# INNOVATIVE, ENVIRONMENTAL REMEDIATION TECHNOLOGIES DEVELOPED BY AN ACADEMIA/GOVERNMENT/INDUSTRY PARTNERSHIP

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## ABSTRACT

The Waste-management Education & Research Consortium (WERC) was initiated in 1990 to meet the personnel and technology needs for environmental restoration at Department of Energy (DOE) sites and elsewhere. Since its beginning, WERC has conducted 166 project years (number of projects times number of years) and has graduated over 200 engineers and scientists from the member institutions. Part of WERC's mission is to deliver advanced technologies to the field demonstration stage for evaluation. This paper describes WERC, those technologies which have entered field demonstration, and how the technology development and education have enhanced one another.

## KEY WORDS

technology development, field demonstration, education, consortium

## INTRODUCTION

The Waste-management Education & Research Consortium (WERC), led by the New Mexico State University (NMSU) College of Engineering, provides educational and technological support in the areas of waste management, environmental remediation and source reduction of pollution. WERC is a consortium consisting of:

- NMSU, which serves as the contracting partner
- Navajo Community College (NCC)
- New Mexico Institute of Mining and Technology (NMIMT)
- The University of New Mexico (UNM)
- Los Alamos National Laboratory (LANL)
- Sandia National Laboratories (SNL)
- several industrial partners, who assist as affiliate members

WERC has developed a network of experts from universities, national laboratories and industries to solve waste problems. WERC has expertise in several areas including:

- project management and coordination
- site investigation and identification of wastes and related impacts
- design and implementation of surface and groundwater remediation schemes

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- design and development of chemical, biological and thermal treatment facilities
- design and development of materials handling and segregation facilities
- design and development of waste landfills
- on-site training and education
- compliance monitoring
- environmental monitoring
- risk analysis

WERC has established an infrastructure and a program to effectively expand the world's capability to address issues associated with needs in waste management, such as:

- providing a national resource of technology development and technology transfer and education, including retraining of a global workforce that rapidly transfers state-of-the-art information to industry and government
- developing and transferring new technologies and using these to train students in state-of-the-art techniques
- increasing human expertise and sensitivity to environmental issues

## Technology development

Technology development and application projects that WERC has undertaken range from characterization and clean-up of waste to economics and public policy. WERC projects include all environmental media and emphasize conversion to site demonstration. Economic benefits include job creation and start-up of new technological industries. Recent research projects have been conducted on the topics of:

- air quality
- biocorrosion
- bioremediation
- contaminant transport
- ground water
- hazardous waste management
- nuclear waste storage
- petroleum waste management
- radioactive waste management
- risk and perception
- robotics
- sensors for waste management
- site assessment
- soil remediation
- thermal waste destruction

## Technology transfer

Technology transfer is accomplished through several methods, including:

- faculty/student internships
- site clean-up demonstrations
- development of environmental laboratories
- industrial partnerships
- conference presentations
- refereed journals

WERC has established five facilities to directly interface with the education programs

and support technology development and technology transfer. Capabilities include organics, heavy metals, inorganics and radioactive species analysis. The facilities are:

### Carlsbad Environmental Monitoring & Research Center (CEMRC)

CEMRC was established in 1991 as a division of WERC and New Mexico State University. The Center is an independent, world-class, laboratory research organization for the study of health and environmental impacts associated with technological development, including nuclear waste storage.

### Soil-Water-Air Testing Facility (SWAT)

Located on the NMSU campus in Las Cruces, SWAT provides analytical services in the areas of toxic and hazardous waste to researchers from the universities and other organizations. The laboratory is equipped for physical, inorganic, organic and bacterial analysis of soil, water, air and plants.

### Hobbs Oil-Water Experimental Facility (HOWE)

HOWE provides for educational, research and development programs related to environmental and waste disposal concerns of the petroleum industry. A field laboratory is available which consists of a watered out petroleum reservoir and supporting equipment.

### Navajo Dryland Environments Laboratory (NDEL)

NDEL provides hands-on training with analytical monitoring to students at Navajo Community College in Shiprock, NM. NDEL supports field and laboratory research in geology, hydrology and resource management.

### Environmental Radioactive Measurement Laboratory (ERML)

The role of ERML, located at UNM, and the Waste Isolation Pilot Plant site near Carlsbad, NM, is exploratory development and research associated with transuranic waste isolation and mixed waste management. It provides support for monitoring WIPP activities and for instrumenting experiments planned by other facilities.

## Education

WERC has established itself as a model, world-class center for expanding the nation's capabilities to address current and future environmental issues. Providing quality, state-of-the-art technical education and training in environmental education serves as the cornerstone of WERC. All WERC members, including the national laboratories, provide education services, student internships, educational support, and collaborative technology development projects. All WERC education programs include interactive televised courses from member universities to provide multidisciplinary education. Major WERC educational programs are:

- Undergraduate and graduate options, minors and degrees in environmental engineering and management.
- Associate degree programs aimed at training technicians for industry needs, including one program specifically designed for Native American Tribal Colleges.
- Courses on environmental process design with technology transfer between universities at an international level.
- Pre-college education programs designed to make pre-college students aware of state-of-the-art technology and promote systemic changes at precollege institutions.

- An Environmental Fellows Program to provide graduate-level technology information to emerging leaders from government and industry.

- The annual WERC International Environmental Design Contest is the only competition of its kind in the world that features university students solving an environmental challenge in a competitive format.

WERC's education programs reach more than 600 students in New Mexico each year, and more than 200 engineers and scientists have graduated with WERC-related minors, certificates or training. Since 1990, broadcast environmental education courses have reached more than 2,000 professionals in the United States. At present, nearly 10,000 students and professionals have viewed WERC programs dealing with all aspects of waste management and environmental restoration.

The Waste-management Education & Research Consortium has, in a short period of time, established a leadership position in environmental education, research and development, training (through short, long and professional courses), outreach programs and technology transfer. WERC has forged a solid working foundation through industrial and academic collaboration in the United States and throughout the world.

## TECHNOLOGY DEMONSTRATIONS

The technology development and application projects undertaken by WERC range from characterization of waste to remediation, risk evaluation, economics and public policy. Between 30 and 40 projects are undertaken each year and have resulted in many innovative applications. Eight of these are being demonstrated in the field for application to commercial or government issues.

WERC's success with technology development is attributed to the multi-organizational, multi-disciplinary expertise that it applies to the development projects. All of the successful projects have common characteristics. Some of these are:

- The development by a partnership of multi-disciplinary academic faculty combined with national laboratory personnel or industry personnel or both.

- The involvement of all partners at the beginning of the research phase so that they can provide the demonstration sites or for commercial application after the research is successful.

- The plans for each research project include, from the start, a plan for continuation of the project, either at a government site or a commercial application, when the research is successful.

- Sufficient support (e.g. laboratory analysis, project management, etc.) is provided to the researchers to assist with the success of the project.

In addition to the above characteristics, a major impetus to the success has been the enthusiasm of the faculty and the students who are very involved because they are working at the state-of-the-art for developing technologies that are applicable today to problems in the field. Furthermore, information transfer is multiplied several times over because the students and the faculty build the research into their courses, thus transmitting current knowledge to thousands of other students.

As mentioned above, a key aspect of the technology development projects is to convert laboratory results into field demonstrations. The following paragraphs provide synopses of eight selected WERC technology development projects which have reached the field demonstration phase.

## Sequential Biological Treatment of Groundwater Contaminated with Carbon Tetrachloride and Nitrate

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Nirmala Khandan, NMSU
Rodney S. Skeen, Battelle Pacific Northwest Laboratories
Donald E. Pearson, Chemlabs, Inc.
Richard E. Speece, Vanderbilt Univ.

Carbon tetrachloride is a toxic degreasing agent that has found its way into ground water at many industrial and national laboratory sites. This project focuses on the problem at the Hanford Site, in Washington, where ground water is contaminated with both carbon tetrachloride and nitrate.

A sequential system will produce in-place remediation of ground water contaminated with carbon tetrachloride and nitrate. This system is faster and more effective than current treatment schemes. This process, when combined with remediation techniques for radionuclides, may provide a complete in situ treatment scheme for the contaminated ground water at the Hanford site.

## Development and Field Testing of Fluorescent Silica Colloids for Contaminated Ground Water Flow Testing

H.E. Nuttall, Dept. of Chemical and Nuclear Engineering, UNM
Doug Smith, Center for Micro-Engineered Ceramics, UNM
Bruce Robinson, Los Alamos National Laboratory

Understanding and quantifying the movement of contaminated ground water is a critical and currently very costly step in remediation programs. By using silica colloids, contaminated ground water can be traced in a effective and environmentally safe manner.

This project is designed to take laboratory results to field demonstration within a 12 month period. Results will provide a new and cost-effective tool for site characterization that will aid subsequent remediation of contaminated ground water sites.

## Development of Tensiometric Barriers for Containment and Remediation at Waste Sites

Bruce Thomson, Dept. of Civil Engineering, UNM
John Stormont, Sandia National Laboratories
Mark Ankeny, Daniel B. Stephens & Associates

Escape of contaminants from waste disposal facilities presents a difficult challenge for environmental restoration strategies. Containing the pollutants to prevent further contamination is required, yet containment is often difficult to achieve.

In this technology, dry air is injected into an unsaturated formation using horizontal wells to reduce the soil moisture content. The unsaturated hydraulic conductivity of the media is reduced to the point where liquid phase transport becomes negligible and forms a barrier.

This project will undergo field testing so that tracers can be used to validate the concept and develop design parameters.

## BTEX Removal from Contaminated Water Using Tailored Zeolites

Fernando Cadena, Civil Engineering Dept., NMSU

The problem of leaking underground storage tanks became evident in the 1970s and present estimates of leaky gasoline storage tanks vary between 75,000-100,000. This number is expected to increase by 350,000 over the next decade.

Solutions to petroleum-contaminated ground water supplies are complex and, in most cases, current solutions are inefficient and uneconomical. This project has demonstrated that surface-altered zeolites will remove both inorganic and organic contaminants from water.

The field demonstration project will test zeolites on produced waters, contaminated ground water, and possibly refinery effluents. Two major oil companies, UNOCAL and Texaco, will collaborate in the project.

## Pipeline Leak Detection System for Oil Spills Prevention

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Larry R. Scott, Lynx Petroleum Consultants, Inc.

The objective of this project is to develop an instrumentation system to passively monitor pressurized oil and gas pipelines for evidence of leaking. Current detection methods use fluid volume/pressure losses or visual examination to find leaks. Early detection and alarm of leaks could result in reductions of leaked fluid, thereby reducing the environmental impact and remediation cost.

The system will be based on spectral analysis of the acoustic energy resulting from the jetting action of the leak.

The first year of research was a lab experiment using a pipe with leak simulated by a metering valve. Acoustic emission signals were investigated as functions of pipe pressure, leak rate and distance from the leak. The observation was that even with relatively low pipe pressure and leak rate, the spectrum of the leak signal was significantly different from the background signal. The acoustic power detected showed a linear increase as the function of leak rate. A similar observation was made for the signal as a function of pipe pressure. Attenuation of the signal along the pipe was not significant in the lab scale.

To investigate signal attenuation along the pipeline and verify if designed systems can work under regular conditions, a field experiment was designed and performed. In the field experiment, oil-producing pipelines were investigated. Results of the investigation show that even at very unfavorable conditions (low pressure, low gas content), leaks can be detected from a distance of up to 200 ft. Measurements confirmed that an acoustic emission signal is strongly attenuated in a buried pipeline. Field investigation allowed for the evaluation of the applicability of the proposed system and for the design of the prototype. The prototype is currently being tested.

## Polymer Gel as a Barrier for Ground Spill Containment

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Brian Dwyer, Sandia National Laboratories
Larry Hersman, Sandy Wagner, Los Alamos National Laboratories

Contaminants from chemical and oil spills can migrate to aquifers, risking degradation of drinking water and rural aquifers.

In this process a barrier will be formed by injection into the ground of liquefied polymer solution, which will then polymerize, in a controlled fashion, in place. The injected material will have a viscosity close to water so the power and other costs associated with the pumping will be low.

## Control of Uranium Migration by Microbial Action

Larry Barton, Biology Dept., Bruce M. Thomson, Dept. of Civil Engineering, UNM
Patrick Longmire, Los Alamos National Laboratory
Armand Groffman, Jacobs Engineering Group

Uranium contamination in ground water is a problem at both uranium mills and weapon production facilities. This project will use bacteria to remove soluble uranium, a mobile contaminant, from ground water. This research will increase knowledge of bacteria-uranium interactions and assist in remediation of uranium-contaminated sites.

The focus of the research is to use bacteria with the capability of reducing U(VI) to U (IV).

### Subsurface Characterization of Buried Waste Sites: Site Demonstration Project

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Ray Harrigan, Jim Phelan, John Cochran, David Betsill, Rarilee Conway, John Feddema, Charles Little, Sandia National Laboratories
Gerald Sandness, Dave Bennett, Battelle Pacific Northwest Laboratories
Richard Russell, Jack Foley, GEOCENTERS
Larry Stolarczyk, RTR, Inc.

Many old waste sites have inaccurate data on their exact location. Different technologies have been developed to characterize underground storage and waste sites. This project is developing a computer software package for the analysis of waste site characterization data using multiple ground sensing methods, to apply to a selected site.

The program software will allow analysis of these multiple data types and will yield an optimal estimate of buried material locations. This project will make site remediation safer and more cost effective.

## SUMMARY

WERC has proven to be a successful model for education, technology development and technology transfer. In this paper, those aspects of WERC which lead to this success have been highlighted. Of specific interest are the eight technology development projects which have reached the field demonstration phase. Final reports on the technology applications will be submitted to WERC in late 1995.

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