gas treatment system removes solid particles, vaporized water, and organic vapors from the air stream. A cyclone separator and baghouse remove most of the particulates. Vapors from the cyclone separator are cooled in a venturi scrubber, countercurrent washer, and chiller section before they are treated in a vapor-phase carbon adsorption system. The liquid residues from the system are centrifuged, filtered, and passed through two activated carbon beds arranged in series (see photograph below).

By-products from the DAVES include (1) treated, dry solids representing about 96 to 98 percent of the solid waste feed, (2) a small quantity of centrifuge sludge containing organics, (3) a small quantity of spent adsorbent carbon, (4) wastewater that may need further treatment, and (5) small quantities of baghouse and cyclone dust that are recycled through the process.



Desorption and Vapor Extraction System (DAVES)

The centrifuge sludge can be bioremediated, chemically degraded, or treated in another manner. Recycling Sciences International, Inc., has patented an electrochemical oxidation process (ECO) and is developing this process as an adjunct to the DAVES. The ECO is designed to detoxify contaminants within the DAVES in a closed-loop system.

This technology removes the following contaminants from soil, sludge, and sediment: volatile and semivolatile organics, including polychlorinated biphenyls (PCB), polynuclear aromatic hydrocarbons, pentachlorophenol, volatile inorganics such as tetraethyl lead, and some pesticides. In general, the process treats waste containing less than 10 percent total organic contaminants and 30 to 95 percent solids. The presence of nonvolatile inorganic contaminants (such as metals) in the waste feed does not inhibit the process; however, these contaminants are not treated.

STATUS:

This technology was accepted into the SITE Program in April 1995. EPA is selecting a demonstration site for this process. Preferred demonstration wastes include harbor or river sediments containing at least 50 percent solids contaminated with PCBs and other volatile or semivolatile organics. Soils with these characteristics may also be acceptable. About 300 tons of waste is needed for a 2-week test. Major test objectives are to evaluate feed handling, decontamination of solids, and treatment of gases generated by the process.

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**RKK, LTD.
(CRYOCELL®)**

TECHNOLOGY DESCRIPTION:

CRYOCELL® is a barrier system which provides real-time monitoring capability, earthquake resiliency, and diffusion-free full enclosure contaminant isolation. The system is repairable in situ and removable upon completion of containment needs.

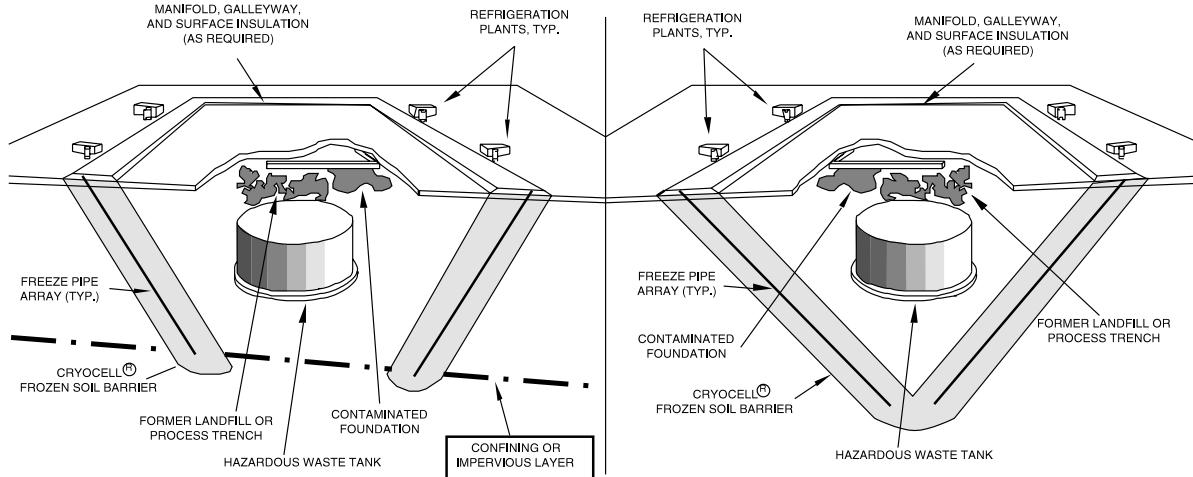
CRYOCELL® design involves installing an array of freeze pipes, using standard well-drilling equipment, which surround the contaminated source or groundwater plume much like the ribs of a canoe. Once installed, the array of freeze pipes is connected to freeze plants by a distributive manifold and supplied with cooled brine at a design temperature of -10°C to -40°C to freeze the volume of soil between the pipes, resulting in a 12- to 16-foot barrier.

The barrier's thickness and temperature may be varied through design to match containment requirements. If no subsurface confining impervious layer is present, the array can be installed using an angled or "V"-shaped configuration beneath the contaminated zone, completely enclosing the site. If additional barrier

thickness is a design requirement, a parallel array of freeze pipes is installed in staggered spacing outside the first array. This configuration allows the entire inner volume of soil between the two arrays to be frozen, thereby increasing barrier thickness per design up to 75 feet. The depth of the containment envelop can be in excess of 500 feet.

CRYOCELL® engineering is site-specific and considers many cost-related factors, including waste type, topography, soil conditions, thermal conductivity, and groundwater movement. A computer program incorporates all site characteristics into a three-dimensional model that engineers use to establish the most efficient design and estimate the cost of CRYOCELL® for a specific site.

A thick frozen soil barrier offers a number of advantages for confining hazardous waste. The barrier does not degrade or weaken over time and is repairable in situ. If ground movement fractures the barrier, the fissures can be filled and resealed quickly. Maintenance costs are extremely low, allowing continued use for extended periods. In addition, the frozen barrier is environmentally benign. When the site is decontaminated, the frozen



Schematic Diagram of CRYOCELL®

soil is allowed to melt and the pipes are removed. The technique is an alternative to conventional containment systems using steel, concrete, slurry walls, or grout curtains. The figure on the previous page illustrates two typical containment systems.

WASTE APPLICABILITY:

RKK, Ltd. (RKK), reports that CRYOCELL® can provide subsurface containment for a variety of sites and waste, including underground tanks; nuclear waste sites; plume control; burial trenches, pits, and ponds; in situ waste treatment areas; chemically-contaminated sites; and spent fuel storage ponds. CRYOCELL® is designed to contain all known biological, chemical, or radioactive contaminants. frozen soil barriers are adaptable to any geometry; drilling technology presents the only constraint.

RKK reports that the technology can isolate sensitive areas within large active operations (for example, sites within chemical and nuclear facilities), smaller raw material and waste management units (for example, tank farms, burial trenches, and waste treatment lagoons), and operational chemically contaminated sites, such as chemical plants, refineries, and substations. The technology can also contain a site or contamination during an in situ remediation project. It can also provide a redundant barrier for cut-off contamination processes, and reduces flow of groundwater into a contaminated zone.

Contaminants are contained in situ, with frozen native soils serving as the containment medium. Frozen soil barriers are impervious to chemical attack and are virtually impermeable at subzero temperatures. In addition, frozen soil barriers have great inertia, so they can remain frozen for as long as two years without refrigeration.

CRYOCELL® is economically favorable for intermediate- and long-term containment at large sites, and maintenance costs are extremely low. CRYOCELL® generates no waste streams or residues.

STATUS:

This technology was accepted into the SITE Demonstration Program in summer 1994. A treatability study was completed at the Department of Energy's (DOE) Oak Ridge National Laboratory in 1995. Results from the study are documented in a DOE Innovative Technology Summary Report, titled *Frozen Soil Barrier Technology*, and, *Subsurface Contaminants Focus Area Technology Summary*, (DOE/EM-0296), August 1996.

The RKK technology is being considered by DOE for use at other hazardous waste sites. RKK receives academic, technical, and scientific support through a cooperative and licensing agreement with the University of Washington.

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SELENTEC ENVIRONMENTAL TECHNOLOGIES, INC.
(Selentec MAG*SEPSM Technology)

TECHNOLOGY DESCRIPTION:

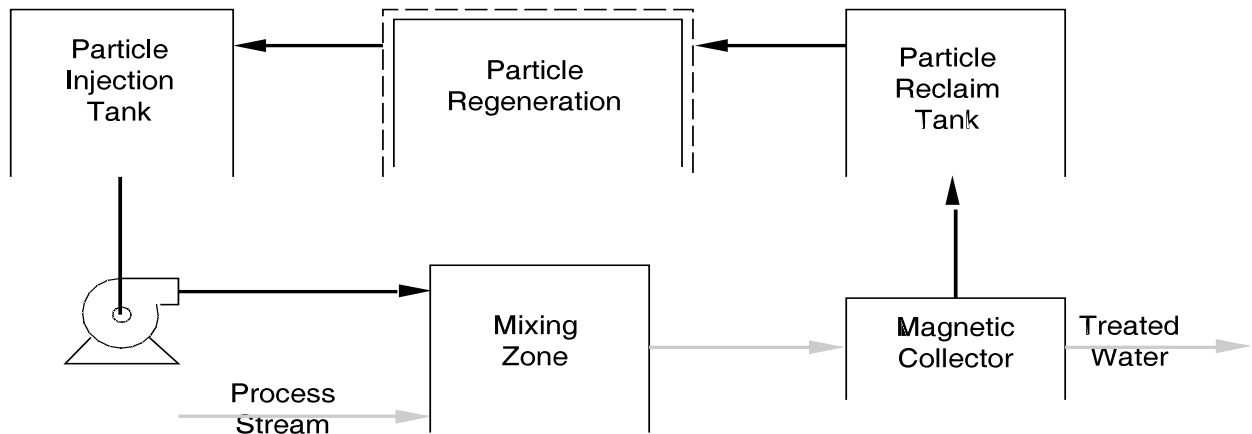
The MAG*SEPSM process uses the principles of chemical adsorption and magnetism to selectively bind and remove heavy metals or radionuclides from aqueous solutions such as groundwater, wastewater, and drinking water. Contaminants are adsorbed on specially formulated particles which have a core made from magnetic material; these particles are then separated (along with the adsorbed contaminants) from the solution using a magnetic filter or magnetic collector. The magnetic core has no interaction with the contaminant.

The proprietary adsorbing particles are made of a composite of organic polymers and magnetite. The particles can be manufactured in two forms: one with an ion exchanger and/or chelating functional group attached to the particle surface (amidoxime functionalized resin), or one with inorganic adsorbers bound to the surface of the particles (clinoptilolite). These particles have high surface areas and rapid adsorption kinetics.

A typical MAG*SEPSM treatment system consists of:

- a particle contact zone
- a particle handling system, including particle injection components, a magnetic separator, and particle reclaim components
- a particle regeneration system (where applicable)

The process stream enters a contact zone (usually a tank - other configurations are used for particular applications) where MAG*SEPSM particles are injected and mixed. The contact zone provides the necessary solution flow characteristics and contact time with the particles to ensure that the contamination will be adsorbed onto the active surface sites of the particles. The mixture then flows through a magnetic collector, where the contaminated particles are retained while the treated process stream passes through (see figure below).



Schematic Diagram of the Mag*SEPSM Treatment System

Depending on the application, type of particle, and contaminant concentration, the particles may be re-injected into the flow stream, collected and disposed of, or regenerated and reused. The regeneration solution is processed to recover (concentrate and remove) the contaminants and may be recycled.

The MAG*SEPSM process is able to selectively remove (either ex situ or in situ) the following contaminants from aqueous solutions: titanium, copper, cadmium, arsenic, cobalt, molybdenum, platinum, selenium, chromium, zinc, gold, iodine, manganese, technetium, mercury, strontium, iron, ruthenium, thallium, cesium, cobalt, palladium, lead, radium, nickel, silver, bismuth, thallium, antimony, zirconium, radium, cerium, and all actinides. The process operates at flow rates up to 2,000 gallons per minute (gpm).

WASTE APPLICABILITY:

The MAG*SEPSM technology reduces heavy metal and radionuclide contamination in water and wastewater. The technology has specific applications in environmental remediation and restoration, treatment of acid mine drainage, resource recovery, and treatment of commercial industrial wastewater. MAG*SEPSM particles can be produced to incorporate any known ion exchanger or sorbing material. Therefore, MAG*SEPSM can be applied in any situation where conventional ion exchange is used.

STATUS:

The MAG*SEPSM technology was accepted into the SITE Program in 1996 and is also one of 10 technologies participating in the White House's Rapid Commercialization Initiative. In addition, in 1997 the MAG*SEPSM technology received a Research and Development (R&D) 100 Award from the R&D trade publication as one of the 100 Most Technologically Significant New Products of 1997.

Selentec has completed a demonstration of the MAG*SEPSM technology at the U.S. Department of Energy's Savannah River Site. Heavy metal concentrations in coal pile runoff water were significantly reduced to below drinking water standards. Another demonstration of the technology is planned for Savannah River whereby radioactive cesium will be removed streams. The technology is also being used to remove mercury from heavy water drums at Savannah River.

The first commercial unit of the MAG*SEPSM technology was put into service on November 18, 1998, at a dairy in Ovruch, Ukraine. For this application, the unit is removing radioactive cesium from contaminated milk produced near the Chernobyl Nuclear Reactor Plant.

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SIVE SERVICES (Steam Injection and Vacuum Extraction)

TECHNOLOGY DESCRIPTION:

Steam Injection and Vacuum Extraction (SIVE) uses steam injection wells in conjunction with dual-phase extraction wells for in situ treatment of contaminated soil and groundwater. The injected steam strips volatile and semivolatile organic compounds as it permeates the contaminated zones. The steam increases the subsurface temperature, which increases mass transfer and phase exchange rates, reduces liquid viscosities, and accelerates desorption of contaminants from the matrix. The moisture and warmth provided by the steam also accelerates biodegradation of residual contaminants. As a result, contaminants are extracted or degraded at increased rates as compared to conventional isothermal vapor and liquid extraction systems.

SIVE-LF (Linear Flow) is an enhanced SIVE method designed for relatively shallow depths. With the SIVE-LF process, as illustrated in the figure below, steam is forced to flow horizontally and uniformly from one trench, through the contaminant zone, and into another trench, from which the contaminants are extracted. The large open area of the trench faces allow for high injection and extraction rates, which promote low treatment duration. The trenches also allow for installation of an impermeable barrier, such as a polyethylene liner, against one face of the open trench before the trench is backfilled, thus reducing the flow of injected or extracted fluid outside the area of the targeted zones. A surface covering for the treatment area prevents short-circuiting of the flow of injected steam to the atmosphere, and prevents atmospheric air from entering the extraction trench.

Surface equipment for SIVE includes conventional steam generation and delivery systems, and the vacuum extraction system. The vacuum extraction system includes a vacuum blower, steam condenser, other cooling components, and air emission control devices. The condensate generated by the process requires further treatment or off-site disposal. The reliability of the equipment and automatic controls allows SIVE to operate without constant direct supervision.

WASTE APPLICABILITY:

SIVE may be applied to soil or groundwater contaminated with fuels, industrial solvents, oils, and other liquid toxics, and may be applied at any depth. The SIVE-LF process is designed to treat to depths of 30 feet. Because highly volatile contaminants are readily air-stripped without the added effects of steam, the steam-stripping effect will be greatest on the heavier, less volatile contaminants. SIVE also effectively removes floating non aqueous-phase liquids from groundwater.

STATUS:

This technology was accepted into the SITE Demonstration Program in summer 1994. A suitable site for the demonstration is being sought, although at this time the project is considered inactive.

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VORTEC CORPORATION (Vitrification Process)

TECHNOLOGY DESCRIPTION:

Vortec Corporation (Vortec) has developed an oxidation and vitrification process for remediating soils, sediments, sludges, and mill tailings contaminated with organics, inorganics, and heavy metals. The process can vitrify materials introduced as dry granulated materials or slurries.

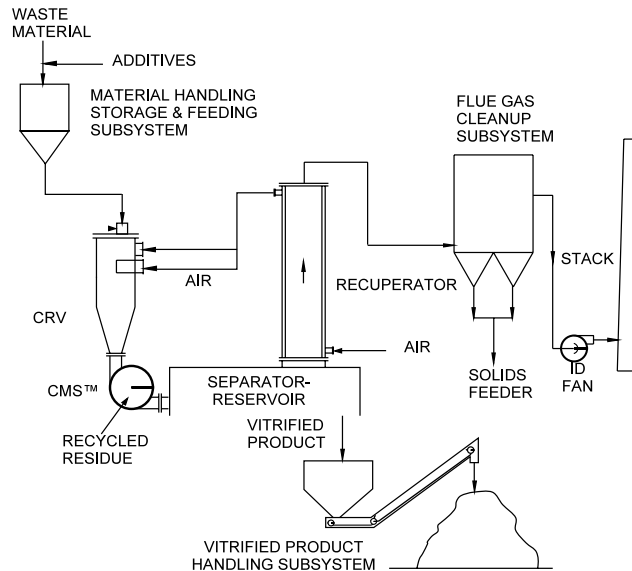
The figure below illustrates the Vortec vitrification process. Its basic elements include (1) a cyclone melting system (CMS™); (2) a material handling, storage, and feeding subsystem; (4) an air preheater (recuperator); (5) an air pollution control subsystem; and (6) a vitrified product handling subsystem.

The Vortec CMS™ is the primary system and consists of two major assemblies: a counterrotating vortex (CRV) reactor and a cyclone melter. First, slurried or dry-contaminated soil is introduced into the CRV. The CRV (1) provides a high temperature environment; (2) preheats the suspended waste material along with any glass-forming additives

mixed with soil; and (3) destroys any organic constituents in the soil. The average temperature of materials leaving the CRV reactor chamber is between 2,200 and 2,800°F, depending on the melting characteristics of the processed soils.

The preheated solid materials exit the CRV and enter the cyclone melter, where they are dispersed to the chamber walls to form a molten glass product. The vitrified, molten glass product and the exhaust gases exit the cyclone melter through the tangential exit channel and enter a glass- and gas-separation chamber.

The exhaust gases then enter an air preheater to heat the incoming air and are subsequently delivered to the air pollution control subsystem for particulate and acid gas removal. The molten glass product exits the glass- and gas-separation chamber through the tap and is delivered to a water quench assembly for subsequent disposal.



Vortec Vitrification Process

Unique features of the Vortec vitrification process include the following:

- Processes solid waste contaminated with both organic and heavy metal contaminants
- Handles waste quantities ranging from 5 or more than 400 tons per day
- Recycles particulate residue collected in the air pollution control subsystem into the CMS™. These recycled materials are incorporated into the glass product.
- Produces a vitrified product that is nontoxic according the EPA toxicity characteristic leaching procedure (TCLP) standards. The product has long-term stability.

WASTE APPLICABILITY:

The Vortec vitrification process treats soils, sediments, sludges, and mill tailings contained organic, inorganic, and heavy metal contamination. Organic materials included with the waste are successfully destroyed by the high temperatures in the CRV. The inorganic constituents in the waste material determine the amount and type of glass-forming additives required to produce a vitrified product. This process can be modified to produce a glass cullet that consistently meets TCLP requirements.

STATUS:

The Vortec vitrification process was accepted into the SITE Emerging Technology Program in May 1991. Research under the Emerging Technology Program was completed in winter 1994, and Vortec was invited to participate in the SITE Demonstration Program.

Construction of a 1.5-ton-per-hour, transportable system for treating contaminated soil at a Department of Energy site in Paducah, Kentucky, was initiated in October 1996. A SITE demonstration was scheduled to occur in early 1999. A 50-ton-per-day system has been purchased by Ormet Aluminum Corporation of Wheeling, West Virginia for recycling aluminum spend pot liners, which are considered cyanide- and fluoride-containing waste (K088). The recycling system became operational in 1996. Vortec is offering commercial systems and licenses for the CMS™ system.

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WESTERN RESEARCH INSTITUTE (Contained Recovery of Oily Wastes)

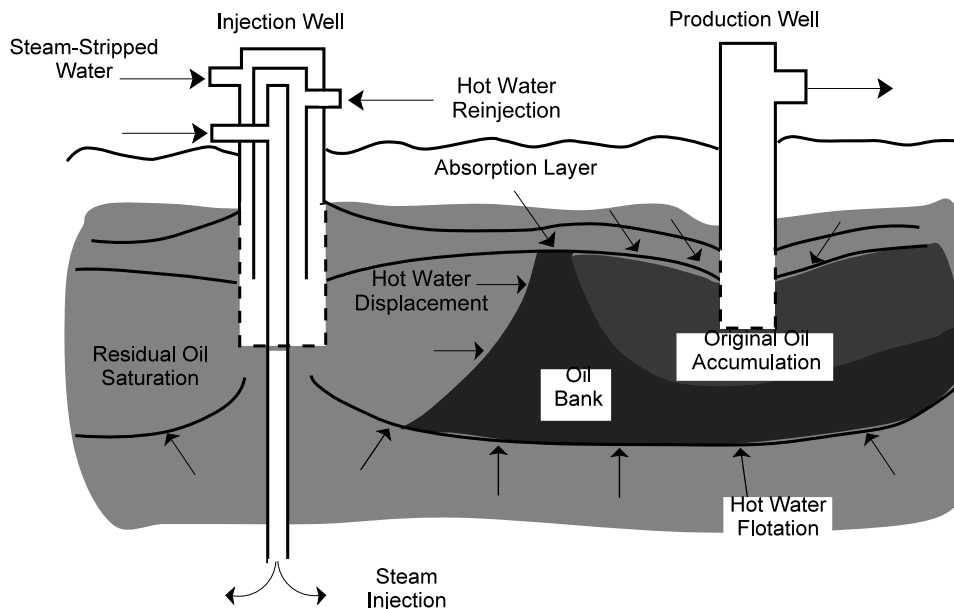
TECHNOLOGY DESCRIPTION:

The contained recovery of oily wastes (CROW®) process recovers oily wastes from the ground by adapting a technology used for secondary petroleum recovery and primary production of heavy oil and tar sand bitumen. Steam or hot water displacement moves accumulated oily wastes and water to production wells for aboveground treatment.

Injection and production wells are first installed in soil contaminated with oily wastes (see figure below). If contamination has penetrated into or below the aquifer, low-quality steam can be injected below the organic liquids to dislodge and sweep them upward into the more permeable aquifer soil regions. Hot water is injected above the impermeable regions to heat and mobilize the oily waste accumulation. The mobilized wastes are then recovered by hot water displacement.

When the organic wastes are displaced, organic liquid saturation in the subsurface pore space increases, forming a free-fluid bank. The hot water injection displaces the free-fluid bank to the production well. Behind the free-fluid bank, the contaminant saturation is reduced to an immobile residual saturation in the subsurface pore space. The extracted contaminant and water are treated for reuse or discharge.

During treatment, all mobilized organic liquids and water-soluble contaminants are contained within the original boundaries of waste accumulation. Hazardous materials are contained laterally by groundwater isolation and vertically by organic liquid flotation. Excess water is treated in compliance with discharge regulations.



CROW® Subsurface Development

The CROW[®] process removes large portions of contaminant accumulations; stops the downward and lateral migration of organic contaminants; immobilizes any remaining organic wastes as a residual saturation; and reduces the volume, mobility, and toxicity of the contaminants. The process can be used for shallow and deep areas, and can recover light and dense nonaqueous phase liquids. The system uses readily available mobile equipment. Contaminant removal can be increased by adding small quantities of selected biodegradable chemicals in the hot water injection.

In situ biological treatment may follow the displacement, which continues until groundwater contaminants are no longer detected in water samples from the site.

WASTE APPLICABILITY:

The CROW[®] process can be applied to manufactured gas plant sites, wood-treating sites, petroleum-refining facilities, and other areas with soils and aquifers containing light to dense organic liquids such as coal tars, pentachlorophenol (PCP) solutions, chlorinated solvents, creosote, and petroleum by-products. Depth to the contamination is not a limiting factor.

STATUS:

The CROW[®] process was tested in the laboratory and at the pilot-scale level under the SITE Emerging Technology Program (ETP). The process demonstrated the effectiveness of hot water displacement and the benefits of including chemicals with the hot water. Based on results from the ETP, the CROW[®] process was invited to participate in the SITE Demonstration Program. The process was demonstrated at the Pennsylvania Power and Light (PP&L) Brodhead Creek Superfund site at Stroudsburg, Pennsylvania. The site contained an area with high concentrations of by-products from past operations. The demonstration began in July 1995; field work was completed in June 1996. Closure of the site was completed in late 1998.

The CROW[®] process was applied to a tar holder at a former MGP site in Columbia, Pennsylvania. The work was complete in 1998 and documentation for site closure has been submitted to the EPA.

A pilot-scale demonstration was completed at an active wood treatment site in Minnesota. Over 80 percent of nonaqueous-phase liquids were removed in the pilot test, as predicted by treatability studies, and PCP concentrations decreased 500%. The full-scale, multiphase remediation is presently underway. Results indicate that organic removal is greater than twice that of pump-and-treat. The project is operating within the constraints of an active facility. Treatability studies, pilot testing, and full-scale projects are planned.

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**WHEELABRATOR TECHNOLOGIES INC.
(WES-PHix® Stabilization Process)**

TECHNOLOGY DESCRIPTION:

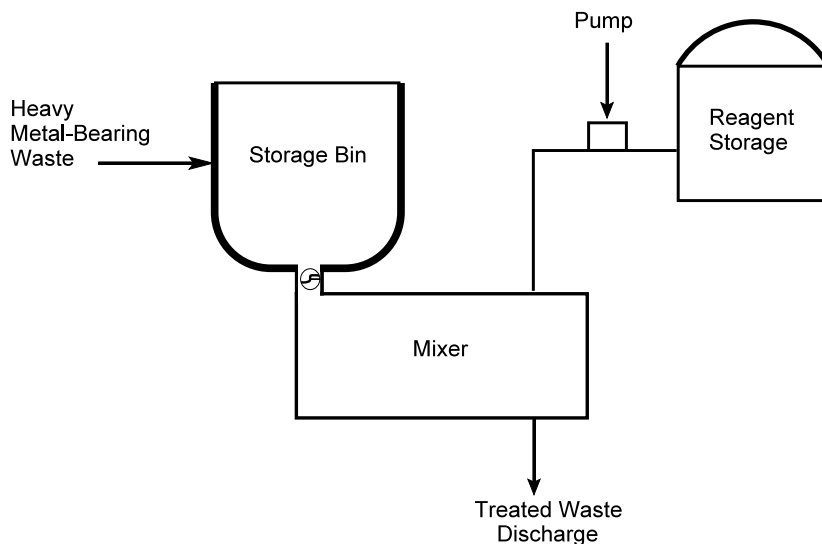
WES-PHix® is a patented stabilization process that significantly reduces the solubility of certain heavy metals in solid waste streams by altering the chemical composition of the waste material. The process does not produce a solidified mass, unlike most other stabilization technologies.

The figure below illustrates the process. First, waste is fed at a controlled rate into a mixing device, such as a pug mill. The full-scale WES-PHix® process uses a pug mill with a capacity of 40 to 200 tons per hour. The stabilization reagent is then added to and mixed with the waste for about 1 minute. Once stabilized, the waste is removed by a conveyor from the end of the mixer. For some wastes containing cadmium, small amounts of lime must also be added. The WES-PHix® Process uses a proprietary form of soluble phosphate to form insoluble and highly stable metal phosphate minerals. Reaction kinetics are rapid; thus, no curing step is necessary. As a result, metal concentrations in the treated waste are less than toxicity characteristic leaching procedure (TCLP) regulatory limits. In addition, the use of small quantities of liquid phosphate reagent creates only a minimal increase in the weight of the stabilized waste.

Equipment requirements include a metering device for feeding the waste stream to the mixer, and a storage tank for the liquid reagent. Over-sized items such as boulders or wood debris require crushing or removal by screens before treatment. No posttreatment is necessary with this process. Treated residuals can be transported for final disposal with dump trucks or roll-off container vehicles.

WASTE APPLICABILITY:

This process was originally developed to treat municipal waste combustion ash containing heavy metals. The commercial-scale process has treated over 7 million tons of ash. However, laboratory treatability data indicate that the technology can also treat contaminated soils, slags, sludges, foundry sands, and baghouse dusts. Recent research indicates that the process is particularly effective at stabilizing lead, cadmium, copper, and zinc in a variety of media, as measured by TCLP and other laboratory leaching tests.



WES-PHix® Stabilization Process

STATUS:

The WES-PHix[®] process was accepted into the SITE Demonstration Program in spring 1993. The demonstration, which was scheduled to occur at the Jack's Creek site in Maitland, Pennsylvania, has been postponed.

FOR FURTHER INFORMATION:

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