EPA/600/R-10/001/June 2010/www.epa.gov/landscience

United States
Environmental Protection
Agency

Land Research Program Science Applications Through Partnerships: A Progress Report 2005-2009

SCIENCE

U.S. Environmental Protection Agency
Office of Research and Development

Land Research Program Science Applications Through Partnerships: A Progress Report 2005-2009

U.S. Environmental Protection Agency
Office of Research and Development

NOTICE

Contents

List of Figures

List of Tables

This page left intentionally blank.

Executive Summary

The purpose of this report is to present examples of research by EPA's Office of Research and Development (ORD) that have contributed to addressing complex, environmental cleanup issues at hazardous waste sites from 2005 to 2009. Research activities, which lead to environmental outcomes, are key measures of a high performing research organization.

ORD partnered with EPA's Regional staff to document where scientific findings contributed to site-specific decisions and also reduced the cost of cleanup. ORD also compiled information on use of ORD methods and models in EPA and State guidance documents for remediation of hazardous waste sites.

The report highlights six research areas in which ORD has contributed to addressing technical and scientific challenges, and describes the outcomes resulting from partnering with various stakeholders. The research areas are: 1) groundwater contamination, 2) contaminated sediments, 3) site characterization, 4) landfills, 5) underground storage tanks, and 6) materials management.

Research has led to improved remediation and mitigation of pollution at hazardous waste sites and reduced the cost of cleanup. Outcomes include:

- Saving more than $100 million to remediate contaminated groundwater as a result of partnering with site managers across the country to use improved technologies.

- Assisting States with contaminated sediment assessment and remediation problems by applying new methodologies. The methods have been included in State guidance for hazardous waste cleanup.

- Applying statistical methods for site characterization in State guidance documents.

- Transferring an alternative cover technology for landfills to States, counties, and Federal agencies to provide a cost-effective alternative to traditional landfill covers. The technology transfer is estimated to have saved over $200 million.

- Providing new methods and models to States to better assess and remediate leaking gasoline and gasoline additives from underground storage tanks.

- Supporting EPA's Regions and Office of Solid Waste and Emergency Response (OSWER) with technical reports and guidance on material management issues.

The report provides examples of research outcomes to support the priority of EPA's Administrator for "Cleaning Up Our Communities." Scientific solutions described in the report can be applied to other sites or documents.

This page left intentionally blank.

Introduction

The Office of Research and Development (ORD) is the research arm of the U.S. Environmental Protection Agency (EPA). ORD provides policy makers and environmental managers with innovative tools, based on sound scientific research, to make informed environmental decisions that protect the environment and public health. The science conducted by ORD's research programs provides critical information required to solve environmental issues and protect our air, water, and land.

ORD's Land Research Program (LRP) focuses on developing the science and technology needed to restore and revitalize land contaminated by hazardous waste. The research program is aligned with the EPA Administrator's priorities of cleaning up our communities and assuring the safety of chemicals.

This report provides examples of responsive, relevant research supporting decisions addressing cleanup issues at hazardous waste sites, primarily from 2005 to 2009. The report presents research topics and includes tables identifying where ORD contributed to address technical and scientific challenges and the outcomes resulting from partnering with various stakeholders. Most LRP outcomes are the result of partnerships with remedial project managers, staff from other EPA offices, Federal agencies, States, and local governments (Appendix A). For some projects, cost savings are documented based on projected savings from a Record of Decision (ROD), which is a legal agreement that provides justification for the remedial action (treatment) at a Superfund site.

ORD's research supports EPA's Office of Solid Waste and Emergency Response (OSWER) and EPA Regional offices that work with States and communities to clean up hazardous waste sites. Within OSWER, ORD's partners include the Office of Superfund Remediation and Technology Innovation (OSRTI), Office of Resource Conservation and Recovery (ORCR), Office of Emergency Management (OEM), and the Office of Underground Storage Tanks (OUST). Additional research partners include Regional and State staff who implement the programs as well as regulated and responsible parties and contractors that perform site specific assessment and remediation.

Relevance: Uses and Outcomes of Land Research Program Activities

ORD programs produce relevant, high quality research products that partners use to make scientifically sound decisions.[1] Measuring the outcomes of research products is important in judging the relevance of a research program. Figure 1 presents the flow of research outputs (e.g., publications, methods, and models) to clients, resulting in short-term outcomes, intermediate outcomes and, then, with actions from the research user, environmental outcomes leading to long-term outcomes.[2]

The Logic Diagram (Figure 1) describes three levels of outcomes:

1. Short-term outcomes—Partners use
2. Intermediate outcomes—Regions, States, and private sector use
3. Environmental outcomes—cost-effective reductions in risk

For further information on performance measures see Appendix B.

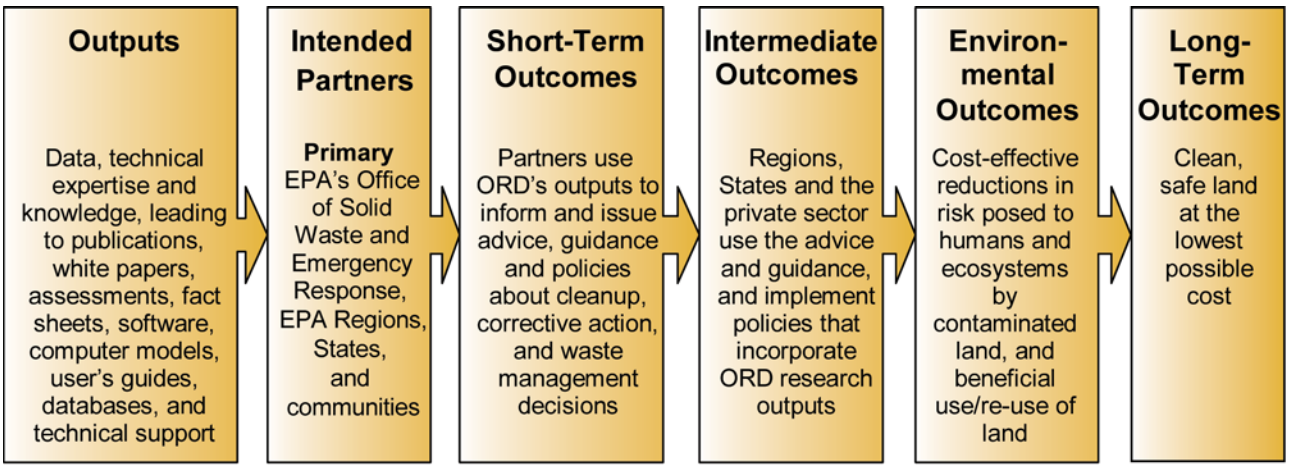


Figure 1. Land Research Program Logic Diagram

---

[1] Further information on research outcomes and related annual performance measures are available at epa.gov/landscience

[2] The National Research Council (2008) defined research activities leading to intermediate and ultimate outcomes. Evaluating Research Efficiency in the U.S. Environmental Protection Agency, National Research Council, 2008 "In its discussion the committee uses the terms inputs, outputs, and outcomes as defined by OMB, except as modified: Inputs are agency resources—such as funding, facilities, and human capital—that support research. Outputs are activities or accomplishments delivered by research programs, such as research findings, papers published, exposure methods developed and validated, and research facilities built or upgraded. Outcomes are the benefits resulting from a research program, which can be short-term, such as an improved body of knowledge or a comprehensive science assessment, or long-term, such as lives saved or enhancement of air quality, that may be based on research activities or informed by research but require additional activities by many others. The committee distinguishes these two types of outcomes using the terms, intermediate outcomes and ultimate or end outcomes."

Groundwater Contamination

Over 80 percent of the most serious hazardous waste sites in the United States have adversely affected the quality of nearby groundwater. Experience has shown that cleaning up contaminated groundwater using conventional methods can be time-consuming and costly, and is often not completely effective in reducing pollution.

EPA research is providing innovative solutions to cleaning up groundwater contaminants, resulting in more effective removal or containment of the pollutants, and reduction in cost and often cleanup time. Three classes of groundwater contaminants are being studied – dense non-aqueous phase liquids (DNAPLs), inorganic species, and fuel components, including oxygenates.

Researchers are advancing the development of remediation techniques, such as in-situ chemical oxidation (ISCO), monitored natural attenuation (MNA), and permeable reactive barriers (PRBs) to treat groundwater contaminants. Investigating site characterization improvements ensures that contaminants can be better evaluated and the most effective remediation technique can be selected.

EPA scientists and Remedial Project Managers (RPM) have worked together to apply these technologies to solve a variety of groundwater contamination challenges. Projected cost savings, typically from Records of Decision (ROD), indicate the benefits of this working relationship, totaling over $100 million for the 14 sites presented in Table 1. The application of these technologies enables site managers to reach solutions to complex environmental problems that are cost-effective and reduce risks to the public.

APPLICATION

A new ORD technology developed and applied to treat hexavalent chromium at the Macalloy Corporation Superfund Site in Charleston, SC successfully reduced contaminant levels and resulted in an estimated $500,000 cost savings.

Table 1 provides other examples of how research has contributed to solving site-specific groundwater contamination problems.

Table 1. Applications for Groundwater Contaminants

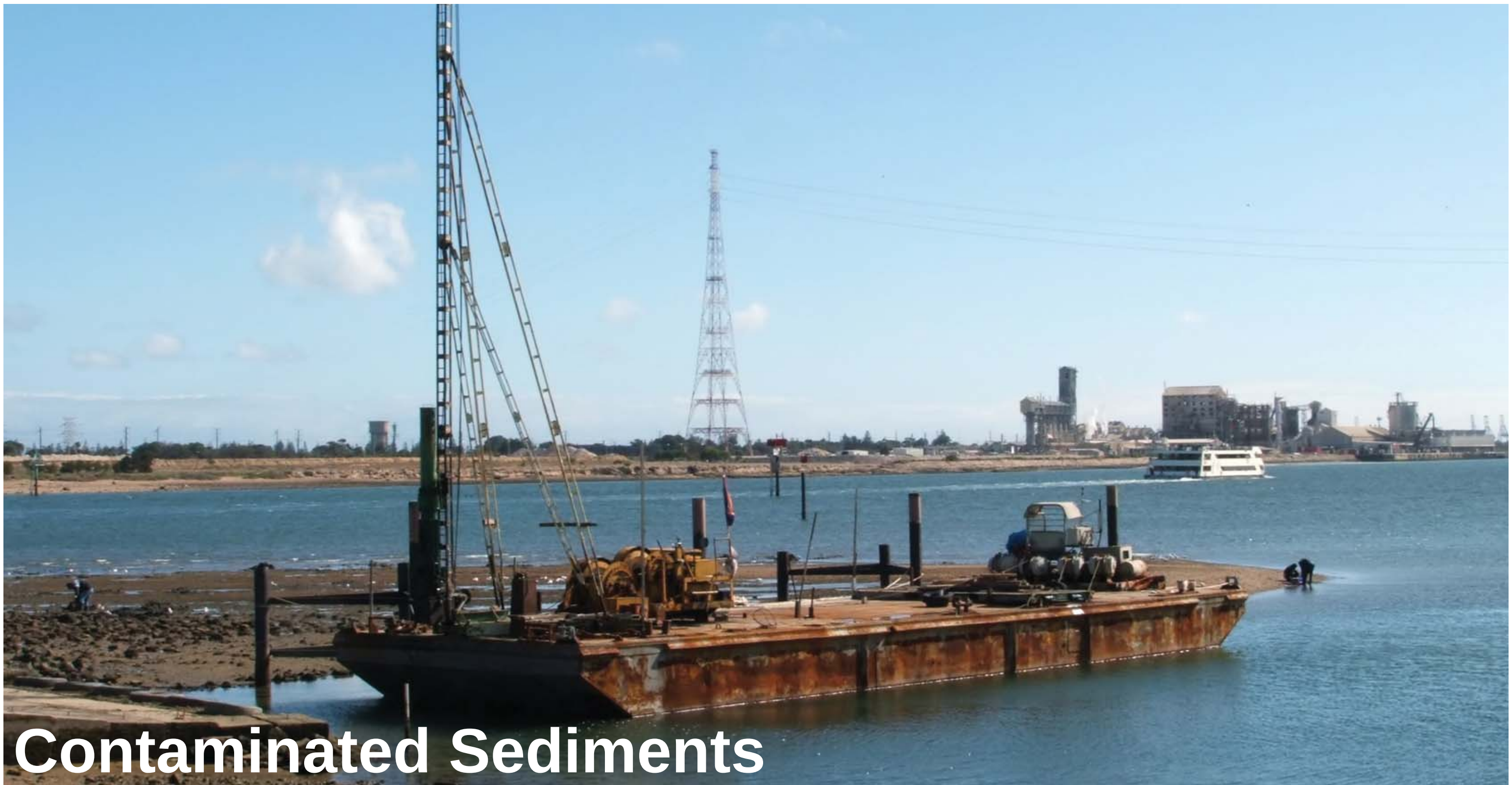
Site	Problem/ Technology Applied	Outcome	Reference
Parkview Well Superfund Site Operable Unit (OU) 2: Grand Island, NE, EPA Region 7	ORD partnered with Region 7 staff to provide technical guidance on the use of in-situ chemical oxidation (ISCO) process to remove volatile organic compounds (VOCs) from groundwater	Cost savings is estimated to be $70 million compared to conventional pump and treat (P&T) alternative	Record of Decision (ROD), OU2 2007 (see pages 26-33, and 52): *http://www.epa.gov/superfund/sites/rods/fulltext/r2007070002056.pdf*
Industri-Plex Superfund Site OU2 (including Wells G&H Superfund Site OU3): Woburn, MA, EPA Region 1	ORD partnered with Region 1 staff on site characterization, remedy selection, the field investigation, and was instrumental in selecting a cost-effective remedy solution. Monitored Natural Attenuation (MNA) technology and in-situ enhanced bioremediation (ISEB) were used to reduce arsenic transport from the site to a wetland	Cost savings is estimated to be $11 million compared to conventional P&T alternative	ROD for OU2 and Wells G&H OU3 2006 (see tables K-3 & K-8). ROD OU2 and Wells G&H OU3 2006 (see page 97 and tables K-3 & K-8): *http://www.epa.gov/ne/superfund/sites/industriplex/70376.pdf* Proposed Plan 2005 (see pages 6-8): *http://www.epa.gov/region01/superfund/sites/industriplex/233375.pdf*
Billings PCE Groundwater Site: Billings, MT, EPA Region 8	ORD partnered with Region 8 staff to provide technical guidance to apply a new soil treatment using sodium permanganate to remove chlorinated VOCs from soil	On-site treatment resulted in cost savings estimated to be $700,000 compared to offsite treatment	“Billings PCE On-site Soil Treatment Cost Savings,” January 29, 2009, provided by on scene coordinator (OSC)
Pemaco Superfund Site: Maywood, CA, EPA Region 9	ORD partnered with Region 9 staff to serve as a technical lead to apply electrical resistance heating (ERH) to remove VOCs from groundwater	ERH, combined with P&T, and MNA, is believed to be the only method that will meet cleanup goals and is anticipated to meet remedial action objectives in the shortest amount of time	ROD 2005 (see pages 100-103): *http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dc283e6c5d6056f88257426007417a2/a92b6aa03e480880882571a000592991/$FILE/PEMACO_ROD_JAN_2005.pdf* Proposed Plan 2004 (see pages 11-16): *http://yosemite.epa.gov/R9/SFUND/R9SFDOCW.NSF/db29676ab46e80818825742600743734/8fe2b4e33364497e88257007005e9404!OpenDocument*
Solvents Recovery Service of New England: Southington, CT, EPA Region 1	ORD partnered with Region 1 staff to apply in-situ thermal treatment and MNA to remove VOCs. ORD assisted on site characterization and the remedial investigation/feasibility study (RI/FS) process, countered technical positions held by the principal responsible party (PRP) consultants, and articulated the scientific basis for EPA’s decision	As a result of ORD’s work, the Region is applying a groundwater remediation technology, even though the site was originally considered too technically impractical to clean up. This treatment is the most cost-effective of the alternatives evaluated	ROD OU3 2005 (see pages 57-62 & 110-112): *http://www.epa.gov/superfund/sites/rods/fulltext/r0105008.pdf* Proposed Plan 2005 (see pages 10-11): *http://www.epa.gov/region01/superfund/sites/srs/229296.pdf* Draft Feasibility Study 2005 (see pages 5-6): *http://www.epa.gov/region01/superfund/sites/srs/222220.pdf*

Table 1. Applications for Groundwater Contaminants

Site	Problem/ Technology Applied	Outcome	Reference
Savage Municipal Water Supply Well Superfund Site OU1: Milford, NH, EPA Region 1	ORD partnered with Region 1 staff on pilot tests and field application of ISCO remediation to treat contamination by chlorinated solvents	By speeding up the remediation, this method is expected to result in significant cost savings to the State due to less time for P&T	The preliminary closeout report indicated using ISCO is planned and that these treatments will result in reduced contaminant levels. Preliminary Close Out Report 2006 (see pages 3-4 & 8-9): *http://www.epa.gov/region1/superfund/sites/savage/256592.pdf*
Fulton Avenue Superfund Site: North Hempstead, NY, EPA Region 2	ORD partnered with Region 2 staff to identify technical issues to address in the draft feasibility study report. ISCO was used to treat perchloroethylene (PCE) contamination and to restore the water quality in the aquifer more quickly than the other methods	ISCO accounts for 16% of total project costs, but significantly contributes to improved outcomes because the timeframe of remediation is shortened. ISCO technology has a $1.2M cost savings over P&T	ROD 2007 (see pages 25, 33, & Appendix VI): *http://www.epa.gov/superfund/sites/rods/fulltext/r2007020002542.pdf*
Savannah River Site, L-Area Southern Groundwater (LASG): Aiken, SC, EPA Region 4	ORD's technical review recommended a comprehensive performance monitoring program to ensure that remedial action objectives were met. MNA was used to treat contamination of groundwater from PCE, trichloroethylene (TCE), and tritium	Cost savings is $13 million (co-mingled VOCs and Tritium Plume = $3,346,000 and Tritium Plume West of the Reactor = $10,125,000) when compared to the next cheapest alternative	ROD LASG 2007 (see pages 42-43 & 52): *http://www.epa.gov/superfund/sites/rods/fulltext/r2007040001556.pdf*
10th Street OU2 Superfund Site: Columbus, NE, EPA Region 7	ORD partnered with Region 7 staff to review documents and apply pilot study results into the final design. ISCO was determined to be the most effective of the treatment alternatives at the least cost for PCE and TCE contaminated groundwater	Cost savings is estimated to be $1.3 million compared to other treatments	ROD OU2 2005 (see pages 27-32 & 38-39): *http://www.epa.gov/superfund/sites/rods/fulltext/r0705051.pdf* ROD 2005; semi-annual chemical oxidation injections began 2007 and additional injections were completed in 2009
Altus AFB, OK, EPA Region 6	ORD partnered with Region 6 and AF staff to apply a permeable reactive barrier (PRB) to treat TCE contaminated groundwater instead of conventional P&T	Cost savings is estimated to be $8 million	ORD highlight: *http://www.epa.gov/region6/6pd/rcra_c/pd-c/altus.pdf*

Table 1. Applications for Groundwater Contaminants

Site	Problem/ Technology Applied	Outcome	Reference
ASARCO East Helena plant: Helena, MT, EPA Region 8	ORD partnered with Region 8 staff in the evaluation of cleanup technologies that would be appropriate to treat arsenic and selenium contaminated groundwater	Studies showed that zero valent iron (ZVI) PRB converted mobile dissolved arsenic into immobile arsenic compounds, but the PRB was not effective in removing selenium. So PRBs were removed as an available technology	The case was settled in December, 2009 and the increased cost settlement was in the best interest of the environment and the East Helena community. January 4, 2010 letter of thanks from Region 8 Enforcement Office to the groundwater team managed by Dr. Robert Puls
Hollingsworth Solderless Terminal: Ft. Lauderdale, FL, EPA Region 4	ORD partnered with Region 4 staff on the application of ISEB to remediate TCE contamination	Cost savings is $600,000 when compared to ISCO	Technical memorandum to Galo Jackson from Shaw Environmental, Inc. regarding Hollingsworth Solderless Terminal Site (HSTS)-Remedial Evaluation (see page 6)
Macalloy Corporation Superfund Site: Charleston, SC, EPA Region 4	ORD patented technology for in-situ reduction was used to remediate hexavalent chromium	Cost savings is $500,000 when compared to the ZVI-PRB alternative	Site delisted in 2006. ROD 2002 (see pages 9-35 & 9-36): *http://www.epa.gov/superfund/sites/rods/fulltext/r0402084.pdf*
Ogden Railyard OU4: Odgen, UT, EPA Region 8	Used guidance for MNA remediation of chlorinated VOC contamination	ORD partnered with OSWER staff to produce an OSWER Directive. The Directive will result in comprehensive data gathering requirements and will improve monitoring and remediation performance data	ESD OU 4 2006: *http://www.epa.gov/superfund/sites/rods/fulltext/e0806001.pdf*



Contaminated Sediments

Contaminated sediments continue to cause significant environmental problems that impair the uses of many water bodies and are often a contributing factor to the more than 3,200 total fish consumption advisories that have been issued nationwide. When addressing remediation of chemically contaminated sediments in rivers, lakes, and other water bodies, which can cause harm to aquatic life and public health, EPA works with States and responsible parties to clean up these hazardous releases. Their removal or containment, however, poses considerable remediation challenges, often requiring new scientific and technological approaches.

EPA research into conventional and innovative sediment remediation techniques—including dredging, capping, and monitored natural attenuation—is addressing the cost, limitations, and uncertainties of cleanup efforts. Research products to support ecological and human health risk assessments include: Biota-Sediment Accumulation Factors (BSAF), a PCB Residue Effects Database (PCBRes), and Ecological Sediment Benchmarks (ESB). BSAFs are used to evaluate the transfer of chemicals from sediments into the aquatic food chain. Output from the BSAF dataset can interface with the PCBRes to determine if accumulated levels may be of concern relative to effects documented in the toxicological literature.

Scientists are collaborating with partners to evaluate remediation methods and monitoring tools at contaminated sites. They are also evaluating the use of passive samplers that can simulate the uptake of PCBs in fish. These samplers may be an effective tool to determine the effectiveness of risk management approaches to cleaning up contaminated sediments.

APPLICATION

ORD's technical expertise and assistance led to the effective treatment of arsenic in sediment and groundwater in Fort Devens, MA. The project manager in EPA's Region 1 Office called the support "priceless."

Examples of sediment research products and site-specific support are in Tables 2 and 3.

Table 2. Sediment Technology Applications

SITE	Problem Addressed	Why Chosen	Outcome
Fort Devens Superfund Site, Plow Shop Pond (Red Cove) AOC72: Worcester, MA, EPA Region 1	Source control of a groundwater (GW) plume so that remediation of contaminated sediments will have long-term effectiveness	ORD's work will be the foundation for the remedial investigation (RI) and for a remedy, if needed. ORD suggested soil volatile extraction (SVE) as more cost effective remedy than in-situ chemical oxidation (ISCO) at the site. Recommendations for remediation include supplemental pump and treat (P&T) system, permeable reactive barrier (PRB), or in-situ manipulation of an aquifer impacted by landfill	"…their [ORD] assistance, support and the results on this research project are priceless. ORD's project has been an incredible jump start for Red Cove."- G. Lombardo, Regional Project Manager (RPM) OSWER 2009 National Notable Achievement Award to the ORD team. ORD research began in 2005, participation ongoing; RI began in 2009
Tennessee Products (Chattanooga Creek): Chattanooga, TN, EPA Region 4	Polycyclic aromatic hydrocarbons (PAHs) (creosote) contamination	Active Sediment Caps, AquaBlok®, is a cost effective alternative to dredging and it will minimize advective transport	ORD's suggested monitoring plan will save $10,000 annually. Record of Decision (ROD) 2006; Final Close Out Report for the site 2008: *http://www.epa.gov/Region4/waste/npl/npltn/tennprtn.htm*
Grand Calumet River, IN, Area of concern (AOC), Great Lake National Program Office (GLNPO) at EPA Region 5	Contamination by PAHs	Active Sediment Caps, AquaBlok®, is a cost effective alternative to dredging and it will minimize advective transport	Research on sorbents and sorption capacity and studies on the physical stability of various active caps in dynamic environmental settings will improve the feasibility study process by realistically estimating the caps' ability to reduce advective transport, physical longevity, and replacement cost. Design 2008/2009
Olin Chemical (Macintosh Plant): Macintosh, AL, EPA Region 4	Mercury contamination	Active Sediment Caps, AquaBlok®, is a cost effective alternative to dredging and it will minimize advective transport	As described above research will improve the feasibility study process. RI/FS due fall 2009; ROD 2010
Lake Hartwell, SC, EPA Region 4	Polychlorinated biphenyls (PCB) contamination of lake; fish contamination	ORD team collected monitoring data to show the effectiveness of the remediation	Technical guidance on Monitored Natural Remediation (MNR) was used at the sediment sites. ORD worked with the RPM on a ROD mandated monitoring plan
Ashtabula River, OH, AOC GLNPO at EPA Region 5	PCB contamination of river, fish contamination	ORD team collected data on dredging residuals/resuspension, bioavailability, risk reduction, and application of new tools	Data supports GLNPO remediation effectiveness evaluation by generating field information on application of biological methods and semi-permeable membrane devices (SPMDs)

Table 3. Sediment Methods and Models Used in Site Assessment

Site Name or User	Problem Addressed	User Application	Outcome, Documentation
Biota-Sediment Accumulation Factors (BSAF)			
Lower Passaic River Restoration Project: NJ, EPA Region 2	Lack of site-specific BSAF; therefore, needed a literature value	Used BSAF dataset to help bound the value chosen from the literature	Risk assessment still in draft form; Focused Feasibility Study (FFS) uses ORD databases (BSAF, Eco-SSL) for value guidance Draft FFS: 2007 *http://www.ourpassaic.org/projectsites/premis_public/index.cfm?fuseaction=EarlyAction*
Portland Harbor Superfund Site: Harbor Oil site; Portland, OR, EPA Region 10	Sediments contaminated with PCBs, metals, arsenic, pesticides, and PAHs	BSAFs used to describe the accumulation of sediment-associated organic compounds or metals in tissues of ecological receptors. Guidance was followed in developing BSAFs in Remedial investigation/feasibility study (RI/FS)	Portland Harbor RI/FS: Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report-Appendix E: 2007. EPA/600/R-06/045: *http://www.epa.gov/r10earth/cleanup/PH/Round2/2007-02-21_CompR2Rep_AppE.pdf*
Ecological Sediment Benchmarks (ESB)			
Big John Salvage-Hoult Road Superfund Site: Fairmont, WV, EPA Region 3	Monongahela River and tributary sediment contamination from this site and potentially from an adjacent national priorities list (NPL) site	ESBs are the most complete compilation on the relative toxicity of PAHs and their derivatives	The analytical data collected have been used in the weight of evidence approach to derive an ecologically-protective concentration of PAHs in the river sediments. It will be used to determine relative contribution from each of the NPL sites. 2006. PAH Mixtures: EPA-600-R-02-013
Hog Island Inlet: St. Louis River AOC, GLNPO at EPA Region 5	Sediment contamination	Benchmarks address bioavailability to support assessment/remedial target review	ESBs were used to develop/evaluate sediment remedial target for PAHs. Also, the following reports were used to evaluate post-remediation conditions: 2005-2006. PAH Mixtures: EPA-600-R-02-013; Metal Mixtures: EPA-600-R-02-011
Ruddiman Black Lagoon – Trenton Channel: Detroit River and Creek – Muskegon, MI, GLNPO. Similar support at 8 GLNPO sites. EPA Region 5	Sediment contamination	Benchmarks address bioavailability to support assessment/remedial target review	ESBs supported the use of a residual cover after sediment remediation based on projected residual sediment concentrations (PAHs and metals). Also, the following reports were used to evaluate post-remediation conditions: PAH Mixtures: EPA-600-R-02-013; Metal Mixtures: EPA-600-R-02-011

Table 3. Sediment methods and models used in site assessment

Site Name or User	Problem Addressed	User Application	Outcome, Documentation
Indian River Power Plant: DE, EPA Region 3	Sediment contamination	Chemical partitioning (EqP) was used in estimating pore water concentrations and to evaluate the toxicity of the PAHs to benthic organisms	Quotient summed to yield a Toxicity Unit (TU). TU used to estimate benthic toxicity and identifies PAHs that may be responsible. Bioavailability data used to establish cleanup level. PAH Mixtures: EPA-600-R-02-013
(Former) General Motors Corporation (GM) Assembly Plant Site: the lower Hudson River estuary Sleepy Hollow, NY, EPA Region 2	Contamination by metals, PAHs, and petroleum compounds	Both simultaneously extracted metals/acid volatile sulfide (SEM/AVS) and interstitial (pore) water benchmarks used for toxicity evaluation	Toxicity data supported clean-up agreement. Work Plan: Supplemental Sediment Investigation Work Plan for Brownfield Cleanup Agreement-West Parcel Former General Motors Assembly Plant Site." 2006. Metal Mixtures: EPA-600-R-02-011 *http://www.dec.ny.gov/docs/remediation_hudson_pdf/swpwoutfig.pdf*
ESB used in guidance Texas Commission on Environmental Quality (TCEQ)	Ecological risk assessment	TCEQ: Update to Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas RG-263	*http://www.tceq.State.tx.us/remediation/trrp/guidance.html* (guidance temporally unavailable online as of 8/26/09), 2006
ESB used in guidance U.S. Geological Survey	Water quality assessment	Website Guidance USGS: National Water-Quality Assessment (NAWQA) Program	*http://water.usgs.gov/nawqa/pnsp/benchmarks/source.html#II*
ESB used in guidance, Europe	Water management	EUGRIS: portal for soil and water management in Europe	*http://www.wugris.info/displayresource.asp?ResrouceID=6410&Cat=document*
ESB used in guidance, SedWeb	Sediment assessment	SedWeb: Links to EPA documents, guidance, and databases	*http://www.sediments.org/*
PCB Residue Effects Database (PCBRes)			
Portland Harbor (Oregon) Superfund Site: Portland, OR, EPA Region 10	Sediment and biota contamination	Benchmark data used for Hazard Quotient (HQ) calculations. PCBRes information used to derive tissue based toxicity reference values, EqP PAH benchmarks used as comparison in baseline RA	1) Draft RI report, and 2) methodology as a case study for the Pellston workshop book on tissue residue approaches (in collaboration with Dave DeForest). Draft RI: End of July, 2009
LCP Chemicals site, Georgia; Holtra Chem/Honeywell, NC; Anniston, AL; EPA Region 4	Sediment and biota contamination	PCBRes used to obtain toxicity information and tissue residue effects levels	PCBRes used in draft risk assessment

Site Characterization

Hazardous waste sites must be properly characterized before appropriate remedial actions can be developed. This involves determining what contaminants are present and their concentrations in soil, groundwater, and any other media. Many conventional site characterization techniques are time-consuming and may not provide appropriate data, leaving considerable uncertainty about key issues.

EPA research is leading to faster and more accurate methods to identify and quantify commonly occurring and difficult-to-address contaminants, including dioxins, polychlorinated biphenyls (PCBs), pesticides, and metals. Immunochemical and other bioanalytical methods that promote more rapid site characterization and monitoring of remediation effectiveness have also been developed. Field sampling and analytical methods have been proven, and guidance from these efforts has been widely disseminated to site managers and other decision makers.

Researchers are developing statistical methods to reduce data uncertainty, as well as advanced statistical analysis software to assess the validity of analytical data. ProUCL, a statistical software EPA typically uses for determining exposure point concentrations, has gained acceptance in State guidance and is used by thousands of registered risk assessment users. The SCOUT software program (*http://www.epa.gov/nerlesd1/databases/scout/abstract.htm)*, a compilation of the latest statistical techniques that help site managers evaluate data, is used worldwide in academia, industry, and government. Research is solving many site-specific problems across the nation.

APPLICATION

ORD's latest statistical techniques for site characterization, compiled in a database called SCOUT 2008, have been downloaded more than 2,000 times worldwide and are used by scientists in academia, industry, and government.

Tables 4 and 5 provide other examples of the applications of several analytical methods and the use of the ProUCL model by various States.

Table 4. Statistical Methods

State, Federal Agency or Country	Title of Guidance Document	Website Link
ProUCL Statistical Method Applications		
	ProUCL definition: Statistical software for the determination of upper confidence limits typically used by regulators for the determination exposure point concentrations, 2007	*http://www.epa.gov/nerlesd1/tsc/software.htm*
Indiana Department of Environmental Management	ProUCL Statistical Analysis Tool	*http://www.in.gov/idem/4209.htm*
New Jersey Department of Environmental Protection	Guidance Document: Directions to Determine 95% Upper Level of the Mean Using ProUCL Version 4.0, 2008	*http://www.nj.gov/dep/srp/guidance/rs/proucl.pdf*
Arizona Department of Environmental Quality	Tank Programs Division: Introduction to underground storage tanks (UST) Tier 2 Evaluation Software, 2008	*http://www.azdeq.gov/environ/waste/ust/lust/tier2.html*
Department of Energy (DOE) Los Alamos National Laboratory (LANL) and the Environmental Programs (EP) Directorate	SOP for Performing Human and Ecological Risk Screening Assessments, 2009	*http://www.lanl.gov/environment/all/docs/qa/ep_qa/SOP-5244.pdf*
Oregon Department of Environmental Quality	Calculating the One-Sided 90% Upper Confidence Limit of the Mean	*http://www.deq.State.or.us/lq/upperconfidencelimit.htm*
Ohio Environmental Protection Agency	Guidance for Computing the 95% UCL of an Environmental Data Set, 2005, updated 2009	*http://www.epa.State.oh.us/derr/vap/tgc/VA30007-09-028.pdf* *http://www.epa.ohio.gov/portals/30/vap/tgc/VA30007-09-028.pdf*
Montana Department of Environmental Quality	Montana Department of Environmental Quality Remediation Division Action Level for Arsenic in Surface Soil, 2005	*http://deq.mt.gov/Statesuperfund/PDFs/ArsenicPositionPaper.pdf*
Italy	Allegato2: Elaborazioni mediante software ProUCL 3.0 delle concentrazioni di PCBtot sugli alimenti di origine vegetale	*http://www.aslbrescia.it/asl/media/documenti/pcb/brescia_aprile_2008/15%20-%20Allegato%201%20-%202.pdf*
Federal Remediation Technologies Roundtable	Site Screening	*http://www.frtr.gov/decisionsupport/DST_Tools/ProUCL.htm*
Virginia Department of Environmental Quality	Voluntary Remediation Program Risk Assessment Guidance, 2008	*http://www.deq.State.va.us/vrprisk/raguide.html*
State of Hawaii Department of Health: Office of Hazard Evaluation and Emergency Response	Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan, 2009	*http://www.hawaiidoh.org/tgm.aspx*
New Hampshire Department of Environmental Services: Environmental Health Program	Technical Background for the 2008 Update to the New Hampshire Statewide Mercury Fish Consumption Advisory, 2008	*http://des.nh.gov/organization/commissioner/pip/publications/ard/documents/r-ard-08-1.pdf*

Table 5. Analytical Methods

Problem Addressed	Why Chosen	User Application	Outcome, Documentation
Volatile organic carbon (VOC) extraction and analysis	Vacuum distillation method has been successfully developed to improve the extraction of VOCs from difficult matrices	Technique was used to create two SW-846 methods (8261A and 5032) and has been practiced in several Regional laboratories and Superfund's Quality Assurance Testing laboratory	RCRA SW-846 methods (8261A and 5032)
Polychlorinated biphenyls (PCB) Congener Analysis	Lack of a sensitive method to distinguish PCB congeners	ORD developed a comprehensive method for the determination of PCB congener analysis (journal article)	New method is capable of distinguishing 196 of the 209 PCB congeners. Method provides superior separation of PCB congeners that were difficult to separate
Toxaphene	Initial research was in support of Office of the Inspector General (OIG) request (2005-P-00022) for information on the effectiveness of the existing methodology to determine toxaphene and its congeners	ORD developed a method to improve the analysis and it is currently undergoing round-robin studies in conjunction with the Office of Resource Conservation and Recovery to determine the method's robustness	Method for the analysis of toxaphene to be incorporated into SW-846 methods manual
Field portable X-ray Fluorescence (FPXRF) technologies	The purpose of field demonstrations is to test multiple technologies that accomplish the same analytical objective (e.g., measure dioxins in soils and sediments)	Reports are produced for each manufacturer's technique, method, instrument, etc.	Data from the XRF demonstration was incorporated directly into the new SW-846 Method 6200
Leaching Test Methods	Standard leaching method is too simplistic to be applicable	ORD developed an improved leaching test method. It provides information pertinent to the draft regulation of coal combustion ash	SW-846 Draft Method 1313 - 1316: Liquid-Solid Partitioning as a Function of Eluate pH Using a Parallel Batch Extraction Test: *http://www.epa.gov/waste/hazard/testmethods/sw846/pdfs/6200.pdf*
Leaching Test Methods	Standard leaching method is too simplistic to be applicable	ORD developed tests for determining consistency in leaching test data. It provides information pertinent to the draft regulation of coal combustion ash	SW-846 Draft Method 1317: Concise Test for Determining Consistency in Leaching Behavior

This page left intentionally blank.

Landfills

EPA engineers and scientists are working to make municipal solid waste (MSW) landfills more sustainable by reducing the potential for greenhouse gas emissions generated at landfills, while providing the nation with an economical disposal option and reducing long-term risks associated with landfills.

Researchers are focusing on two innovative approaches to make landfills more sustainable: bioreactor landfills and alternative landfill covers. Bioreactor landfills use moisture to enhance the waste degradation process. Researchers are examining the effects of introducing different types of liquid waste into solid waste landfills. Studies suggest that bioreactor landfills encourage the settlement of solid waste and increase the generation rate of methane to approximately five times that of conventional landfills. Captured methane can be used to produce energy.

Alternative covers for landfills promote evapotranspiration (ET) for environmentally protective and less costly solutions compared to traditional landfill covers. Technology transfer activities have included training and installation of ET covers at State, local, and U.S. Department of Defense facilities. Over the last five years, EPA's Alternative Covers Assessment Program (ACAP) partnered with over 40 facility managers to receive regulatory approval for alternative covers, which resulted in significant cost savings of tens of millions of dollars per year, compared to conventional Resource Conservation and Recovery Act (RCRA)-engineered covers. A discussion of costs for ET covers is presented in Appendix C.

APPLICATION

Over the last five years, ORD scientists have partnered with over 40 landfill managers to transfer technology on alternative landfill covers. This resulted in installation cost savings totaling over 200 million dollars.

Table 6 highlights 12 examples of how research has contributed to solving landfill problems.

Table 6. Technology Transfer of Alternative Landfill Covers

Site Name or User	Problem addressed/ User Application	Outcome	Documentation and Contacts
Altamont Landfill & Resource Recovery Facility: Altamont, CA (Private, Municipal solid waste (MSW), active), EPA Region 9	Evapotranspiration (ET) cover Prairie	Total Savings = $11,800,000 (Cover Size = 472 x Savings per Acre of $25,000) approved full scale	Waste Management Inc. Ken Lewis *http://www.cluin.org/products/altcovers/usersearch/lf_details.cfm?Project_ID=1*
Douglas County Recycling and Disposal Facility: Omaha, NE (Private, MSW, active), EPA Region 7	ET Prairie	Total Savings = $1,650,000 (Cover Size = 55 acres x Savings per Acre of $30,000) Installed	Waste Management Inc. Ken Mertl, District Manager *http://www.cluin.org/products/altcovers/usersearch/lf_details.cfm?Project_ID=11*
Lewis and Clark County Landfill: Helena, MT (Municipal, MSW, active), EPA Region 8	ET Prairie	Total Savings = $430,000 w/ + $1million potential (Cover Size = 8.9 acres so far [240 acres planned] x Savings per Acre of $48,000)	Lewis & Clark County Public Works Department, Will Selser *http://www.cluin.org/products/altcovers/usersearch/lf_details.cfm?Project_ID=34*
Milikin Landfill: San Bernardino County, CA, EPA Region 9	Monolithic ET Cover with native seasonal grasses, perennial bunch grasses, and shallow rooting shrubs could be expected to limit infiltration to less than 0.04% of rainfall	Total Savings = $3,200,000 (Cover Size = 80 x Savings per Acre of $40,000) 2005	GeoLogic Associates Gary Lass *http://www.clu-in.org/products/altcovers/usersearch/lf_details.cfm?Project_ID=42*
U.S. Marine Corps Air and Ground Combat Center (MCAGCC) at Twenty-nine Palms: Twenty-nine Palms, CA, EPA Region 9	Monolithic ET Cover	Total Savings = $1,600,000 (Cover Size = 40 x Savings per Acre = $40,000) 2005	MCAGCC, Clay Longson, Officer-in-Charge of Construction *http://www.clu-in.org/products/altcovers/usersearch/lf_details.cfm?Project_ID=62*
Denver Arapahoe Disposal Site (DADS) Landfill: Arapahoe County, CO, EPA Region 8	Monolithic ET Cover-Full scale	Total Savings = $4,725,000 (Cover Size = 1350 x Savings per Acre of $3,500) 2006	Colorado Department of Public Health Ron Forlina *http://www.clu-in.org/products/altcovers/usersearch/lf_details.cfm?Project_ID=70*
Finley Buttes Regional Landfill: Bordman, OR, EPA Region 10	Monolithic ET Prairie	Total Savings = $75,000,000 (Cover Size = 510 x Savings per Acre of $147,000). 2006	Waste Connections, Inc. Dan Swanson dansw@wcnx.org *http://www.cluin.org/products/altcovers/usersearch/lf_details.cfm?Project_ID=15*

Table 6. Technology Transfer of Alternative Landfill Covers

Site Name or User	Problem addressed/ User Application	Outcome	Documentation and Contacts
Marine Corps Logistics Base Superfund Site: Albany, GA (DOD, mixed, Superfund), EPA Region 4	Pilot study found that ET cover had superior performance in comparison to a traditional clay cover. It was chosen for use at the site and eliminated the clay cap as a contingency remedy in the Engineering Study Design	Total Savings = $5,000,000 (Cover Size = 12 x Savings per Acre of $416,000) 2005	*http://www.cluin.org/products/altcovers/usersearch/lf_details.cfm?Project_ID=37* *http://www.epa.gov/superfund/sites/rods/fulltext/e0405040.pdf*
Walsh Landfill Superfund Site (aka Welsh Landfill): Honeybrook, PA, EPA Region 3	Focused Feasibility Study (FFS) showed that ET cover would meet remedial action objectives and prevent further degradation of groundwater quality. Density of trees will be approximately 770 trees per acre.	Total Savings = $350,000 (Cover Size = 7 x Savings per Acre of $50,000) [S. Acre Estimate] Record of Decision (ROD) Amendment estimates cost savings approximately $1,220,000 when ET is compared to the cap components of the 1990 ROD remedy, installed 2006 ROD Amendment 2003	*http://www.epa.gov/superfund/sites/rods/fulltext/a0303066.pdf* *http://www.clu-in.org/products/altcovers/usersearch/lf_details.cfm?Project_ID=69*
Solvents Recovery Service of New England: NJ (also a groundwater site), EPA Region 2	Volatile Organic Compounds (VOC) groundwater plume. Decrease the groundwater flow into the pump and treat (P&T) system and contribute to cleaning the groundwater of the site. 2,500 mixed-species trees were planted over the plume area. Ongoing monitoring tests indicate significant reduction of contamination and contribution to remediation between 25 and 30% of annual flow	Anticipated cost savings of $12,170,000. ACAP was over 90% less expensive than excavation and off-site disposal of the contaminated soils. Capping in conjunction with deed restrictions and long-term maintenance offers the same overall protection of human health and environment as excavation. ROD 2005	*http://www.epa.gov/superfund/sites/rods/fulltext/r0105008.pdf* *http://www.epa.gov/region01/superfund/sites/srs/229296.pdf* *http://www.epa.gov/region01/superfund/sites/srs/222220.pdf*
Sunshine Canyon Landfill: San Bernardino, CA, EPA Region 9	Monolithic ET Arid Ecosystem achieves regulatory approval using ACAP data and designs	Total Savings = $6,480,000 (Cover Size = 162 x Savings per Acre of $40,000)	GeoSyntec Consultants Tarik Hadj-Hamou THadj-Hamou@geosyntec.com *http://www.clu-in.org/products/altcovers/usersearch/lf_details.cfm?Project_ID=83*

Table 6. Technology Transfer of Alternative Landfill Covers

Site Name or User	Problem addressed/ User Application	Outcome	Documentation and Contacts
Fort Carson: Fort Carson, CO, EPA Region 8	Achieves regulatory approval using ACAP data and designs. Monolithic ET Prairie-Native warm- and cool-season prairie grasses	Total Savings = $1,500,000 (Cover Size = 15 x Savings per Acre of $100,000)	Earth Tech Pat McGuire, Senior Hydrologist pat_mcguire@earthtech.com USACE-Omaha Don Moses donald.d.moses@nw02.usace.army.mil Colorado Department of Public Health and Environment Susan Chaki Susan.Chaki@State.co.us

Underground Storage Tanks

Releases from leaking underground storage tanks (USTs) require States to spend nearly $1 billion annually for remediation efforts. Conventional site characterization techniques often result in inadequate conceptualization of the site, leading to ineffective and inefficient remedial actions. Our scientists and researchers in ORD are working with States and industry to address major challenges faced in developing, selecting, and implementing efficient and cost-effective clean-up remedies for UST sites. These challenges include developing accurate conceptual site models, installing adequate monitoring well networks, and effectively characterizing the chemical compositions present in the fuels stored in USTs.

Accurate computer models can be used to refine conceptual site models and predict contaminant behavior and remedial effectiveness. Scientists developed Optimal Well Location (OWL), a simple tool to evaluate existing monitoring well networks and assist in selecting new monitoring well locations. The Plume Diving Calculator, which estimates prospects for plume diving, was also developed and disseminated to address problematic issues associated with USTs.

Other research into UST issues, including widespread groundwater contamination from methyl t-butyl ether (MTBE), other oxygenates, and lead-scavenger additives, has increased understanding of the effects these fuel components have on contaminant fate and transport, toxicology, characterization, and remedial technologies for UST sites. Studies on fuel composition have led to identification and documentation of issues with lead scavengers and biofuels, as well as a better understanding of MTBE biodegradation and vapor releases from USTs. These studies are helping States improve the quality of their collected data, thereby enabling better remedial and risk management decision making.

APPLICATION

To cleanup leaking underground storage tanks, ORD has provided extensive technical information about the fate of gasoline and fuel additives in the environment and offered remediation expertise directly to State project managers.

Table 7 presents the tools and training activities ORD produces to support States in UST remediation activities.

Table 7. Underground Storage Tank Groundwater Remediation

Problem Addressed	Why Chosen	User Application	Outcome, Documentation
ORD Underground Storage Tank (UST) Models			
Develop a simple tool to evaluate existing monitoring well networks and assist in the selection of new monitoring well locations	ORD developed the Optimal Well Location (OWL) model. It was used by the American Petroleum Institute (API): Regulatory and Scientific Affairs Department	API Technical Protocol for Evaluating the Natural Attenuation of methyl t-butyl ether (MTBE)	*http://www.api.org/ehs/groundwater/oxygenates/upload/4761new.pdf. 2007*
Plumes can dive because of aquifer recharge. The Plume Diving Calculator can estimate the prospects for plume diving assuming simplified flow in a water table aquifer. Inputs to the calculator are the hydraulic conductivity and recharge rate	The Plume Diving Calculator was used by API Soil and Groundwater Technical Task Force	Task Force Report; Downward Solute Plume Migration: Assessment, Significance, and Implications for Characterization and Monitoring of "Diving Plumes"	*http://www.api.org/ehs/groundwater/upload/bull24-2.pdf. 2006*
Plumes can dive because of aquifer recharge	InterState Technology Regulatory Council (ITRC) chose the Plume Diving Calculator as the best model for its guidance document	ITRC Technology Overview: Overview of Groundwater Remediation Technologies for MTBE and TBA	*http://www.itrcweb.org/Documents/MTBE-1.pdf. 2005*
Plumes can dive because of aquifer recharge	The Plume Diving Calculator was cited for use in New England InterState Water Pollution Control Commission report	Leaking UST Line: A Report on Federal and State Programs to Control Leaking Underground Storage Tanks	*http://www.deq.louisiana.gov/portal/Portals/0/UndergroundStorageTank/lustline52.pdf. 2006*
MTBE/ Ethylene dibromide (EDB) biodegradation, vapor releases of gasoline from USTs and EDB contamination levels in light non-aqueous phase liquids (LNAPL) at leaded gasoline release sites	Data obtained by ORD on EDB concentrations in New Hampshire non-aqueous phase liquids (NAPL) drew attention to ongoing EDB threat from large, poorly weathered leaded gasoline releases	The New Hampshire Department of Environmental Services (DES) responded to ORD's information with a large-scale investigation of EDB at gasoline releases sites and found EDB to be an issue at over 60 sites	ORD's research directly influenced the State's program implementation, enhancing the science behind their prioritization of release management Letter of commendation from Thomas Burack, New Hampshire DES Commissioner, May 2009

Table 7. Underground Storage Tank Groundwater Remediation

Problem Addressed	Why Chosen	User Application	Outcome, Documentation
Underground Storage Tanks Research Applications (UST)			
The unique properties of MTBE (and other oxygenates) led to increased incidents release from conventional UST systems, resulting in widespread groundwater contamination. MTBE releases have been documented in every State	ORD provided research into transport and fate, toxicology, and remedial technologies for MTBE (and other oxygenates)	ORD sponsored a field demonstration of three drinking water treatment methods for removal of MTBE. It documented the applicability of analytical methods for MTBE. Through various communication methods, ORD provided aid to States with analytical methods, effective characterization methods, and tools for cleanup of MTBE releases	ORD enabled the States to develop a better understanding of the transport, fate, and characterization of MTBE plumes leading to an enhanced understanding of plume diving. States also improved the quality of collected data on the presence of MTBE and other fuel oxygenates at leaking UST sites, thus enabling more effective remedial and risk-management decision making
Lead Scavengers, EDB and 1,2-dichloroethane, may persist for long periods of time in certain groundwater environments	Assistance was needed to determine the scope and magnitude of the occurrence of lead scavengers at leaking UST sites and to identify key transport and fate mechanisms in order to more effectively mitigate the threat to drinking water	ORD analyzed groundwater samples from 102 sites in 19 States and published a report of lead scavenger research	ORD enabled the States to develop a better understanding of which types of sites might still be contaminated with lead scavengers. They developed a better understanding of the transport, fate, and plume characterization. Improved data quality resulted in better remedial and risk management decision making
Gasoline Composition – Gasoline is a complex mixture of hundreds of petroleum hydrocarbons and other organic compounds plus synthetic additives. Its composition changes seasonally, geographically, and temporally, which results in a large number of boutique fuels	Over the past several years, ORD collected samples of gasoline (and other automotive fuels) from several cities around the country. ORD personnel have presented results of this investigation at the past few national UST conferences and published a technical report	Fuel composition data better enables States to design characterization, monitoring, and remediation tailored to the toxic constituents most likely to be in spilled fuels	ORD's support provided States with information about the contaminants anticipated to be present at leaking UST sites so that vulnerable populations can be better protected from exposure to constituents of gasoline in drinking water. It also enabled more accurate determination of when a release occurred. *http://www.epa.gov/nrmrl/pubs/600r06153/600r06153.pdf*

Table 7. Underground Storage Tank Groundwater Remediation

Problem Addressed	Why Chosen	User Application	Outcome, Documentation
Biofuels have differences from conventional fuels in transport and fate characteristics, and different chemical compositions compared to their petroleum counterparts. This necessitates the use of different analytical methods and (potentially) cleanup technologies, and potential incompatibilities with certain UST system components that can lead to the increased incidence of release	ORD produced technical tools that educate State UST program personnel about biofuels and provided technical assistance in the use of these models. FOOTPRINT – is a screening level model to predict the impact of ethanol on the size of the benzene plume from an UST HSSM-MT3D – is a three-dimensional multiphase transport and fate model with reaction terms for assessing impacts of ethanol fuel releases	Incorporation of models into site assessment for proper placement of sampling intervals leads to better site characterization and more efficient remediation	ORD's support ensured that States are aware that ethanol-blended gasoline releases typically generate longer benzene, toluene, ethylbenzene, and xylene (BTEX) plumes than conventional gasoline, and that higher ethanol blends can generate significant amounts of methane that present a vapor intrusion hazard. *http://www.epa.gov/ada/csmos/models/footprint.html*

Materials Management

EPA is addressing critical issues associated with materials management to reduce risks from waste products, promote their beneficial reuse, and find cost-effective ways to treat problems such as acid mine drainage. Scientists are also providing new insights into contaminant speciation and bioavailability under actual field conditions at Superfund sites.

Conventional methods to determine levels of metals such as lead, arsenic, and organic pesticides do not adequately address their bioavailability under site-specific conditions. Innovative methods to determine contaminant speciation and bioavailability provide better data for more accurate risk assessments. Reliable bioavailability data improve the accuracy of exposure and risk calculations for metals found at Superfund sites. Research is also increasing our understanding of toxicity issues associated with reuse of materials, such as coal combustion residue, gypsum in drywall, and mining materials (chat) in road-making materials.

The use of bioreactors to treat acid mine drainage and remote monitoring of mining sites has led to successful partnerships among researchers, site managers, and academia.

APPLICATION

Through partnerships, ORD has developed and tested bioreactors for treating acid mine drainage and developed monitoring for remote mining sites. The research has led to improved water quality from old mining sites.

Table 8 presents examples of sites where ORD has supported States in their materials management activities.

Table 8. Materials Management

Problem Addressed	Why Chosen	User Application	Outcome, Documentation
An approach to remediate lead, arsenic, organic pesticides in the soil matrix	ORD research developed an alternative approach to remediate lead contaminated sites which considers bioavailability of contaminants in soil. ORD contributed to Office of Superfund Remediation and Technology Innovation (OSRTI) guidance to assist EPA site coordinators nationwide. Remediations can be based not on total metal concentration, but on species and bioavailability	Addition of low cost soil amendments can alter bioavailability, reducing estimated risk from contaminants and the remediation cost	Proposed Record of Decision (ROD) change at Barber Orchards site, NC based on enhanced understanding of contaminant species and their relation to bioavailability. Supports improved assessment of exposure and risk *http://www.epa.gov/superfund/health/contaminants/bioavailability/*. 2009
Flue gas desulfurization (FGD) is used in the production of some drywall products. Evaluate mercury in FGD for worker safety issues	Research modified worker risk assessments for those working to produce drywall comprised of FGD. FGD was characterized and species were determined. Evaluated issues associated with the landfill disposal of FGD drywall	ORD answered key science questions on material reuse to enable guidance on FGD in drywall	Guidance document prepared for Region 5. October 28, 2008 memo from Region 5 Mario Mangino to R5 Julie Gevrenov entitled, Update to: "Draft screening level evaluation of mercury health risk from worker exposure to gypsum dust during construction-demolition activities" (December 16, 2005)
Need to understand the level of risk associated with reuse of specific mineral processing waste	Research needed to determine the risks associated with using mineral processing waste (chat) in roadway construction	Region 6 staff, working with ORD researchers, designed experiments to model real-world application of this material in asphaltic road pavement materials to examine leaching characteristics. Leaching from chat in roadways was determined to exhibit minimal risk	EPA fact sheet and technical paper published. Science issues were addressed and chat is being used as road base. *http://epa.gov/region06/6sf/pdffiles/tar_creek_chat_rule_fact_sheet_june_2007.pdf*
Evaluate bioreactor landfill operational techniques to reduce long-term risk at waste disposal sites	To support the Research Development and Demonstration (RD&D) Rule, guidance was needed for the increasing numbers of bioreactors operated and in development. A better understanding of emissions/carbon assessment was needed	In collaboration between a leading member of waste management industry and ORD, wet cell landfill bioreactor techniques were examined at full scale for application limits, waste degradation, leachate pretreatment, emissions control, and improvement of gas collection and utilization	OSWER RD&D Rule issued and supported by this research. Rule will change how municipal waste landfills are operated to mitigate long-term risk. *http://www.epa.gov/waste/nonhaz/municipal/landfill/bioreactors.htm, www.bioreactor.org*

Table 8. Materials Management

Mining Site Remediation	Why Chosen	User Application	Outcome, Documentation
Standard Mine Superfund Site: Crested Butte, CO, EPA Region 8	Treatment for heavy metals (e.g., cadmium, zinc, lead, and copper) contamination from acid mine drainage of surface water into town drinking water supply	ORD working with Region 8 staff installed a pilot biochemical reactor (BCR) containing three distinct zones (i.e., limestone drainage, organic substrate, and standing water). It reduced heavy metal concentrations. Data were collected remotely using a solar-powered sampling system with transmission of results via satellite	Pilot demonstrates the success of BCRs at cold, remote locations. The combination of metals removal and sulfide generation provided a strong indication that bacteria-mediated metal sulfide precipitation occurred in the BCR. Removal values for cadmium, copper, lead, and zinc were ~98% in the BCR. 2007. *http://www.epa.gov/region8/superfund/co/standard/RutkowskiSME2009.pdf* *http://www.epa.gov/superfund/sites/nplsnl/n0801669.pdf*
Lilly/Orphan Boy mine: near Helena, MT, EPA Region 8	A treatment method was needed to reduce metal contamination from acid mine drainage	A bioreactor of organic matter (consisting primarily of cow manure, combined with decomposed wood chips, and alfalfa straw) was installed to effectively remove metals	Dissolved metals concentrations decreased considerably and pH of the mine water increased. When compared with a more traditional lime treatment system, using the assumption of a 30-year treatment period, the bioreactor was estimated to be less expensive with cost savings ranging from $200,000-$300,000. *http://www.epa.gov/nrmrl/pubs/600r08096/600r08096.pdf*
Nevada Stewart Mine, EPA Region 9	A treatment method was needed to reduce metal contamination from acid mine drainage	ORD worked with Region 9 staff to install a permeable reactive barrier (PRB) to effectively remove zinc and iron from discharge water flowing from the abandoned mine	*http://www.epa.gov/nrmrl/pubs/600r06153/600r06153.pdf*

This page left intentionally blank.

Appendix A

Acknowledgement of ORD, Regional, and State Partnerships

Sites	Partners
Groundwater	
Parkview Well Superfund Site OU2: Grand Island, NE (Region 7)	Bradley Vann (current RPM); Robert Weber (Former RPM); Scott Huling (ORD)
Hollingsworth Solderless Terminal: Ft. Lauderdale, FL (Region 4)	Galo Jackson (RPM); Scott Huling (ORD)
Macalloy Corporation Superfund Site: Charleston, SC (Region 4)	Craig Zeller (RPM); Ralph D. Ludwig, Chunming Su, Steve Acree, Randall Ross, Frank Beck, Pat Clark, and Kyle Jones.
Industri-Plex Superfund Site OU2 (including Wells G&H Superfund Site OU3): Woburn, MA (Region 1)	Joseph LeMay (RPM); Robert Ford and previously Robert Puls (ORD)
Billings PCE Groundwater Site: Billings, MT (Region 8)	Kerry Guy (OSC); Scott Huling (ORD)
Pemaco Superfund Site: Maywood, CA (Region 9)	RoseMarie Caraway (RPM); Eva Davis (ORD)
Solvents Recovery Service of New England: Southington, CT (Region 1)	Karen Lumino (RPM); Scott Huling, Eva Davis, Randal Ross, and Ann Keely (ORD)
Ogden Railyard OU4: Odgen, UT (Region 8)	Erna Waterman (RPM); Steve Acree (ORD)
Savage Municipal Water Supply Well Superfund Site OU1: Milford, NH (Region 1)	Robin Mongeon (State Lead, NHDES); Richard Goehlert (RPM); Scott Huling (ORD)
Delatte Metals Superfund Site: Ponchatoula, LA (Region 6)	Katrina Higgins-Coltrain (RPM); Ralph Ludwig (ORD)
Altus AFB, OK (Region 6)	John Wilson (ORD)
Fulton Avenue Superfund Site: North Hempsted, NY (Region 2)	RPM: Kevin Willis (R2); PI: Scott Huling (ORD)
Savannah River Site, L-Area Southern Groundwater (LASG): Aiken, SE (Region 4)	RPM: Turpin Ballard (R4); Robert Ford and Steve Acree (ORD)
10th Street OU2 Superfund Site: Columbus, NE (Region 7)	RPM: Nancy Swyers (R7); PI: Scott Huling (ORD) and Michelle Simon (ORD)
ASARCO East Helena plant: Helena, MT (Region 8)	RPM: Linda Jacobson (R8); PI: Rick Wilkin and Steven Acree (ORD) Pat Clark (ORD)
Contaminated Sediments	
Fort Devens Superfund Site, Plow Shop Pond (Red Cove) AOC72: Worcester, MA (Region 1)	RPM: Ginny Lombardo and Bill Brandon (R1); Kirk Scheckel, Thabet Tolaymat, Aaron Williams, Pat Clark, Robert Ford, Steven Acree, and Brad Scroggins (ORD)
Fort Devens Superfund Site, Plow Shop Pond (Red Cove) AOC72: Worcester, MA (Region 1)	PI: Bob Lien (ORD)
Tennessee Products (Chattanooga Creek): Chattanooga, TN (Region 4)	RPM: Craig Zeller (R4); PI: Ed Barth (ORD)
Grand Calumet River, IN Area of Concern (Region 5)	Area coordinators: Mike Mikulka, David Petrovskey (R5); PI: Ed Barth (ORD)

Sites	Partners
Pine St. Canal: Burlington, VT (Region 1)	RPM: Karen Lumino (R1); PI: Ed Barth (ORD)
Olin Chemical (Macintosh Plant): Macintosh, AL (Region 4)	RPM: Beth Walden (R4); PI: Ed Barth (ORD)
Passaic River, NJ (Region 2)	RPM: Alice Yeh (R2); PI: Ed Barth (ORD)
Lake Hartwell, SC (Region 4)	Jim Lazorchak, Dennis Timberlake, ORD, Craig Zeller, RPM, R4
Ashtabula River, OH (GLNPO) (Region 5)	Marc Mills, Jim Lazorchak, ORD; Marc Tuchman, GLNPO
Sediment Remediation Research	Souhail Al-Abed (ORD)
Underground Storage Tanks	
Underground Storage Tank (UST) Models	Fran Kremer, Jim Weaver, John Wilson, ORD
Specific Model	Users
OWL (Optimal Well Location)	American Petroleum Institute (API): Regulatory and Scientific Affairs Department
Plume Diving Calculator	API Regulatory Analysis and Scientific Affairs, Soil and Groundwater Technical Task Force
Plume Diving Calculator	InterState Technology Regulatory Council (ITRC)
Plume Diving Calculator	New England InterState Water Pollution Control Commission
Materials Management	
Standard Mine Superfund Site: Crested Butte, CO (Region 8)	RPM: Christina Progess (R8); David Reisman, ORD
Lilly/Orphan Boy mine: near Helena, MT (Region 8)	Program Manager: Diana Bless ORD
Alternative Landfill Covers	Steve Rock, ORD for all sites, Users identified in table
Site Characterization	
ProUCL John Nocerino, ORD	
General	
Randall Wentsel, Patricia Erickson, Jane Denne, Doug Wolf, Ann Brown, ORD; Jennifer Fairbrother, student contractor	

Appendix B

Performance Measures for Research Organizations

Performance measures for research organizations need to focus on increasing the research excellence of the organization. Effective measures are useful for two reasons: they enable appropriate evaluation of the research organization and they are utilized by the research managers within the organization to improve the program. Developing effective performance measures, however, is not a straightforward process. The Government Accounting Office noted in its 1997 report on *Measuring Performance of Federal R&D*:

- The very nature of the innovative process makes measuring the performance of science-related projects difficult.
- There is no single indicator or evaluation method that adequately captures the results of R&D.

Edward Brown[1] agreed that developing meaningful performance metrics for research organizations is difficult. He discussed two main reasons why: the likely outcomes of research cannot be quantified in advance, and outputs leading to outcomes can take years to occur. A report by the National Research Council (NRC) in 2008[2] also noted the difficultly in developing performance measures for research organizations and stressed the importance of expert review. Within this context, Brown proposed three performance questions that stakeholders want answered:

1. Is the research relevant?
2. Is the program productive?
3. Is the research of highest quality?

Relevance is defined as "a relation to the matter at hand."[3] For research activities, relevance is the use of the researchers' expertise and research products by partners to support environmental decisions. The ultimate goal in the utilization of research is enabling environmental outcomes. For productivity, Brown Stated there were no valid metrics for technical performance. However, he stated that input from partners and peer reviews could provide evaluations of program productivity. The quality of a research program includes innovative scientists producing high-caliber products and publications in state-of-the-art facilities. The NRC (2008) Stated that expert review could address investment efficiency, strategic directions, and research quality.

[1]Brown, E. (1997). Measuring Performance at the Army Research Laboratory: The Performance Evaluation Construct. *Army Research Laboratory Journal of Technology Transfer*. 22(2): 21-26.

[2]Evaluating Research Efficiency in the U.S. Environmental-Protection Agency, National Research Council, 2008

[3]Relevance - Definition and More from the Free Merriam-Webster Dictionary." *Dictionary and Thesaurus - Merriam-Webster Online*. Web. 10 Mar. 2010. <http://www.merriam-webster.com/dictionary/relevance>.

Performance Measures

Research program performance measures can be evaluated by activities that primarily address the quality and relevance of the researchers and their research products.

Measures of high-quality research

- Independent peer review can evaluate the strategic directions of the program, the quality of the research being conducted, and evidence of program performance and relevance. ORD activities include:
  - External peer review (e.g., Science Advisory Board, Board of Scientific Counselors [BOSC]).
  - Peer review of the Multi-Year Research Plans.
  - Laboratory or document peer review.
- Tracking citation of open literature publications that identify high-impact papers.
- Acknowledging the number of awards and external recognition of the research scientists.
- Utilizing state-of-the-art facilities.

Measures of relevant research

Relevance of a research program can be evaluated through documenting uses and short-term and long-term outcomes of research products. Lines of evidence include:

- Documenting site-specific applications of research.
- Documenting use of research products in guidance.
- Receiving feedback from partners on application of research products.
- Documenting how research informs regulatory and other EPA decisions.
- Measuring partners citations of research products.
- Communicating with stakeholders on the impacts of research activities and the new research challenges facing EPA Regions and Program Offices. Communication can be facilitated through Research Coordination Teams, program reviews, Deputy Assistant Administrator meetings, seminars, and site specific technical support.

This page left intentionally blank.

Appendix C

Landfill Research:

Alternative Covers Assessment Program Cost Analysis

The Alternative Covers Assessment Program (ACAP) has led to the increased use of evapotranspiration (ET) landfill covers over the past decade with many sites achieving regulatory approval for alternative covers using ACAP data and designs. The utilization of alternative covers when feasible can result in significant cost savings in comparison to conventional Resource Conservation and Recovery Act (RCRA) clay liners. However, cost savings per acre are site specific and depend on many variables making it problematic to assume that cost savings will be the same per acre from one location to another. Further, cost savings are estimated utilizing the assumption of how much a conventional Resource Conservation and Recovery Act subtitle 'C' (compacted clay) cover would cost if installed rather than an alternative cover, but it is possible to consider comparisons between similar sites in estimating such costs.

A range of cost savings are available from various sources. Sandia National Laboratories completed a performance and cost comparison of several landfill cover designs and found that an ET alternative cover provided cost savings of $83.65/m^2 (~$340,000/acre) (1998$) in comparison to the RCRA subtitle 'C' cover and $16.10/m^2 (~$65,000/acre) in comparison to a geosynthetic clay liner (GCL). A capillary barrier alternative cover provided cost savings of $64.90/m^2 (~$260,000/acre) compared to the RCRA subtitle 'C' cover.[1] A cost comparison between RCRA/GCL and alternative covers at several Air Force landfills indicated a cost savings of $200,000-$250,000/acre (1999$).[2,3] Further, it has been conservatively estimated that the use of ET covers on appropriate Air Force landfills could result in a total cost savings of $0.5-$0.75 billion (1999$).[4] Analysis at the U.S. Army facility at Fort Carson, Colorado showed a potential cost savings of approximately $100,000/acre (2001$).[5] The Texas Commission on Environmental Quality (TCEQ) suggests that "the design, engineering, surveying, construction, and quality assurance of an ET cover system typically totals $40,000 to $75,000 per acre, compared with twice that amount for a standard composite cover."[6]

Cost savings of alternative covers (both total and per acre) for this document were solicited by ACAP principle investigator, Dr. Steve Rock, National Risk Management Research Laboratory, from site and project managers. These estimates, as previously stated, require estimating what a conventional cover would cost if utilized at the site in comparison to known costs for the alternative cover. Site managers may have to consider the costs of nearby conventional landfill caps, but the cost savings are estimates from individual manager's professional judgments.

[1] Dwyer, Stephen F. (1998). Construction Costs of Six Landfill Cover Designs. Sandia National Laboratories Report SAND98-1988. Available at: http://prod.sandia.gov/techlib/access-control.cgi/1998/981988.pdf (last accessed 8/24/2009).
[2] Hauser, V., Gimon, D., Hadden, D., and Weand, B. (1999). Survey of Air Force Landfills, Their Characteristics, and Remediation Strategies. Prepared for: Air Force Center for Environmental Excellence. Available at: http://www.afcee.af.mil/shared/media/document/AFD-071203-171.pdf (last accessed 8/24/2009).
[3] Hauser, V., Weand, B., and Gill, M. (2001). Alternative Landfill Covers. Prepared for the Air Force Center for Environmental Excellence. For use by the InterState Technology & Regulatory Cooperation (ITRC) at the Alternative Landfill covers Summit, September 2001. Available at: http://www.afcee.af.mil/shared/media/document/AFD-071203-177.PDF (last accessed 8/24/2009).
[4] Ibid.
[5] McGuire, P., England, J., and Andraski, B. (2001). An Evapotranspiration Cover for Containment at a Semiarid Landfill Site. Abstract for the 2001 International Containment & Remediation Technology Conference and Exhibition: Orlando, Florida. Available at: http://www.containment.fsu.edu/cd/content/srch_f_m.htm (last accessed 8/24/2009).
6 Semrad, S. (2009). "A New Cover for Closed Landfills," Natural Outlook, Winter 2009. Texas Commission on Environmental Quality. Available at: http://www.tceq.State.tx.us/assets/public/comm_exec/pubs/pd/020/09-01/Outlook-Winter09.pdf (last accessed 8/24/2009)

Exact cost savings were not available for some sites when the information was considered proprietary. Figure 2 demonstrates that of those alternative cover sites with available cost data, 89.5% had cost savings of less than $50,000/acre. Approximately 58% of the sites have cost savings/acre of $21,000-$40,000.

The cost savings per acre of the alternative sites in Table 6 are conservative in comparison to most of the literature values referenced above and similar to the more recent estimated cost savings by the TCEQ.

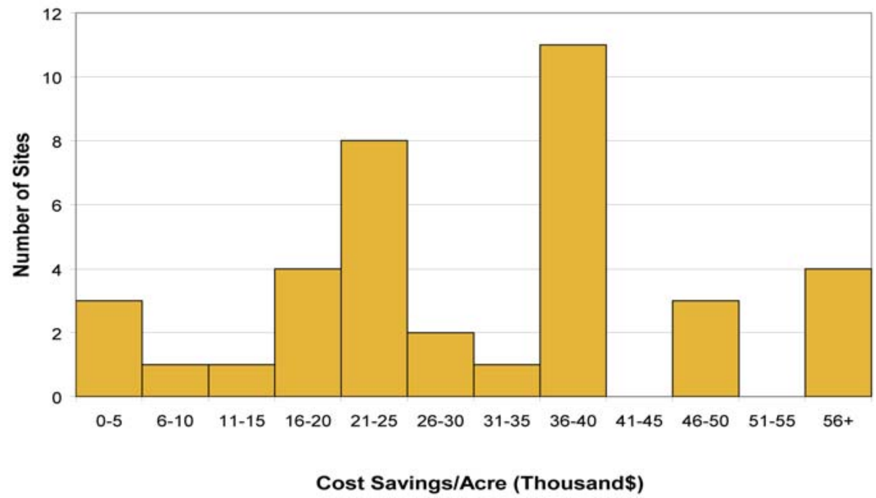


Figure 2. Alternative Cover Sites Cost Savings Per Acre

Printed with vegetable-based ink on paper that contains a minimum of 50% post-consumer fiber content and processed chlorine free.

SCIENCE

EPA
United States
Environmental Protection
Agency

Land Research Program
Office of Research and Development
Washington, DC 20460