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EPA

Bioremediation Field Initiative

BIOREMEDIATION
Field Initiative

CURRENT PARTICIPANTS

A cooperative effort of the U.S. EPA's Office of Research and Development, Office of Solid Waste and Emergency Response, and regional offices, and other federal agencies, state agencies, industry, and universities to expand the nation's field experience in bioremediation technologies for Superfund and other contaminated sites.

Background

Many of today's more promising technologies for solving hazardous waste problems involve bioremediation, an engineered process that relies on microorganisms, such as bacteria or fungi, to transform hazardous chemicals into less toxic or nontoxic chemicals. Until recently, however, the use of bioremediation has been limited by a lack of information on the controlled application of biodegradative processes to environmental cleanups.

In 1990, the U.S. Environmental Protection Agency (EPA) established the Bioremediation Field Initiative as part of its overall strategy to increase the use of bioremediation to treat hazardous wastes at Comprehensive Emergency Response, Compensation, and Liability Act (CERCLA or Superfund) and other contaminated sites. Recognizing the need to gather data on the many different waste types and site conditions suitable for bioremediation, EPA's Superfund program made a major investment in the Initiative. The Initiative is a cooperative effort among EPA's Office of Research and Development (ORD), Office of Solid Waste and Emergency Response (OSWER), and regional offices, and other federal agencies, state agencies, industry, and universities. It is joined with other public and private efforts in bioremediation through EPA's Bioremediation Action Committee (BAC), an affiliation of government, industry, and academic representatives working jointly to expand the use of bioremediation.

A driving force for the Bioremediation Field Initiative is the commitment by the Superfund program to seek the development of more cost-effective solutions, such as bioremediation, to provide more permanent treatment of contaminated sites. Some 45 Superfund projects have already selected bioremediation. These sites demonstrate an ongoing commitment to deploy state-of-the-art technology solutions.

Goals

The Initiative was launched with three primary goals:

- To more fully assess and document the performance of full-scale bioremediation field applications.
- To create a data base of current field data on progress in determining the treatability of contaminants.

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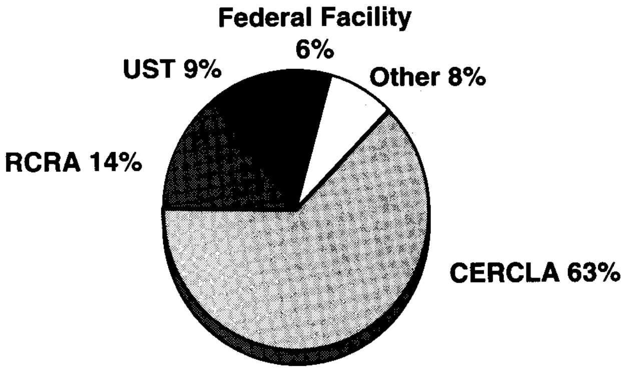

Figure 1. Breakdown of bioremediation sites by legislative authority.

- To provide technical assistance to regional and state site managers using or considering bioremediation. Assistance is provided in various stages of cleanup activities, from site characterization to full-scale implementation.

Activities

Although most of the sites in the Initiative are Superfund sites, bioremediation also is being used to clean up contamination at federal facilities, Resource Conservation and Recovery Act (RCRA) sites, and Underground Storage Tank (UST) sites. The Initiative is providing support to states and regions for intensive evaluation of bioremediation at nine selected hazardous waste sites. These performance evaluations are intended to generate data needed to define the capabilities of bioremediation technology. These data will enable state and EPA project managers, consulting engineers, and industry to make better informed decisions about applying bioremediation in the field. For field performance evaluations, sites are nominated and selected through the regional offices or through the states with concurrence from the regional offices.

In addition to conducting performance evaluations, the Initiative has identified a rapidly growing number of other sites across the country that are considering, planning, or currently operating bioremediation technologies, or that have completed bioremediation activities. The Initiative currently is monitoring progress at over 150 of these sites and creating an electronic data base of site information. For each site, the data base contains information on contaminants, media, type of treatment, status of cleanup, capital costs, and operation and maintenance costs.

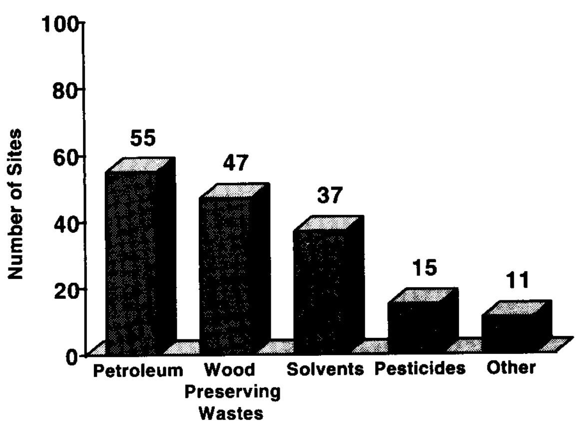

Figure 2. Breakdown of sites by type of contamination.

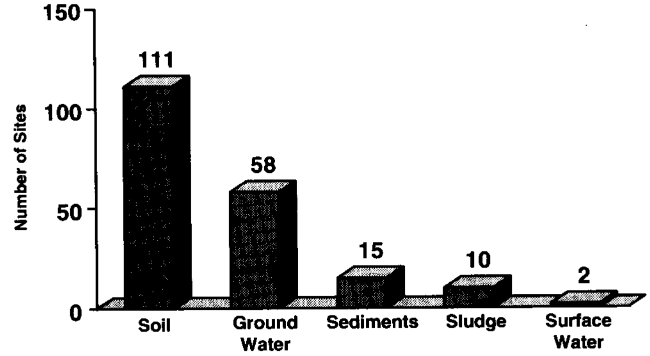

Figure 3. Number of sites treating each media type.

Sites in the data base include federal facilities, Superfund sites, RCRA sites, and UST sites. Over 60 percent of the sites fall under CERCLA authority, but the Initiative has begun to recognize an increasing number of sites under UST and RCRA authority (Figure 1). Monitored sites are distributed throughout all 10 EPA regions, with over 40 percent located in Regions 5 and 9. Analysis of the data base reveals that petroleum is the contaminant most frequently bioremediated, with wood preserving wastes a close second (Figure 2). Soil and ground water are the media most frequently treated with bioremediation technologies (Figure 3). Sites in the data base are undergoing a range of in situ and ex situ treatments, including land treatment, bioventing, bioreactor treatment, nutrient addition, and many other techniques.

The Initiative publishes a quarterly bulletin, entitled *Bioremediation in the Field,* which is distributed to over 5,000 individuals involved in the application of bioremediation. The bulletin contains a matrix of information on the status of sites identified by the Initiative, as well as updates on performance evaluations, new technologies, resources, and regulations. Past articles have discussed an extensive program to remediate Air Force sites using bioventing, permitting issues related to the disposal of polychlorinated biphenyls (PCBs), the impact of new land disposal restrictions on bioremediation, and the use of encapsulated microorganisms for bioprevention and bioremediation.

BIOREMEDIATION FIELD INITIATIVE CONTACTS

[redacted]

Bioremediation Field Initiative Site Profiles

- **Libby Ground Water Superfund Site**
  Libby, Montana
- **Eielson Air Force Base Superfund Site**
  Fairbanks, Alaska
- **Hill Air Force Base Superfund Site**
  Salt Lake City, Utah
- **Public Service Company of Colorado**
  Denver, Colorado
- **Park City Pipeline**
  Park City, Kansas
- **Bendix Corporation/Allied Automotive Superfund Site**
  St. Joseph, Michigan
- **Escambia Wood Preserving Site—Brookhaven**
  Brookhaven, Mississippi
- **Reilly Tar and Chemical Corporation Superfund Site**
  St. Louis Park, Minnesota
- **West KL Avenue Landfill Superfund Site**
  Kalamazoo, Michigan

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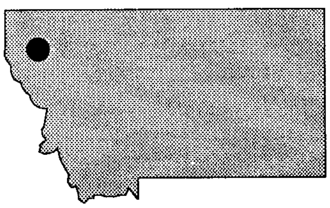
Bioremediation Field Initiative Site Profile: Libby Ground Water Superfund Site

SITE FACTS



Location: Libby, Montana

Laboratories/Agencies: U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), Utah State University (USU), U.S. EPA Region 8

Media and Contaminants: Pentachlorophenol (PCP) and polycyclic aromatic hydrocarbons (PAHs) in soil and ground water

Treatment: Surface soil bioremediation, aboveground fixed-film bioreactor, in situ bioremediation

Date of Initiative Selection: Fall 1990

Objective: To evaluate the performance of three biotreatment processes for degradation of PCP and PAHs

Bioremediation Field Initiative Contact: Scott Huling, U.S. EPA RSKERL, P.O. Box 1198, Ada, OK 74820

Regional Contact: Jim Harris, U.S. EPA Region 8, Montana Office, 301 South Park, Federal Building, Drawer 10096, Helena, MT 59626

Background

The Libby Ground Water Superfund site in Libby, Montana, is located in part at the site of an operating lumber mill currently owned by Champion International Corporation. A wood preserving facility formerly operated at the site contaminated soil and ground water with two wood preservatives: pentachlorophenol (PCP) and creosote (PAHs). PAHs are the primary contaminants of concern associated with the soil phase. PAH-contaminated soils from three primary source areas have been excavated and moved to a central waste pit.

The U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), in cooperation with Utah State University (USU), is carrying out a performance evaluation of three biological treatment processes at the Libby site: (1) surface soil bioremediation in a lined, prepared-bed land treatment unit (LTU); (2) ground water treatment

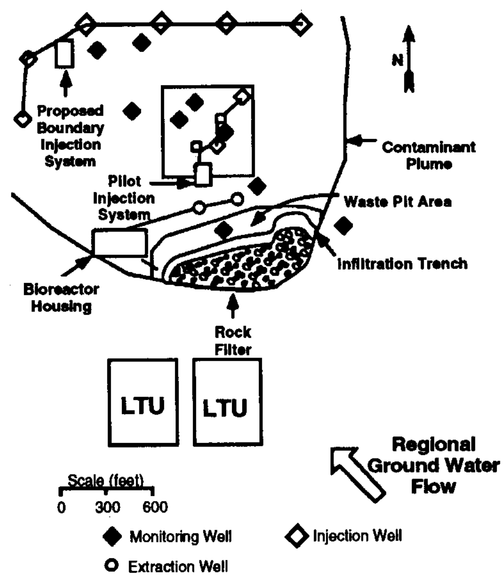


Figure 1. Plan view showing LTU, bioreactor, and ground water injection system (from Piotrowski, M.R. 1991. Full-scale in situ bioremediation at a Superfund site: a progress report. Second Annual West Coast Conference, Hydrocarbon Contaminated Soils and Ground Water. Newport Beach, CA. March 1991).

in an aboveground fixed-film bioreactor; and (3) in situ bioremediation of the upper aquifer. Each process is being evaluated with regard to design, operation, monitoring, and performance. Figure 1 is a plan view of the site, showing the LTU, bioreactor, and ground water injection systems.

Field Evaluation

Surface Soil Bioremediation. The LTU consists of two adjacent 1-acre cells, lined with low-permeability materials to minimize leachate infiltration from the unit (see Figure 2). Contaminated soil is applied to the cells in 9-in. lifts and treated until target contaminant levels are achieved within each lift. Evaluation of the effectiveness of the land treatment includes sampling the soil in the LTU, studying field-scale treatment and toxicity reduction, analyzing the influence of moisture and soil structure, and calculating the mass balance of contaminants in terms of soil and leachate.

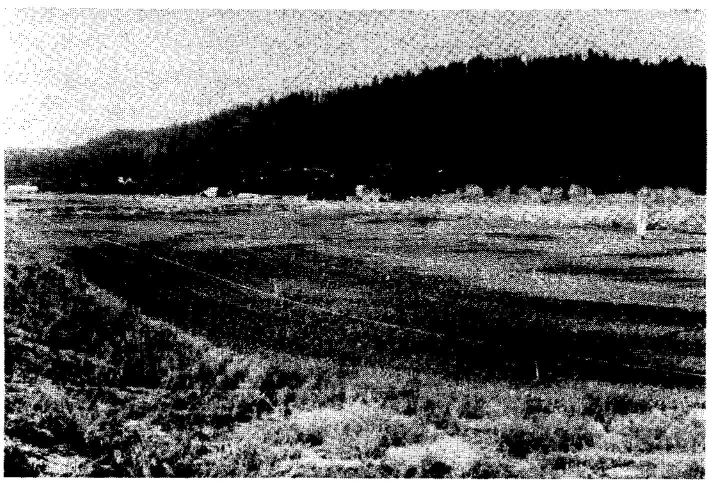


Figure 2. Land treatment unit.

LTU soil analysis data will be used to determine the statistical significance, confidence, and extent of biodegradation at this site. Degradation kinetics and toxicity reduction studies will generate data that can be used to help assess overall bioremediation effectiveness and predict performance of similar bioremediation processes at other sites.

Aboveground Fixed-Film Bioreactor. Aboveground treatment of ground water occurs in two fixed-film reactors, which operate in series. The effluent from these reactors is amended with nutrients and reoxygenated prior to reinjection through an infiltration trench. The Initiative will be monitoring the performance of the bioreactors, including flow composited sampling, analysis of biofilm dynamics, calculation of mass balance of contaminants, and treatment optimization.

In Situ Bioremediation of the Aquifer. The in situ bioremediation system involves addition of hydrogen peroxide and inorganic nutrients to stimulate growth of contaminant-specific microbes. Evaluation of this process will include determining dissolved oxygen profiles across the site, sampling aquifer material to identify contamination and correlate microbial content, distinguishing between abiotic and biotic effects, and correlating dissolved oxygen uptake with biodegradation and toxicity reduction.

Status

Currently, remediation of each lift of soil applied to the LTU takes 32 to 163 days. Based on these results, it is predicted that remediation of the 45,000 yd^3 of contaminated soil will take 8 to 10 years. Preliminary performance data on the fixed-film bioreactors indicate that PAH and PCP removal is taking place. Aquifer core samples have a chemically reduced condition, indicating that the site has an abiotic as well as a biological oxygen demand. Investigators plan several tests to differentiate between the abiotic and biotic oxygen demands.

The Bioremediation Field Initiative was established in 1990 to expand the nation's field experience in bioremediation technologies. The Initiative's objectives are to more fully document the performance of full-scale applications of bioremediation; provide technical assistance to regional and state site managers; and provide information on treatability studies, design, and operation of bioremediation projects. The Initiative currently is performing field evaluations of bioremediation at eight other hazardous waste sites: Park City Pipeline, Park City, KS; Bendix Corporation/Allied Automotive Superfund site, St. Joseph, MI; West KL Avenue Landfill Superfund site, Kalamazoo, MI; Eielson Air Force Base Superfund site, Fairbanks, AK; Hill Air Force Base Superfund site, Salt Lake City, UT; Escambia Wood Preserving Site—Brookhaven, Brookhaven, MS; Reilly Tar and Chemical Corporation Superfund site, St. Louis Park, MN; and Public Service Company, Denver, CO. To obtain profiles on these additional sites or to be added to the Initiative's mailing list, call 513-569-7562. For further information on the Bioremediation Field Initiative, contact Fran Kremer, Coordinator, Bioremediation Field Initiative, U.S. EPA, Office of Research and Development, 26 West Martin Luther King Drive, Cincinnati, OH 45268; or Nancy Dean, U.S. EPA, Technology Innovation Office, Office of Solid Waste and Emergency Response, 401 M Street, SW., Washington, DC 20460.

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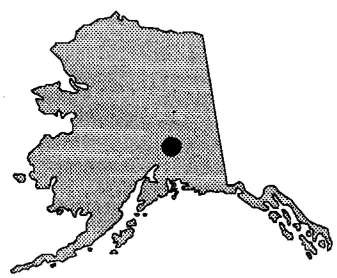
Bioremediation Field Initiative Site Profile: Eielson Air Force Base Superfund Site

SITE FACTS



Location: Fairbanks, Alaska

Laboratories/Agencies: U.S. Air Force, U.S. EPA Risk Reduction Engineering Laboratory (RREL), U.S. EPA Region 10

Media and Contaminants: JP-4 jet fuel in shallow unsaturated soil

Treatment: Bioventing with active and passive soil warming

Date of Initiative Selection: Spring 1991

Objective: To examine the use of soil-warming technologies to enhance the effectiveness of bioventing jet fuel-contaminated soil in a cold climate

Bioremediation Field Initiative Contact: Greg Sayles, U.S. EPA RREL, 26 West Martin Luther King Drive, Cincinnati, OH 45268

Regional Contact: Mary Jane Nearman, U.S. EPA Region 10, 1200 Sixth Avenue, Seattle, WA 98101

Background

Eielson Air Force Base (AFB) in Fairbanks, Alaska, is one of approximately 4,300 Air Force sites contaminated with petroleum hydrocarbons in soil. The Air Force currently is implementing an extensive program to examine the use of bioventing to remediate many of these sites. This program was developed based on preliminary results from Eielson and Hill AFBs, where the Air Force and the U.S. EPA Risk Reduction Engineering Laboratory (RREL) are conducting joint field evaluations of bioventing. (Activities at Hill AFB are summarized in a separate fact sheet.) The results from Eielson AFB will help determine whether bioventing can be pursued at other cold-climate sites in the northern United States.

Characterization

The soil at the Eielson site is a mixture of sand and silt contaminated with JP-4 jet fuel from a depth of roughly 2 ft to the water table at 6 to 7 ft. Prior to bioventing, hydrocarbon concentrations in the soil gas ranged from 600 to 40,000 mg/kg. Although the site is not in the permafrost region, soil temperatures in winter drop to nearly 0°C. Researchers believe that using soil-warming measures to promote high-rate, year-round bioremediation will cost less overall than sustaining low-rate bioremediation at ambient temperatures for an extended period of time.

Field Evaluation

A 1-acre contaminated area was divided into three 50-ft square segments (see Figure 1). One plot, which receives bioventing without heating, serves as a control. The two other plots each undergo one of the following soil-warming techniques:

Passive warming. Plastic covering (mulch) is used to enhance solar warming in late spring, summer, and early fall. During the remainder of the year, heat is retained by applying insulation to the surface.

Active warming. Ground water is circulated to an electric heater, heated to 35°C, and reinjected below the ground surface to the contaminated soil. The heated water is applied at a very low rate (1 gpm) by five

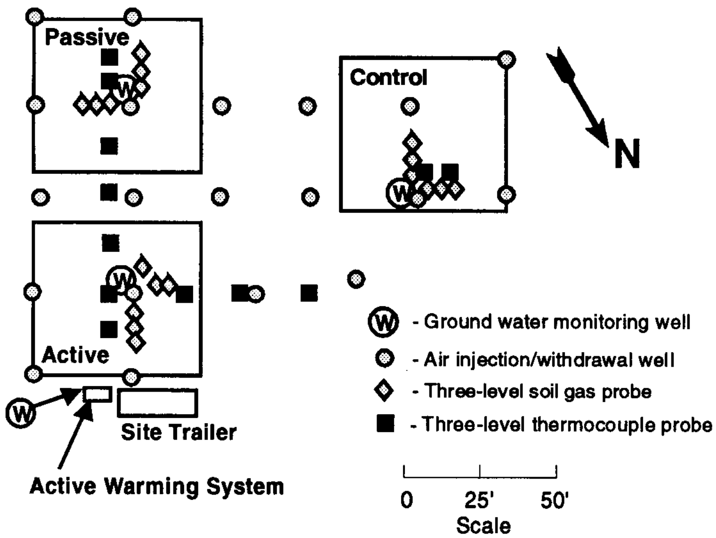


Figure 1. Plan view of actively heated, passively heated, and unheated plots.

soaker hoses, placed 2 ft below the surface. The surface is covered with insulation year round.

The passive warming system is being operated by the Air Force (see Figure 2). RREL is operating the active warming system. Air injection/withdrawal wells are distributed uniformly at 30-ft intervals among the three plots. Air is injected to each well at a rate of 2.5 ft^3/min, providing the plots with relatively uniform aeration. Three-level gas monitoring wells and three-level temperature probes are distributed throughout the site.

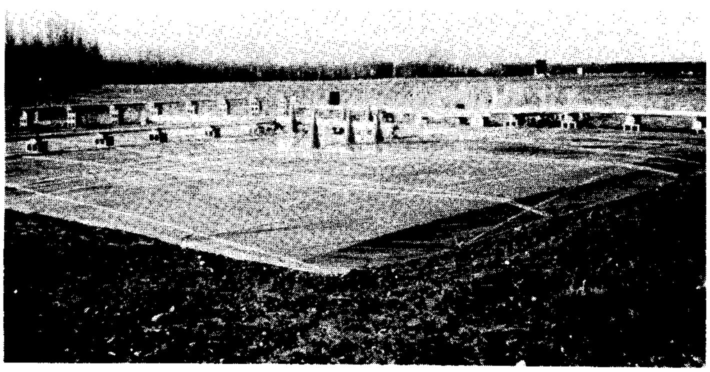


Figure 2. Passively heated plot covered with insulation.

In situ respirometry tests are conducted periodically to measure the in situ rate of oxygen uptake by the microorganisms. During these tests, researchers shut off air injection for 4 to 8 days and monitor the soil gas oxygen concentration over time. The decrease in oxygen concentration, less that observed in a background area, indicates the rate of biodegradation in the contaminated soil.

Status

Researchers began venting air and trickling unheated water to the actively warmed plot in September 1991. Warming of the water began in October 1991. In January 1992, researchers determined that all three plots were aerated adequately, with soil gas oxygen levels ranging from 12 to 20 percent. The temperature remained above 10°C in the actively warmed plot, while temperatures in the passively warmed plot and the control plot dropped to near 0°C. Measured biodegradation rates were twice as high in the actively warmed area as they were in the control. Furthermore, the degradation rate of 2.9 mg/kg/day in the actively warmed plot is comparable to rates observed at bioventing projects in moderate climates. In August 1992, the temperature of the passively warmed plot was 4°C warmer than that of the control plot, suggesting that passive warming is somewhat effective. An economic analysis is planned to determine which warming method, if either, is more cost effective.

The Bioremediation Field Initiative was established in 1990 to expand the nation's field experience in bioremediation technologies. The Initiative's objectives are to more fully document the performance of full-scale applications of bioremediation; provide technical assistance to regional and state site managers; and provide information on treatability studies, design, and operation of bioremediation projects. The Initiative currently is performing field evaluations of bioremediation at eight other hazardous waste sites: Libby Ground Water Superfund site, Libby, MT; Park City Pipeline, Park City, KS; Bendix Corporation/Allied Automotive Superfund site, St. Joseph, MI; West KL Avenue Landfill Superfund site, Kalamazoo, MI; Hill Air Force Base Superfund site, Salt Lake City, UT; Escambia Wood Preserving Site—Brookhaven, Brookhaven, MS; Reilly Tar and Chemical Corporation Superfund site, St. Louis Park, MN; and Public Service Company, Denver, CO. To obtain profiles on these additional sites or to be added to the Initiative's mailing list, call 513-569-7562. For further information on the Bioremediation Field Initiative, contact Fran Kremer, Coordinator, Bioremediation Field Initiative, U.S. EPA, Office of Research and Development, 26 West Martin Luther King Drive, Cincinnati, OH 45268; or Nancy Dean, U.S. EPA, Technology Innovation Office, Office of Solid Waste and Emergency Response, 401 M Street, SW., Washington, DC 20460.

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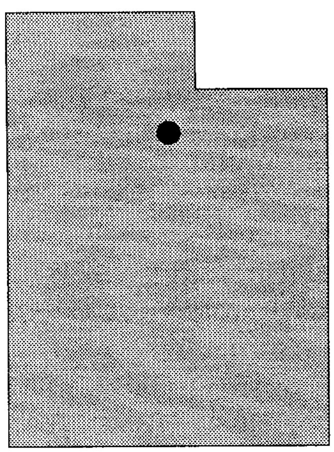
Bioremediation Field Initiative Site Profile:
Hill Air Force Base Superfund Site

SITE FACTS



Location: Salt Lake City, Utah

Laboratories/Agencies: U.S. Air Force, U.S. EPA Risk Reduction Engineering Laboratory (RREL), U.S. EPA Region 8

Media and Contaminants: JP-4 jet fuel in unsaturated soil

Treatment: Bioventing

Date of Initiative Selection: Spring 1991

Objective: To evaluate the effectiveness of bioventing jet fuel in deep vadose zone soil

Bioremediation Field Initiative Contact: Greg Sayles, U.S. EPA RREL, 26 West Martin Luther King Drive, Cincinnati, OH 45268

Regional Contact: Robert Stites, U.S. EPA Region 8, 999 18th Street, Denver, CO 80202-2466

Background

Hill Air Force Base (AFB) near Salt Lake City, Utah, is the site for one of two projects the Bioremediation Field Initiative is undertaking in cooperation with the U.S. EPA Risk Reduction Engineering Laboratory (RREL) and the U.S. Air Force to biovent JP-4 jet fuel spills. The other, at Eielson Air Force Base in Alaska, is described in a separate fact sheet.

Bioventing is the process of supplying oxygen in situ to oxygen-deprived soil microbes by forcing air through contaminated soil at low airflow rates. Because bioventing equipment is relatively noninvasive, this technology is especially valuable for treating contaminated soils at military bases, industrial complexes, and gas stations, where structures and utilities cannot be disturbed.

At Hill AFB, the objectives of the Initiative are to gain experience in bioventing large volumes of soil and determine the effect of airflow rate on biodegradation and volatilization rates. The challenges at this site are (1) to biodegrade contamination that extends deep beneath the surface and (2) to biovent the fuel plume under roads, underground utilities, and buildings.

Characterization

The Hill AFB site is contaminated with JP-4 fuel from a depth of approximately 35 ft to the ground water, which occurs at 95 ft below the surface. The contaminated soil is a mixture of sand, silty sand, and sand interspersed with gravel and clay. Soil samples taken in September 1991 revealed an average total petroleum hydrocarbon (TPH) level of 890 mg/kg, ranging up to 5,000 mg/kg at certain depths. Ground water samples showed an average TPH concentration of 1.5 mg/L, with TPH concentrations in some wells as high as 10 mg/L. The contaminated area extends beneath a tool maintenance building, engine storage yard, and fuel storage yard (see Figure 1).

Field Evaluation

Bioventing performance is being evaluated at three different air injection rates. Unlike soil venting or soil vacuum extraction technologies,

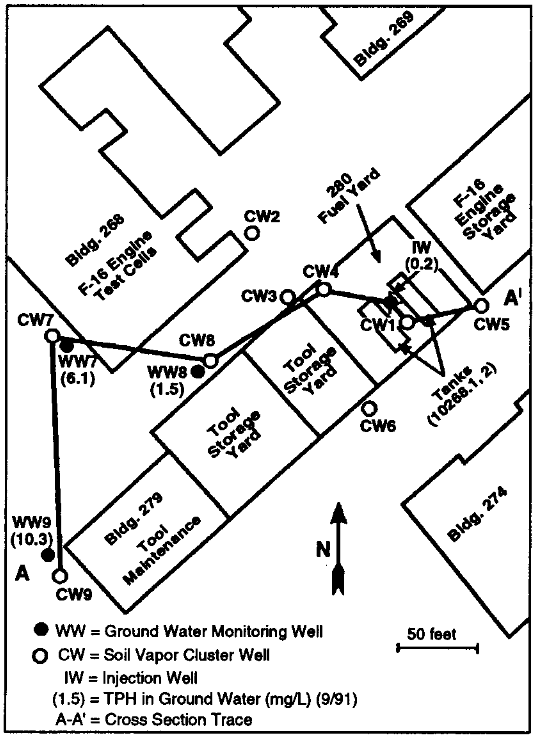


Figure 1. Plan view of contaminated area.

bioventing uses low airflow rates to stimulate biodegradative activity while minimizing volatilization of contaminants in the soil. Higher air injection rates stimulate faster and more widespread biodegradation but also release more volatile emissions to the surface. Figure 2 shows an air injection well at the site. Twice a year, the rate of air injection is reduced to study the tradeoff between the loss in area of influence of the injected air for bioremediation and the decrease in volatilization of organics at the soil surface.

To determine the rate of hydrocarbon loss due to bioventing, RREL conducts semiannual in situ respiration tests. Air injection is shut off for 4 to 8 days, during which soil gas oxygen levels are carefully monitored. The rate of oxygen uptake by microorganisms in the contaminated soil, relative to oxygen loss observed in an uncontaminated area, indicates the rate of biodegradation.

RREL has conducted an inert gas tracer study to determine the transport of gas through the soil. During this study, researchers temporarily injected helium instead of air into the vent well. By monitoring for the inert gas at the various soil gas wells, researchers determined how efficiently the injection well delivers air to the soil.

Status

The U.S. Air Force began bioventing operations in January 1991. Between July and September 1991, RREL installed additional wells to monitor bioremediation performance over the entire 100-ft depth of the contaminated vadose zone. The first flow rate change and in situ respiration test, and the inert gas tracer study took place in fall of 1992. Final soil hydrocarbon analyses will be conducted in summer of 1993. These results will be compared with the initial soil analysis to document overall hydrocarbon loss due to bioventing.

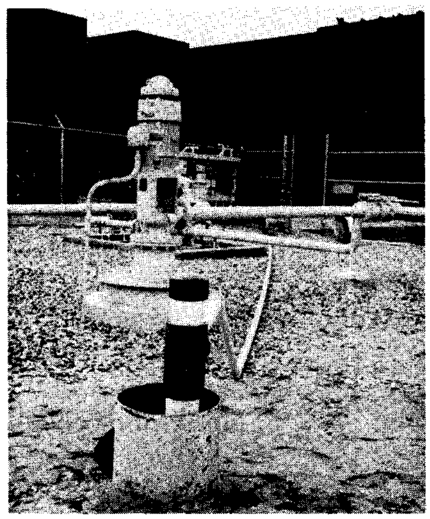


Figure 2. Air injection well at the surface.

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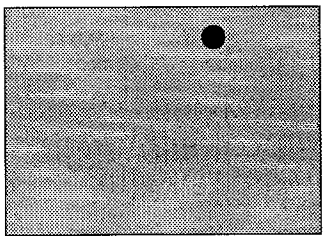
Bioremediation Field Initiative Site Profile: Public Service Company of Colorado

SITE FACTS



Location: Denver, Colorado

Laboratories/Agencies: U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), U.S. EPA Region 8

Media and Contaminants: BTEX in ground water

Treatment: In situ bioremediation of ground water with nutrient and hydrogen peroxide addition

Date of Initiative Selection: Spring 1991

Objective: To evaluate the effectiveness of in situ bioremediation of used oil and the potential for future environmental impact from residual contaminants

Bioremediation Field Initiative Contact: John Wilson, U.S. EPA RSKERL, P.O. Box 1198, Ada, OK 74820

Regional Contact: Suzanne Stevenson, U.S. EPA Region 8, 999 18th Street, Denver, CO 80202-2466

Background

In 1987, Public Service Company of Colorado (PSC), an electric utility, determined that used oil had leaked from a 75-gallon tank at the company's facility at 2701 West 7th Avenue in Denver, Colorado. The tank served as a temporary catch basin for used automotive oil in the facility's garage. A discrepancy between the volume of oil deposited in the tank and the volume pumped out for disposal lead PSC to suspect the leak. Though it is unclear when the leak first occurred, the tank had been in service for 29 years before the leak was discovered. The Bioremediation Field Initiative has conducted a retrospective evaluation of the performance of in situ bioremediation of oil leaked from the tank.

Characterization

PSC found soil concentrations of oil and grease beneath the tank ranging up to 9,600 mg/kg. Soil samples also showed BTEX compounds in the following concentrations: toluene, 3,200 µg/kg; ethyl benzene, 820 µg/kg; and xylenes, 29,600 µg/kg. Ground water sampling detected low levels of BTEX compounds, though levels of xylenes exceeded EPA's proposed drinking water standards.

Field Evaluation

In July 1989, PSC installed an in situ bioremediation system to remediate the contaminated ground water and promote biodegradation of contaminants in the soil above and below the water table and in the aquifer. The treatment took place in several stages. First, ground water was pumped from a recovery well downgradient of the leaking tank at the rate of 11 gallons per minute to ensure the capture and content of contaminants. The recovered water then was treated by carbon adsorption to remove dissolved hydrocarbons before being pumped to a nutrient gallery. In the nutrient gallery, the ground water was amended twice: first with ammonium and phosphate compounds to provide inorganic nutrients; then with hydrogen peroxide to increase the water's level of dissolved oxygen. The amended ground water was then reinjected upgradient of the leaking tank, thereby delivering the nutrients and oxygen needed to sustain aerobic biodegradation in the saturated zone. Figure 1 is a computer-generated model of ground water flow from the injection wells to the recovery well. Figure 2 shows the actual flow of nutrients beneath the leaking oil tank.

To speed remediation of the contaminated soil in the vadose zone, PSC also added batches of nutrients directly to the soil and installed a bioventing system to induce a dynamic flow of ambient air above the water table to highly contaminated areas in the subsurface.

Status

By 1991, concentrations of BTEX in the monitoring wells were approaching the cleanup goals. In March of 1992, PSC submitted an application for closure to the State of Colorado. The site currently is in the monitoring phase. In July of 1992, the U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL) conducted an evaluation of the site, including soil coring to determine the quantity and distribution of residual oil downgradient of the leaking tank, chemodynamic modeling to predict the maximum concentration of BTEX that could partition from residual oil to ground water, and hydrogeologic monitoring to predict the concentration of BTEX in a hypothetical well at the site boundary downgradient of the leaking tank. The results of this evaluation still are being analyzed, but RSKERL's interim conclusion is that, while some hydrocarbons remain at the site, they are not contributing at this time to substantial contamination of ground water in the aquifer.

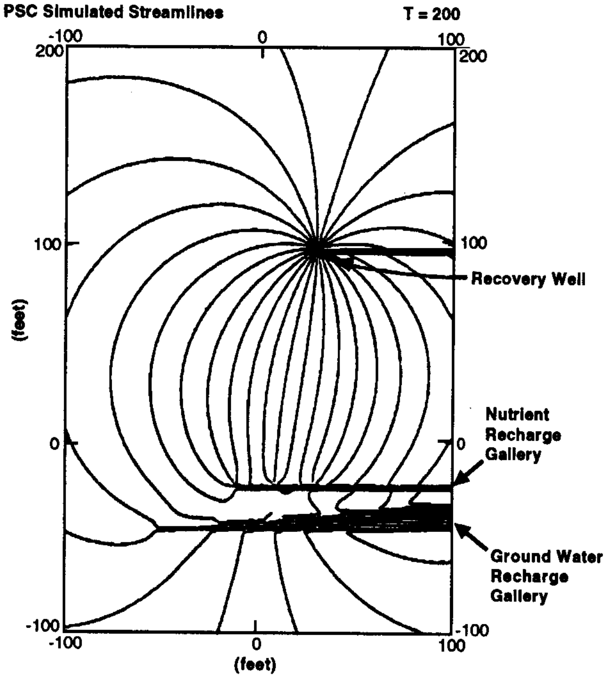


Figure 1. Computer-generated model of ground water flow from injection wells to recovery well.

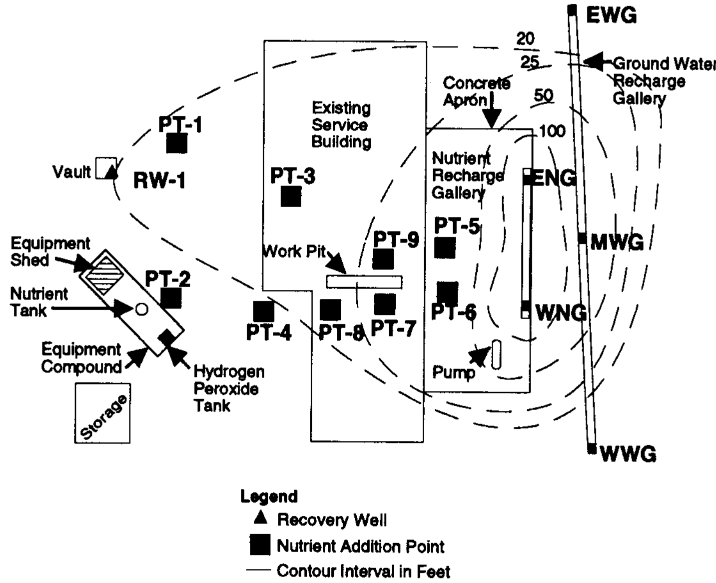
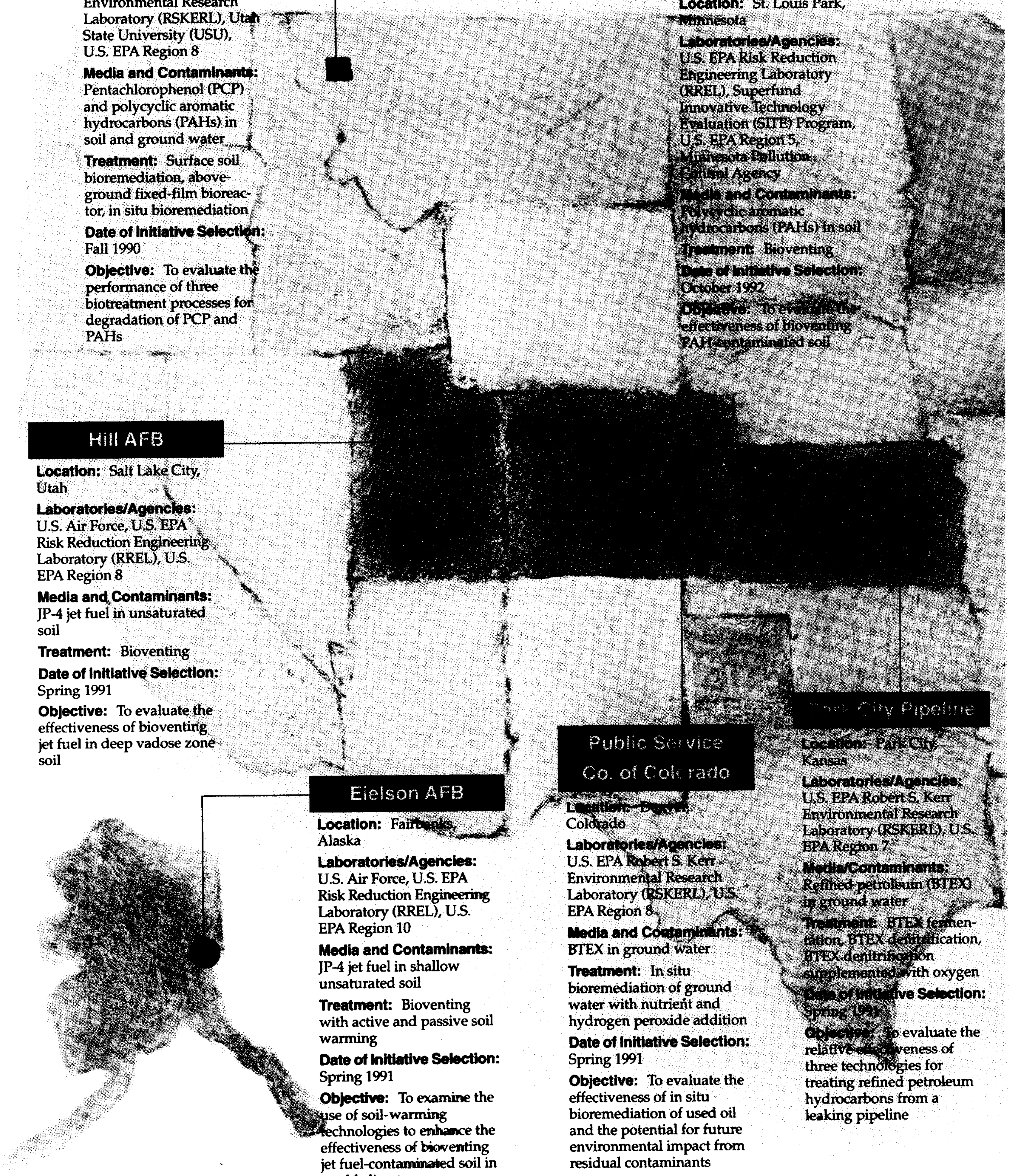


Figure 2. Schematic of site showing flow of nutrients in ground water under leaking tank.

The Bioremediation Field Initiative was established in 1990 to expand the nation's field experience in bioremediation technologies. The Initiative's objectives are to more fully document the performance of full-scale applications of bioremediation; provide technical assistance to regional and state site managers; and provide information on treatability studies, design, and operation of bioremediation projects. The Initiative currently is performing field evaluations of bioremediation at eight other hazardous waste sites: Libby Ground Water Superfund site, Libby, MT; Park City Pipeline, Park City, KS; Bendix Corporation/Allied Automotive Superfund site, St. Joseph, MI; West KL Avenue Landfill Superfund site, Kalamazoo, MI; Eielson Air Force Base Superfund site, Fairbanks, AK; Hill Air Force Base Superfund site, Salt Lake City, UT; Escambia Wood Preserving Site—Brookhaven, Brookhaven, MS; and Reilly Tar and Chemical Corporation Superfund site, St. Louis Park, MN. To obtain profiles on these additional sites or to be added to the Initiative's mailing list, call 513-569-7562. For further information on the Bioremediation Field Initiative, contact Fran Kremer, Coordinator, Bioremediation Field Initiative, U.S. EPA, Office of Research and Development, 26 West Martin Luther King Drive, Cincinnati, OH 45268; or Nancy Dean, U.S. EPA, Technology Innovation Office, Office of Solid Waste and Emergency Response, 401 M Street, SW., Washington, DC 20460.



Libby Ground Water Site

Location: Libby, Montana

Laboratories/Agencies: U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), Utah State University (USU), U.S. EPA Region 8

Media and Contaminants: Pentachlorophenol (PCP) and polycyclic aromatic hydrocarbons (PAHs) in soil and ground water

Treatment: Surface soil bioremediation, above-ground fixed-film bioreactor, in situ bioremediation

Date of Initiative Selection: Fall 1990

Objective: To evaluate the performance of three biotreatment processes for degradation of PCP and PAHs

Reilly Tar and Chemical Corp.

Location: St. Louis Park, Minnesota

Laboratories/Agencies: U.S. EPA Risk Reduction Engineering Laboratory (RREL), Superfund Innovative Technology Evaluation (SITE) Program, U.S. EPA Region 5, Minnesota Pollution Control Agency

Media and Contaminants: Polycyclic aromatic hydrocarbons (PAHs) in soil

Treatment: Bioventing

Date of Initiative Selection: October 1992

Objective: To evaluate the effectiveness of bioventing PAH-contaminated soil

Hill AFB

Location: Salt Lake City, Utah

Laboratories/Agencies: U.S. Air Force, U.S. EPA Risk Reduction Engineering Laboratory (RREL), U.S. EPA Region 8

Media and Contaminants: JP-4 jet fuel in unsaturated soil

Treatment: Bioventing

Date of Initiative Selection: Spring 1991

Objective: To evaluate the effectiveness of bioventing jet fuel in deep vadose zone soil

Eielson AFB

Location: Fairbanks, Alaska

Laboratories/Agencies: U.S. Air Force, U.S. EPA Risk Reduction Engineering Laboratory (RREL), U.S. EPA Region 10

Media and Contaminants: JP-4 jet fuel in shallow unsaturated soil

Treatment: Bioventing with active and passive soil warming

Date of Initiative Selection: Spring 1991

Objective: To examine the use of soil-warming technologies to enhance the effectiveness of bioventing jet fuel-contaminated soil in a cold climate

Public Service Co. of Colorado

Location: Denver, Colorado

Laboratories/Agencies: U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), U.S. EPA Region 8

Media and Contaminants: BTEX in ground water

Treatment: In situ bioremediation of ground water with nutrient and hydrogen peroxide addition

Date of Initiative Selection: Spring 1991

Objective: To evaluate the effectiveness of in situ bioremediation of used oil and the potential for future environmental impact from residual contaminants

Park City Pipeline

Location: Park City, Kansas

Laboratories/Agencies: U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), U.S. EPA Region 7

Media/Contaminants: Refined petroleum (BTEX) in ground water

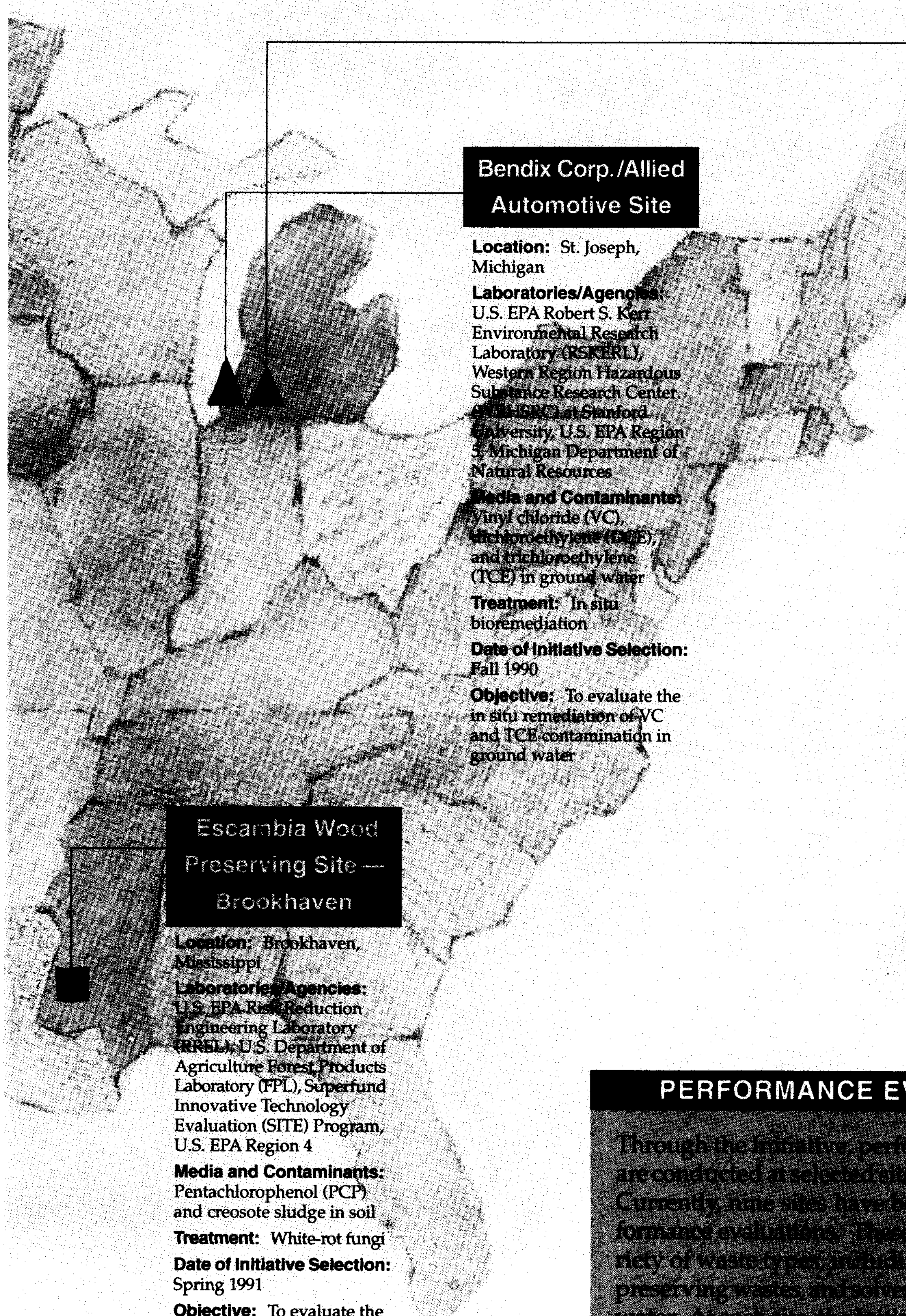
Treatment: BTEX fermentation, BTEX denitrification, BTEX denitrification supplemented with oxygen

Date of Initiative Selection: Spring 1991

Objective: To evaluate the relative effectiveness of three technologies for treating refined petroleum hydrocarbons from a leaking pipeline

Bioremediation Field Initiative

Evaluation Sites



West KL Avenue Landfill

Location: Kalamazoo, Michigan

Laboratories/Agencies: U.S. EPA Risk Reduction Engineering Laboratory (RREL), U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), Center for Microbial Ecology at Michigan State University (MSU), U.S. EPA Region 5, Michigan Department of Natural Resources

Media and Contaminants: Solvents in landfill and ground water

Treatment: In situ bioremediation of landfill material and ground water

Date of Initiative Selection: October 1992

Objective: To evaluate the feasibility of bioremediating the ground water and landfill material

Bendix Corp./Allied Automotive Site

Location: St. Joseph, Michigan

Laboratories/Agencies: U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), Western Region Hazardous Substance Research Center (WRHSRC) at Stanford University, U.S. EPA Region 5, Michigan Department of Natural Resources

Media and Contaminants: Vinyl chloride (VC), dichloroethylene (DCE), and trichloroethylene (TCE) in ground water

Treatment: In situ bioremediation

Date of Initiative Selection: Fall 1990

Objective: To evaluate the in situ remediation of VC and TCE contamination in ground water

Escambia Wood Preserving Site — Brookhaven

Location: Brookhaven, Mississippi

Laboratories/Agencies: U.S. EPA Risk Reduction Engineering Laboratory (RREL), U.S. Department of Agriculture Forest Products Laboratory (FPL), Superfund Innovative Technology Evaluation (SITE) Program, U.S. EPA Region 4

Media and Contaminants: Pentachlorophenol (PCP) and creosote sludge in soil

Treatment: White-rot fungi

Date of Initiative Selection: Spring 1991

Objective: To evaluate the effectiveness of white-rot fungi treatment for wood preserving wastes

KEY TO SITE CONTAMINANTS

PERFORMANCE EVALUATIONS

Through the Initiative, performance [illegible] are conducted at selected sites across [illegible]. Currently, nine sites have been selected [illegible] formance evaluations. These sites [illegible] riety of waste types, including [illegible] preserving wastes, and solvents in soil [illegible] water. At each site, the Initiative is [illegible] the field tests and independent evaluations [illegible] to generate solid cost and performance data [illegible] biotreatment technologies being used.

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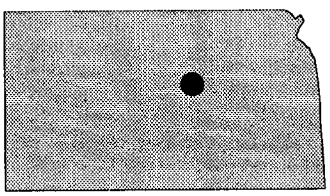
Bioremediation Field Initiative Site Profile: Park City Pipeline

SITE FACTS



Location: Park City, Kansas

Laboratories/Agencies: U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), U.S. EPA Region 7

Media/Contaminants: Refined petroleum (BTEX) in ground water

Treatment: BTEX fermentation, BTEX denitrification, BTEX denitrification supplemented with oxygen

Date of Initiative Selection: Spring 1991

Objective: To evaluate the relative effectiveness of three technologies for treating refined petroleum hydrocarbons from a leaking pipeline

Bioremediation Field Initiative Contact: John Wilson, U.S. EPA RSKERL, P.O. Box 1198, Ada, OK 74820

Background

In the 1970s, a buried pipeline at an oil refinery in Park City, Kansas, started leaking a variety of refined petroleum products and petroleum feedstocks into the water table aquifer. By February 1980, the spill had contaminated ground water near Park City's municipal well #6. To intercept the flow of hydrocarbons from the pipeline to the well, two trenches were excavated to the water table for free product recovery. As a means of disposal, the petroleum in the trenches occasionally was set afire. The west trench was backfilled in August 1982; the east trench was filled in August 1984. The U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL) is performing a field evaluation of three treatments for the contaminated ground water.

Characterization

In 1989, 18 monitoring wells and two sets of five piezometers were installed to define the extent of contamination and the direction of ground water flow. In spring of 1991, 12 more monitoring wells and two sets of piezometers were added to better define the distribution of the oil. The contamination is in the floodplain of the Arkansas River, where 15 to 20 ft of clay overlie a sand aquifer (see Figure 1). The water table is near the interface of the sand and the clay, and the bedrock is

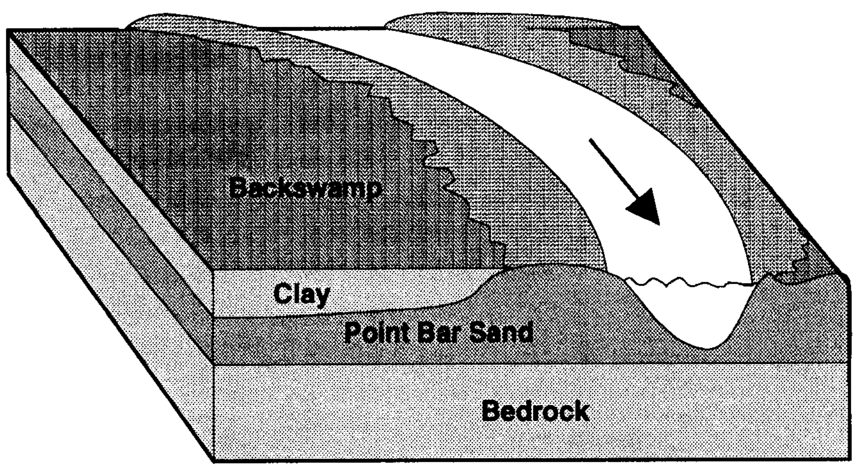


Figure 1. Geological setting of the site.

45 to 50 ft below the surface. Hydrocarbon contamination is confined roughly to an interval between the base of the clay layer and the top of the present water table (see Figure 2).

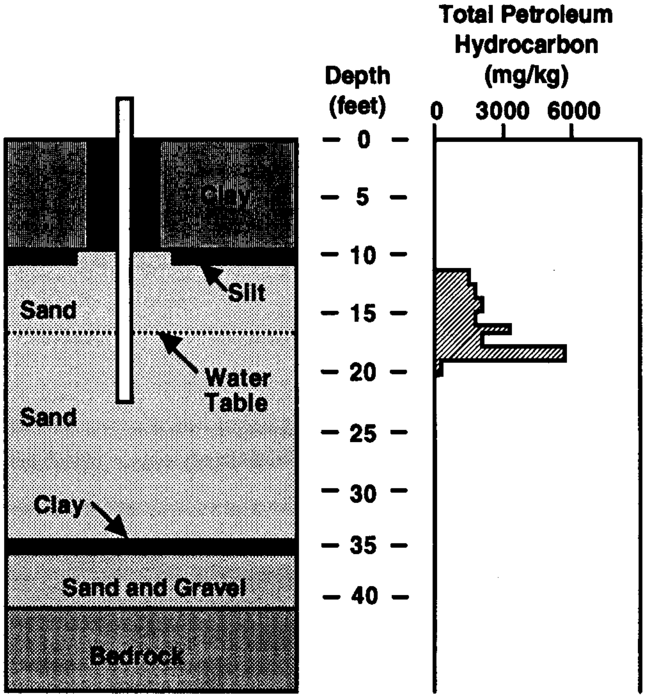


Figure 2. Relationship between spilled hydrocarbons, layers of geological materials, the water table, and monitoring wells.

Field Evaluation

In 1990, more than 400 shallow injection wells were installed at the site. These wells are constructed on a 20-ft grid and cover the entire area affected by the spill. Researchers have divided an area affected by the homogeneous fuel spill into three discrete blocks of about 1 acre each and will apply one of the following experimental treatments to each block:

- BTEX fermentation alone
- BTEX denitrification alone
- BTEX denitrification supplemented with oxygen

Water from a municipal supply well will be pumped to the surface, amended, and recirculated to the aquifer through the injection wells. Each of the three experimental plots will receive approximately 125 gpm. At that rate, the water is estimated to require an average of 6.4 days to recirculate. To maintain the demonstration in a cone of depression, water also will be pumped from a second nearby well.

The water distributed to all three plots will be amended with ammonium chloride at 5 mg/L. Two plots also will receive nitrate at 10 mg/L as nitrogen. The third plot will receive oxygen at 2 mg/L. To act as a tracer, and to enable researchers to estimate the volume of water in the recirculation loop, the recirculated water will be amended with sodium bromide at 50 mg/L.

Status

Researchers have completed microcosm studies on the two denitrification technologies to predict the duration of remediation required. Aquifer core samples from two locations originally showed average BTEX concentrations of 42.6 mg/kg and 24.3 mg/kg, respectively. Toluene, ethylbenzene, *m*-xylene, *p*-xylene, 1,3,5-trimethylbenzene, and 1,2,4-trimethylbenzene degraded to less than 5 µg/L within 20 days in the clean aquifer microcosms amended with nitrate. About half of the *o*-xylene was removed. Benzene and 1,2,3-trimethylbenzene were recalcitrant. Based on these findings, researchers predict that 210 days of treatment will be required to supply enough nitrate to remediate the aquifer. Remediation began in December 1992.

The Bioremediation Field Initiative was established in 1990 to expand the nation's field experience in bioremediation technologies. The Initiative's objectives are to more fully document the performance of full-scale applications of bioremediation; provide technical assistance to regional and state site managers; and provide information on treatability studies, design, and operation of bioremediation projects. The Initiative currently is performing field evaluations of bioremediation at eight other hazardous waste sites: Libby Ground Water Superfund site, Libby, MT; Bendix Corporation/Allied Automotive Superfund site, St. Joseph, MI; West KL Avenue Landfill Superfund site, Kalamazoo, MI; Eielson Air Force Base Superfund site, Fairbanks, AK; Hill Air Force Base Superfund site, Salt Lake City, UT; Escambia Wood Preserving Site—Brookhaven, Brookhaven, MS; Reilly Tar and Chemical Corporation Superfund site, St. Louis Park, MN; and Public Service Company, Denver, CO. To obtain profiles on these additional sites or to be added to the Initiative's mailing list, call 513-569-7562. For further information on the Bioremediation Field Initiative, contact Fran Kremer, Coordinator, Bioremediation Field Initiative, U.S. EPA, Office of Research and Development, 26 West Martin Luther King Drive, Cincinnati, OH 45268; or Nancy Dean, U.S. EPA, Technology Innovation Office, Office of Solid Waste and Emergency Response, 401 M Street, SW., Washington, DC 20460.

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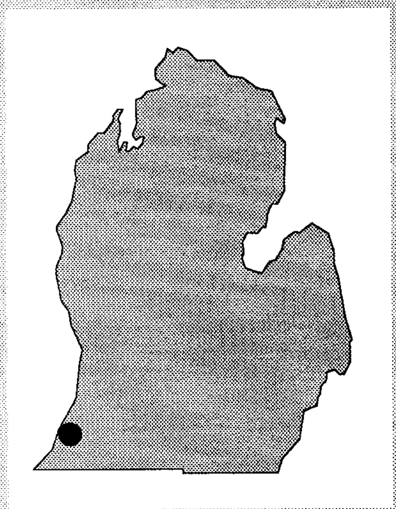
Bioremediation Field Initiative Site Profile:
Bendix Corporation/Allied Automotive Superfund Site

SITE FACTS



Location: St. Joseph, Michigan

Laboratories/Agencies: U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), Western Region Hazardous Substance Research Center (WRHSRC) at Stanford University, U.S. EPA Region 5, Michigan Department of Natural Resources

Media and Contaminants: Vinyl chloride (VC), dichloroethylene (DCE), and trichloroethylene (TCE) in ground water

Treatment: In situ bioremediation

Date of Initiative Selection: Fall 1990

Objective: To evaluate the in situ remediation of VC and TCE contamination in ground water

Bioremediation Field Initiative Contact: John Wilson, U.S. EPA RSKERL, P.O. Box 1198, Ada, OK 74820

Regional Contact: John Kuhns, U.S. EPA Region 5, Waste Management Division, 77 West Jackson Boulevard, Chicago, IL 60604

Background

In 1982, two contaminated ground water plumes with mg/L concentrations of trichloroethylene (TCE), vinyl chloride (VC), and *cis*- and *trans*-1,2-dichloroethylene (*c*- and *t*-DCE) were found to be emanating from the Bendix Corporation/Allied Automotive industrial site in St. Joseph, Michigan (see Figure 1), and the site was placed on the National Priority List. In early 1991, the Western Region Hazardous Substance Research Center (WRHSRC) at Stanford University, in cooperation with U.S. EPA Region 5 and the U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), began a series of studies to examine the feasibility of a proposed in situ treatment for the contaminated ground water.

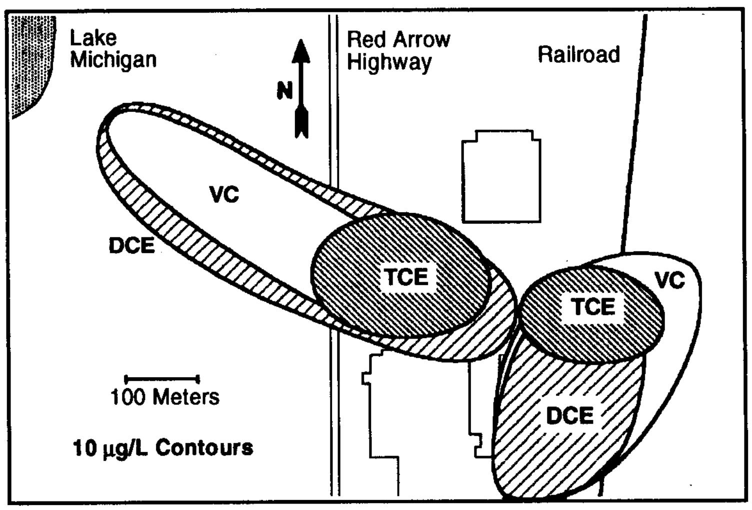


Figure 1. Plan view of site, showing contaminated plumes of TCE, VC, and DCE.

Field Evaluation

Researchers previously had discovered that *c*-DCE, *t*-DCE, and VC could be biodegraded in situ by mixing ground water and a solution of oxygen and methane. In the field, however, simply injecting solutions of oxygen and methane into an aquifer does not adequately mix them with the contaminated ground water. To remedy this problem, WRHSRC proposed using an in situ treatment unit that enhances this mixing. Figure 2 presents a schematic of this system. The unit consists of a well with two screens, a pump, and mixing apparatus. One well screen is located at the bottom of the aquifer and the other

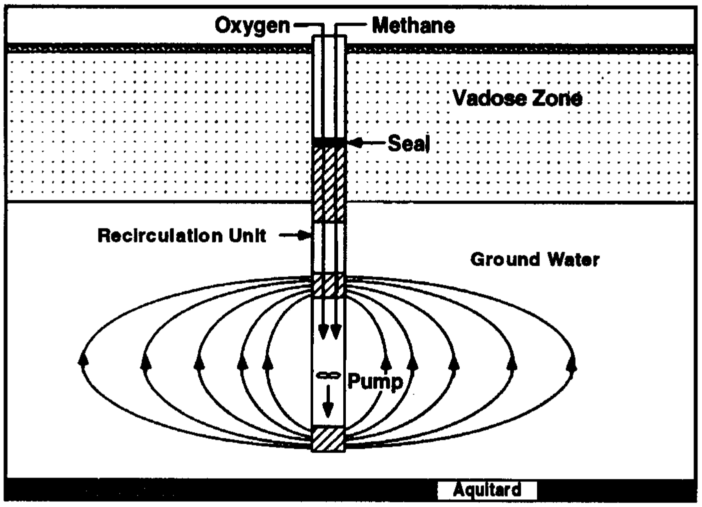


Figure 2. Schematic of the mixing and recirculation system.

is at the water table. Contaminated ground water is drawn into the well through the lower screen, where oxygen and methane are added, then pumped back into the aquifer through the water table screen. The pumping rate in the treatment unit can be adjusted to recirculate the plume through the treatment unit as many times as is necessary to meet cleanup standards.

RSKERL began by sampling and chemically analyzing two transects extending across the plume perpendicular to the flow of ground water. These samples revealed relatively high concentrations of all contaminants within 20 m of the plume's center. Maximum concentrations were 138 mg/L for TCE, 128 mg/L for *c*-DCE, and 56 mg/L for VC. Concentrations of TCE were much higher than expected, leading researchers to suspect that TCE might inhibit the growth of methanotrophic bacterial populations needed to remediate the aquifer.

To investigate this possibility, WRHSRC conducted microcosm studies of aquifer solids. The microcosms showed complete methane utilization regardless of VC or TCE concentration and removal rates of 25 to 80 percent for VC. The studies also showed, however, that TCE is not effectively transformed by the methanotrophic process. Based on these results, WRHSRC speculated that the proposed mixing system might actually dissolve more TCE than it degraded by circulating ground water past highly concentrated, oily-phase TCE. This led WRHSRC to recommend that the proposed system be installed only in areas where TCE concentrations are low and VC is the downgradient contaminant.

Status

Researchers currently are conducting another site characterization to identify regions of the contaminated site with low concentrations of TCE. Previous research has shown that low concentrations of TCE can be transformed in situ to environmentally benign ethene by adding methanol and acetate to the aquifer. A combination of this treatment for TCE and the originally proposed methanotrophic treatment for VC might be used to remediate regions of the site with low TCE concentrations.

The Bioremediation Field Initiative was established in 1990 to expand the nation's field experience in bioremediation technologies. The Initiative's objectives are to more fully document the performance of full-scale applications of bioremediation; provide technical assistance to regional and state site managers; and provide information on treatability studies, design, and operation of bioremediation projects. The Initiative currently is performing field evaluations of bioremediation at eight other hazardous waste sites: Libby Ground Water Superfund site, Libby, MT; Park City Pipeline, Park City, KS; West KL Avenue Landfill Superfund site, Kalamazoo, MI; Eielson Air Force Base Superfund site, Fairbanks, AK; Hill Air Force Base Superfund site, Salt Lake City, UT; Escambia Wood Preserving Site—Brookhaven, Brookhaven, MS; Reilly Tar and Chemical Corporation Superfund site, St. Louis Park, MN; and Public Service Company, Denver, CO. To obtain profiles on these additional sites or to be added to the Initiative's mailing list, call 513-569-7562. For further information on the Bioremediation Field Initiative, contact Fran Kremer, Coordinator, Bioremediation Field Initiative, U.S. EPA, Office of Research and Development, 26 West Martin Luther King Drive, Cincinnati, OH 45268; or Nancy Dean, U.S. EPA, Technology Innovation Office, Office of Solid Waste and Emergency Response, 401 M Street, SW., Washington, DC 20460.

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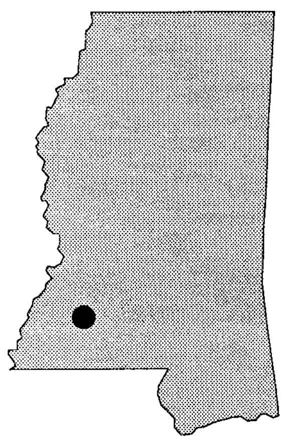
Bioremediation Field Initiative Site Profile: Escambia Wood Preserving Site—Brookhaven

SITE FACTS



Location: Brookhaven, Mississippi

Laboratories/Agencies: U.S. EPA Risk Reduction Engineering Laboratory (RREL), U.S. Department of Agriculture Forest Products Laboratory (FPL), Superfund Innovative Technology Evaluation (SITE) Program, U.S. EPA Region 4

Media and Contaminants: Pentachlorophenol (PCP) and creosote sludge in soil

Treatment: White-rot fungi

Date of Initiative Selection: Spring 1991

Objective: To evaluate the effectiveness of white-rot fungi treatment for wood preserving wastes

Bioremediation Field Initiative Contacts: John Glaser and Richard Brenner, U.S. EPA RREL, 26 West Martin Luther King Drive, Cincinnati, OH 45268

Regional Contact: De'Lyntoneus Moore, U.S. EPA Region 4, Waste Management Division, 345 Courtland Street, Atlanta, GA 30365

Background

The Escambia Wood Preserving Site—Brookhaven in Brookhaven, Mississippi, is a former wood preserving facility that used pentachlorophenol (PCP) and creosote to treat wooden poles. The site contains two pressure treatment cylinders, a wastewater treatment system, five bulk product storage tanks, and seven condenser ponds, including a 3,000,000-gallon, unlined primary surface impoundment. Prior to the installation of the wastewater treatment system in 1983, untreated process wastewater and sludge from the facility were pumped into the primary surface impoundment to evaporate excess water. In 1985, PCP-contaminated sediment and sludge from the condenser ponds were excavated and deposited in the primary surface impoundment. In April 1991, U.S. EPA Region 4 initiated a removal action to eliminate all sources of potential releases to the environment.

In the fall of 1991, PCP-contaminated soil from the condenser ponds was excavated and transferred to test plots to serve as a medium for an 8-week feasibility study on white-rot fungi treatment. A second, 5-month study of one particular strain of white-rot fungus took place from June to November 1992. Both studies were conducted by the U.S. EPA Risk Reduction Engineering Laboratory (RREL) and the U.S. Department of Agriculture Forest Products Laboratory (FPL) under the Superfund Innovative Technology Evaluation (SITE) Program and the Bioremediation Field Initiative.

Characterization

In June 1991, as part of the Field Initiative's feasibility study, site investigators systematically sampled a flat, approximately 18-m by 18-m section of a waste sludge pile of material from the condenser ponds. Laboratory analysis of each sample found PCP concentrations ranging from 25 mg/kg to 342 mg/kg, with an average of 143 mg/kg. Investigators also analyzed composite samples consisting of soil from each of the sample locations for volatile and semi-volatile organics. The composite samples contained elevated concentrations of 44 organic compounds, 12 of which are hazardous constituents of K001 waste. Contaminant concentrations varied greatly within the waste pile; the soil in the feasibility study had particularly high pollutant levels.

Field Evaluation

The feasibility study compared 10 treatments, combining three fungal species, three inoculum loading levels, and the appropriate controls. The experimental method combined a randomized complete block (RCB) design without replication and a balanced incomplete block (BIB) design with treatment replicated four times. Eleven 10-ft by 10-ft plots, each holding about 4 tons of soil, were constructed. In the RCB design, six of the plots each received a separate treatment. In the BIB design, each of the five remaining plots was divided by interior borders into four 2.5-ft by 2.5-ft split plots. The interior plots were used to evaluate one of the treatments from the RCB design and four additional treatments.

Investigators excavated soil from the original sampling location on the waste sludge pile to a depth of approximately 30 cm. After excavation, the soil was mechanically sieved to pass through a 2.5-cm screen, mixed, then placed in the plots to a depth of 25 cm. On September 18, 1991, the plots were inoculated with the fungi. After inoculation, each plot periodically was irrigated and tilled with a garden rototiller. Wood chips were added to each plot to provide a substrate to sustain growth of the fungi. Figure 1 is a schematic of the soil preparation, showing the treatment plots.

Status

Both the SITE program and investigators from FPL collected soil samples during the feasibility study. Sampling and analyses for PCP and polycyclic

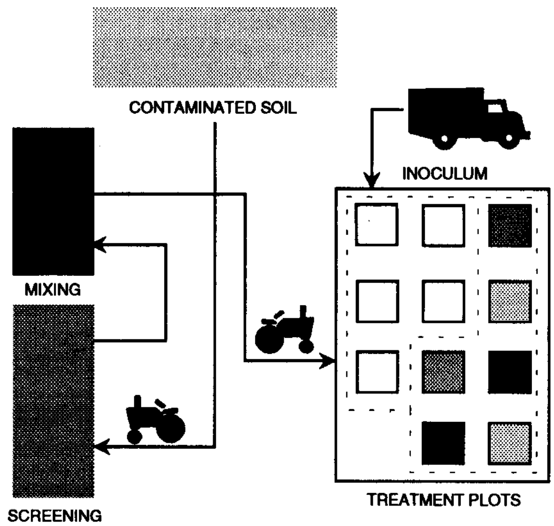


Figure 1. Schematic of soil preparation, from excavation to screening, mixing, placement in treatment plots, and inoculation with fungi.

aromatic hydrocarbons (PAHs) were performed by methods previously used by each group. Initial PCP concentrations in the 10 treatment plots ranged between approximately 300 and 1,000 mg/kg. Results indicated losses of PCP in the treatment plots of up to 89 percent of the initial concentrations. This level of remediation was considered adequate to justify the initiation of a larger scale investigation.

A larger scale investigation of *Phanerochaete sordida* for remediation of the PCP-contaminated soil was initiated in June 1992. Researchers inoculated a 100-ft by 70-ft plot with the fungal species. Two control plots also were established—one with contaminated soil only and the other with contaminated soil and the fungal spawn mix. Sampling was conducted through November 1992 to monitor the transformation of PCP and PAHs. The data currently are being evaluated.

The Bioremediation Field Initiative was established in 1990 to expand the nation's field experience in bioremediation technologies. The Initiative's objectives are to more fully document the performance of full-scale applications of bioremediation; provide technical assistance to regional and state site managers; and provide information on treatability studies, design, and operation of bioremediation projects. The Initiative currently is performing field evaluations of bioremediation at eight other hazardous waste sites: Libby Ground Water Superfund site, Libby, MT; Park City Pipeline, Park City, KS; Bendix Corporation/Allied Automotive Superfund site, St. Joseph, MI; West KL Avenue Landfill Superfund site, Kalamazoo, MI; Eielson Air Force Base Superfund site, Fairbanks, AK; Hill Air Force Base Superfund site, Salt Lake City, UT; Reilly Tar and Chemical Corporation Superfund site, St. Louis Park, MN; and Public Service Company, Denver, CO. To obtain profiles on these additional sites or to be added to the Initiative's mailing list, call 513-569-7562. For further information on the Bioremediation Field Initiative, contact Fran Kremer, Coordinator, Bioremediation Field Initiative, U.S. EPA, Office of Research and Development, 26 West Martin Luther King Drive, Cincinnati, OH 45268; or Nancy Dean, U.S. EPA, Technology Innovation Office, Office of Solid Waste and Emergency Response, 401 M Street, SW., Washington, DC 20460.

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Bioremediation Field Initiative Site Profile:
Reilly Tar and Chemical Corporation Superfund Site

Background

This Bioremediation Field Initiative project is under way in St. Louis Park, Minnesota, at the former site of Reilly Tar and Chemical Corporation's coal tar distillation and wood preserving plant. From 1917 to 1972, wastewater discharges and dumping from this plant contaminated about 80 acres of soil and the underlying ground water with wood preserving wastes. In 1978, the Minnesota Department of Health discovered significant concentrations of polycyclic aromatic hydrocarbons (PAHs) in six municipal drinking water wells neighboring the Reilly Tar plant. St. Louis Park currently is pumping and treating the contaminated ground water plume, but without an effort to control the source of PAHs, pumping and treating might be necessary for several hundred years.

This Initiative project is evaluating bioventing of PAH-contaminated soil through the U.S. EPA Superfund Innovative Technology Evaluation (SITE) Program and the U.S. EPA Risk Reduction Engineering Laboratory's (RREL's) Biosystems Program. Bioventing has proven effective at remediating lightweight petroleum distillates such as JP-4 jet fuel; this is the first evaluation of bioventing's effectiveness for remediation of larger molecular weight hydrocarbons.

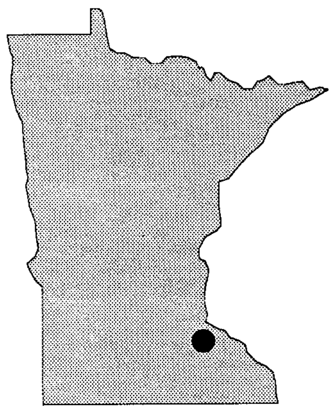
Characterization

The SITE program conducted a preliminary site characterization, including soil sampling, soil gas monitoring, and in situ respiration testing, in August 1992. Soil sampling revealed PAH contamination in sandy vadose soil ranging from 2 to 10 ft below the surface. Soil gas monitoring and respiration tests indicated that the soil's aerobic microbial activity and air permeability are high enough for successful bioventing.

Field Evaluation

In November 1992, baseline soil sampling was conducted and a full-scale bioventing system installed on a 50-ft by 50-ft plot (see Figure 1). A control plot of equal size and contaminant levels also was established to gauge the effectiveness of the bioventing system. The

SITE FACTS



Location: St. Louis Park, Minnesota

Laboratories/Agencies: U.S. EPA Risk Reduction Engineering Laboratory (RREL), Superfund Innovative Technology Evaluation (SITE) Program, U.S. EPA Region 5, Minnesota Pollution Control Agency

Media and Contaminants: Polycyclic aromatic hydrocarbons (PAHs) in soil

Treatment: Bioventing

Date of Initiative Selection: October 1992

Objective: To evaluate the effectiveness of bioventing PAH-contaminated soil

Bioremediation Field Initiative Contacts: Paul McCauley and Richard Brenner, U.S. EPA RREL, 26 West Martin Luther King Drive, Cincinnati, OH 45268

Regional Contact: Daryl Owens, U.S. EPA Region 5, Waste Management Division, 77 West Jackson Boulevard, Chicago, IL 60604

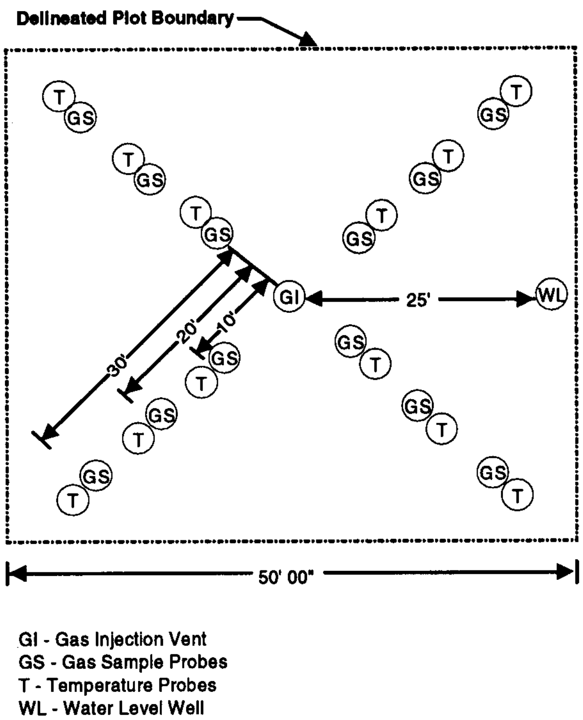


Figure 1. Layout of bioventing installation on experimental plot.

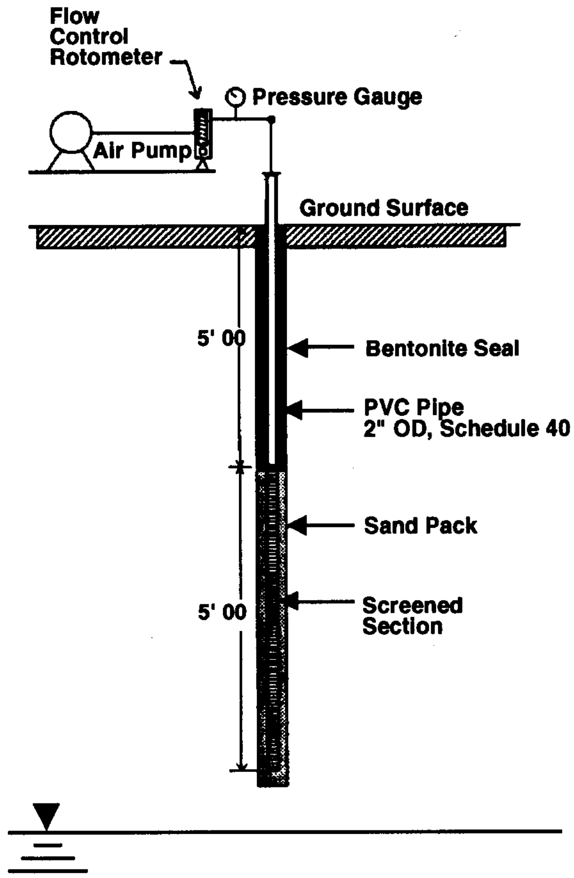


Figure 2. Schematic of air injection vent well.

system consists of one air injection well with screening 5 to 10 ft below ground level (see Figure 2), a 2.5 hp blower, a network of 48 soil gas sampling probes, and a system to monitor soil temperature and ground water elevation. The blower and vent well deliver 100 ft^3 of air per hour to the contaminated soil.

Personnel from the City of St. Louis Park will monitor subsurface temperature, as well as oxygen and carbon dioxide levels, every 2 weeks. In situ respiration tests will be conducted four times per year. At the completion of the project, final soil samples will be collected from the experimental and the control plots.

Status

The demonstration project is expected to last 3 years, at which point it is estimated that soil core samples will show at least a 27 percent reduction in PAH levels. If bioventing successfully remediates PAHs at this rate, complete remediation of the site would take 10 to 15 years should large-scale bioventing be undertaken. The results of this study will determine whether bioventing can be considered at Superfund sites as a cost-effective treatment technology for remediating PAH-contaminated soil.

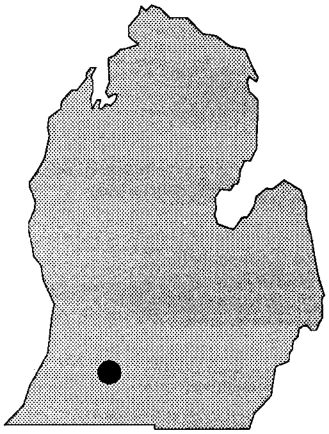
The Bioremediation Field Initiative was established in 1990 to expand the nation's field experience in bioremediation technologies. The Initiative's objectives are to more fully document the performance of full-scale applications of bioremediation; provide technical assistance to regional and state site managers; and provide information on treatability studies, design, and operation of bioremediation projects. The Initiative currently is performing field evaluations of bioremediation at eight other hazardous waste sites: Libby Ground Water Superfund site, Libby, MT; Park City Pipeline, Park City, KS; Bendix Corporation/Allied Automotive Superfund site, St. Joseph, MI; West KL Avenue Landfill Superfund site, Kalamazoo, MI; Eielson Air Force Base Superfund site, Fairbanks, AK; Hill Air Force Base Superfund site, Salt Lake City, UT; Escambia Wood Preserving Site—Brookhaven, Brookhaven, MS; and Public Service Company, Denver, CO. To obtain profiles on these additional sites or to be added to the Initiative's mailing list, call 513-569-7562. For further information on the Bioremediation Field Initiative, contact Fran Kremer, Coordinator, Bioremediation Field Initiative, U.S. EPA, Office of Research and Development, 26 West Martin Luther King Drive, Cincinnati, OH 45268; or Nancy Dean, U.S. EPA, Technology Innovation Office, Office of Solid Waste and Emergency Response, 401 M Street, SW., Washington, DC 20460.

United States Environmental Protection Agency
Office of Research and Development Washington, DC 20460
Office of Solid Waste and Emergency Response Washington, DC 20460

EPA

Bioremediation Field Initiative Site Profile: West KL Avenue Landfill Superfund Site

SITE FACTS



Location: Kalamazoo, Michigan

Laboratories/Agencies: U.S. EPA Risk Reduction Engineering Laboratory (RREL), U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), Center for Microbial Ecology at Michigan State University (MSU), U.S. EPA Region 5, Michigan Department of Natural Resources

Media and Contaminants: Solvents in landfill and ground water

Treatment: In situ bioremediation of landfill material and ground water

Date of Initiative Selection: October 1992

Objective: To evaluate the feasibility of bioremediating the ground water and landfill material

Bioremediation Field Initiative Contacts: John Wilson, U.S. EPA RSKERL, P.O. Box 1198, Ada, OK 74820; Steve Safferman and Fred Bishop, U.S. EPA RREL, 26 West Martin Luther King Drive, Cincinnati, OH 45268

Regional Contact: Dan Cozza, U.S. EPA Region 5, Waste Management Division, 77 West Jackson Boulevard, Chicago, IL 60604

Background

During the 1960s and 1970s, the West KL Avenue Landfill in Kalamazoo, Michigan, was the repository for an estimated 5 million yd^3 of refuse and undetermined amounts of bulk liquid and drummed chemical waste. In 1979, the 87-acre site was closed permanently due to the discovery of contaminants in nearby residential drinking water wells. In 1983, the site was placed on the National Priority List due to the discovery of acetone, methyl ethyl ketone, methyl isobutyl ketone, dichloroethane, benzene, and other contaminants in ground water near the site. The U.S. EPA Risk Reduction Engineering Laboratory (RREL), the U.S. EPA Robert S. Kerr Environmental Research Laboratory (RSKERL), and the Center for Microbial Ecology at Michigan State University (MSU) currently are examining the feasibility of bioremediating the landfill material and underlying contaminant plume.

Characterization

Research conducted in 1990 indicated that the surface system and the aquifer are hydraulically connected, so soluble contaminants leach vertically from the landfill to the saturated zone. The plume of contamination has two lobes that are moving west from the landfill. Figure 1 shows the location of the landfill, nearby lakes, and monitoring wells, as well as the water table surface contour.

Field Evaluation

Research is being conducted under three tasks. The first task, to be conducted by RSKERL, is site characterization and modeling. RSKERL will drill wells in six locations to evaluate the geochemical and hydrological characteristics of the contaminated ground water plume and to monitor the fate and transport of the contaminants. RSKERL will provide site characterization data so that MSU can select appropriate depth intervals to sample for microbial activity.

The second task, to be conducted by MSU, involves the use of microcosms to evaluate the biodegradative capacity of the ground water. Serum bottles with aquifer material and ground water will be used to test for the presence of microorganisms able to degrade representative contaminants. MSU also will use soil-column microcosms to simulate the dynamics of the aquifer environment and estimate the rates of contaminant degradation. Microcosm studies are scheduled to commence in May 1993.

In the third task, which is under way, RREL is using three landfill lysimeter systems to assess the biodegradation of landfill material. One system

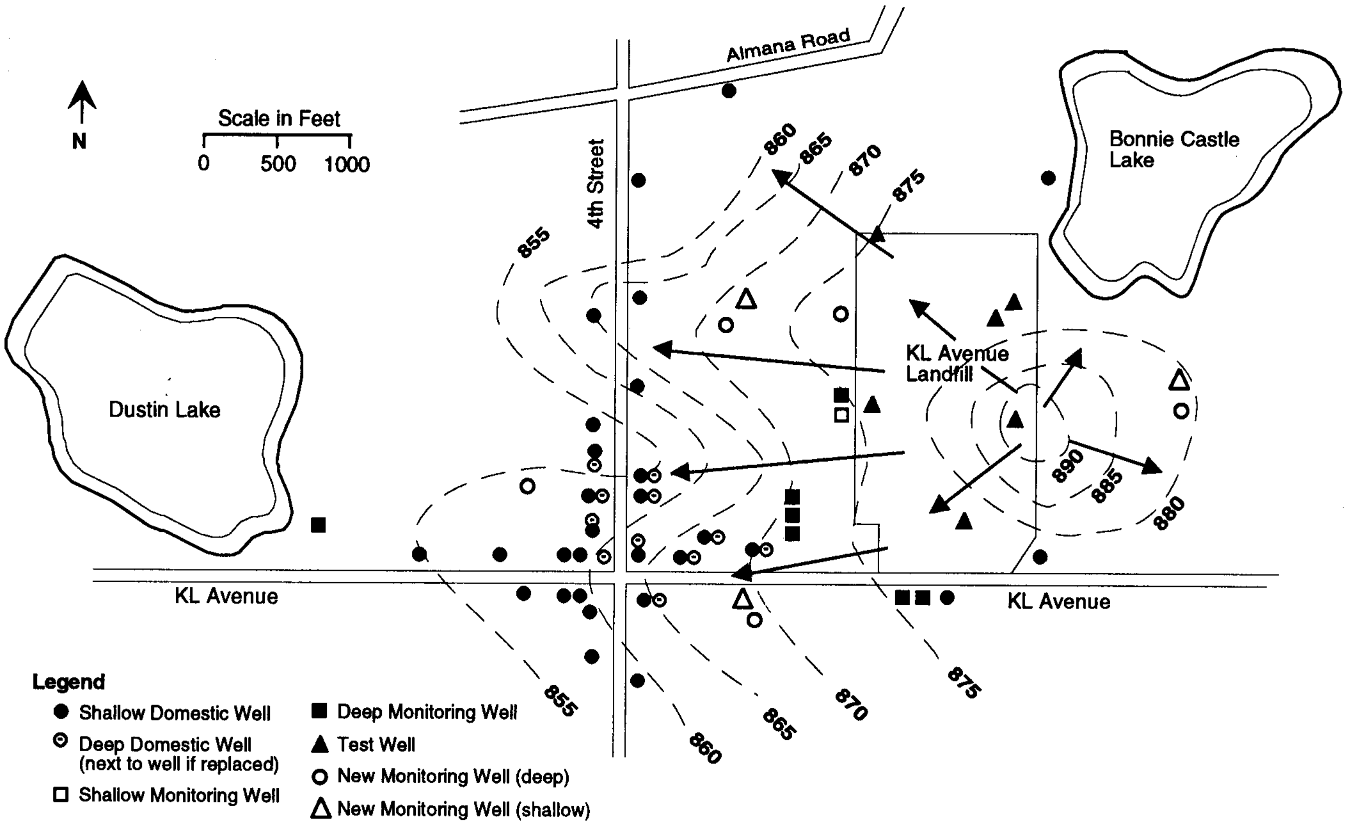


Figure 1. Water table surface contour map showing the location of the landfill, nearby lakes, and monitoring wells.

simulates the effects of a Resource Conservation and Recovery Act (RCRA) cap on the biodegradation of the fill and leachate. A second system serves as a control to assess the biodegradative capacity of the landfill material, simulating existing conditions without a cap. The third system simulates the effects of enhancing naturally occurring bioremediation to optimize biodegradation and biotransformation of the hazardous pollutants in the landfill. RREL obtained landfill samples and loaded the lysimeter systems in January 1993.

Status

A Record of Decision (ROD) was signed by EPA Region 5 in September 1990. The ROD calls for the installation of a RCRA-type landfill cap and a ground water pump-and-treat system utilizing aboveground fixed-film bioreactors. A Consent Decree, entered in the U.S. District Court for the Western District of Michigan on November 17, 1992, ordered the potentially responsible parties to perform the actions described in the ROD. Designs for the landfill cap and the ground water pump-and-treat system are being conducted concurrently with the Bioremediation Field Initiative's evaluation. The actions described in the ROD will be performed unless the ROD is amended based on the results of the Initiative's evaluation of the site.

Preliminary site assessment suggests that natural degradation is occurring in the form of anaerobic dechlorination under sulfate-reducing conditions. Pilot-scale bioremediation of the site will involve anaerobic treatment of leachates under methanogenic and sulfate-reducing conditions. Further site characterization, modeling, and microcosm studies will be conducted in spring of 1993. Laboratory, pilot, and field study results are scheduled to be reported in November 1993.

The Bioremediation Field Initiative was established in 1990 to expand the nation's field experience in bioremediation technologies. The Initiative's objectives are to more fully document the performance of full-scale applications of bioremediation; provide technical assistance to regional and state site managers; and provide information on treatability studies, design, and operation of bioremediation projects. The Initiative currently is performing field evaluations of bioremediation at eight other hazardous waste sites: Libby Ground Water Superfund site, Libby, MT; Park City Pipeline, Park City, KS; Bendix Corporation/Allied Automotive Superfund site, St. Joseph, MI; Eielson Air Force Base Superfund site, Fairbanks, AK; Hill Air Force Base Superfund site, Salt Lake City, UT; Escambia Wood Preserving Site—Brookhaven, Brookhaven, MS; Reilly Tar and Chemical Corporation Superfund site, St. Louis Park, MN; and Public Service Company, Denver, CO. To obtain profiles on these additional sites or to be added to the Initiative's mailing list, call 513-569-7562. For further information on the Bioremediation Field Initiative, contact Fran Kremer, Coordinator, Bioremediation Field Initiative, U.S. EPA, Office of Research and Development, 26 West Martin Luther King Drive, Cincinnati, OH 45268; or Nancy Dean, U.S. EPA, Technology Innovation Office, Office of Solid Waste and Emergency Response, 401 M Street, SW., Washington, DC 20460.

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