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Environmental Monitoring
Systems Laboratory
P.O. Box 93478
Las Vegas NV 89193-3478

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Research and Development

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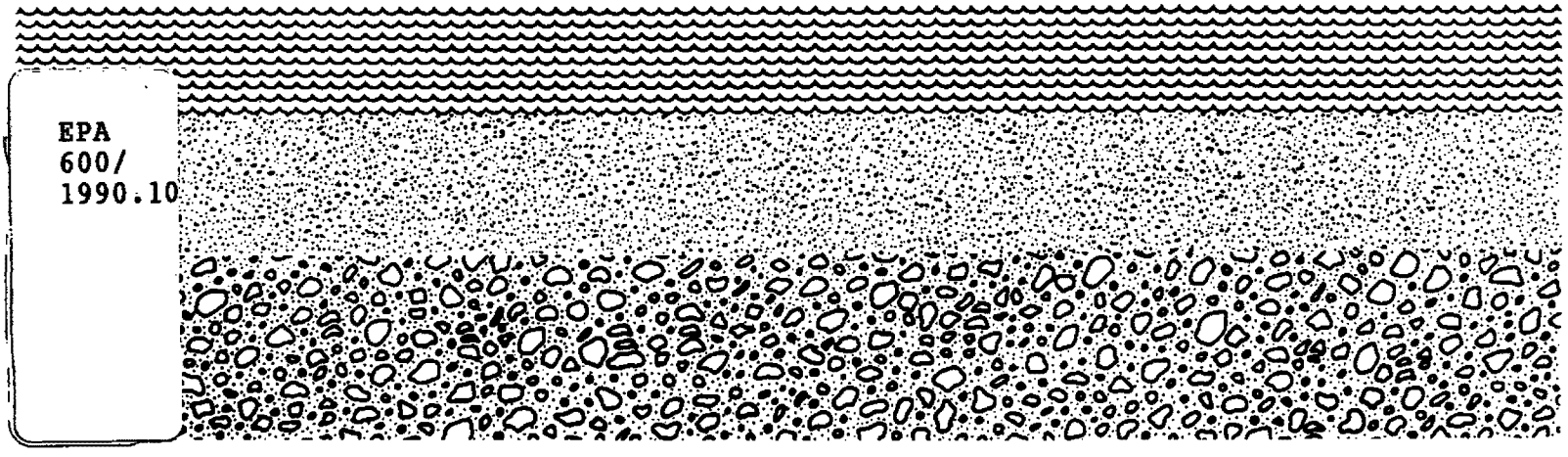
SUBSURFACE MONITORING RESEARCH ACTIVITIES

Advanced Monitoring Systems Division Aquatic and Subsurface Monitoring Branch



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AQUATIC AND SUBSURFACE MONITORING (AMW) BRANCH STAFF
ADVANCED MONITORING SYSTEMS DIVISION

Name	Discipline	Responsibilities
Joseph J. DLugosz	Hydrogeologist	Branch Chief, Hydrogeologic site characterization
Philip B. Durgin	Hydrogeologist	UST/vadose zone hydrology
Kenneth R. Scarbrough	Geologist	Field methods, hydrology/geophysics
Aldo T. Mazzella	Geophysicist	Surface/borehole geophysics
Jane E. Denne	Hydrogeologist	Saturated zone hydrology
Steven P. Gardner	Geohydrologist	Wellhead protection/saturated zone hydrology
William H. Engelmann	Geochemist	Advanced field screening methods/monitoring parameters
J. Lary Jack	Engineering Geologist	Geophysics technical support/TSC coordinator
Lawrence A. Eccles	Hydrologist	Advanced field screening methods/vadose zone hydrology
M. S. (Doug) Bedinger	Hydrologist	Aquifer properties, modeling
Regina M. Bochicchio	Geophysicist	Field geophysics
Valerie A. Gutierrez	AMW Office Manager	Branch support - all areas
Roy C. Baumann	Project Officer Assistant	Financial accounting
Charles O. Morgan	Hydrogeologist	Database management/saturated zone hydrology
New hire	Hydrologist	Data analysis and interpretation
Glen P. Bonner	Computer Aide	Computer support to AMW
Douglas Elliott	Technical Editor	Report review
Monsiri (Pom) Jintasawang	Clerk-Typist	TSC correspondence

SUBSURFACE MONITORING RESEARCH AT THE EMSL- LV

The Environmental Monitoring Systems Laboratory in Las Vegas (EMSL-LV) is conducting ground-water monitoring research to support the Underground Injection Control (UIC) Regulations of the Safe Drinking Water Act (SWDA); the Ground-Water Protection Regulations of the Resource Conservation and Recovery act (RCRA); and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended, which is frequently referred to as Superfund. Geophysical research and technical support programs to assist Superfund hazardous waste site investigations are also being conducted. The program includes research into the geophysical and geochemical detection and mapping of shallow contaminant plumes with both surface-based and downhole methods; the more difficult problem of mapping deeply-buried contaminant plumes associated with injection wells; the validity of indicator parameters for ground-water monitoring; monitoring methodology for the unsaturated or vadose zone; advanced monitoring methods such as real-time, *in situ* monitoring of ground water with fiber optic sensor technology; and external leak detection devices for underground storage tanks (USTs).

ADVANCED TECHNOLOGY FOR GROUND-WATER MONITORING

In situ monitoring of ground-water contaminants with fiber optics technology and fluorescence spectroscopy may offer cost savings over conventional methods and has other operational advantages, such as real-time measurement.

The EMSL-LV is sponsoring exploratory research at the Lawrence Livermore National Laboratory and field validation and characterization at EMSL-LV for the development of fiber optics technology for ground-water monitoring. Remote fiber fluorescence spectroscopy involves the excitation of target substances via fiber optic cables and the detection and measurement of the target substances based on their fluorescence emission spectra. Optrodes for measurement of nonfluorescing chemicals react with the substance of interest and a fiber coating or other substrate to yield a product which fluoresces. Measurement of other parameters such as temperature require optrodes using substances such as ruby which have temperature-dependent fluorescence spectra. The recent development of high quality fiber optic cables at relatively low cost promises to make feasible the remote measurement of chemical concentrations and parameter values at distances of up to 1 km from the spectroscopy processing unit. Concentrations in the part-per-billion range can be measured for some compounds.

VADOSE ZONE MONITORING

RCRA regulations require unsaturated zone monitoring at permitted land treatment or landfarming disposal areas. Monitoring in the vadose zone is designed to detect leaching and percolation of pollutants from hazardous wastes before the pollutants reach the water table. While several methods for vadose zone monitoring have been used in agriculture, they have not been characterized or validated for use at hazardous waste sites. EMSL-LV vadose zone research is intended to select the best available equipment, establish

installation and operational procedures, determine equipment limitations, and describe methods for data interpretation.

GROUND-WATER MONITORING

The SDWA, CERCLA, and RCRA require that underground drinking water sources be protected from contamination. Assurance that protection is being obtained is provided by water quality data from monitoring wells. Continued development of new sampling techniques and equipment, improvements in understanding the processes of ground-water contamination, and the unique character of every monitoring situation are important considerations in obtaining ground-water samples that are representative of *in situ* conditions. A number of variables are being examined.

Research is directed at a better understanding of monitoring well construction methods and their impact on monitoring. A handbook on monitoring well construction is to be provided. Studies of seasonal variability are being conducted at several sites to investigate the role of temporal variability in ground-water monitoring. Ground-water sampling methods are being evaluated. Site characterization, well placement, and spatial variability are other topics under investigation.

UNDERGROUND STORAGE TANKS

EMSL-LV has been evaluating leak detection systems for use outside USTs. Four areas of research have been: instrumentation evaluation, network design,

data analysis, and technical guidance. Performance tests have been developed for instruments that include accuracy, precision, response time, and specificity. Field studies have been completed to evaluate the background concentration of hydrocarbon vapors and changes over time. The research for network design has included computer modelling and physical modelling in the laboratory and in two full-scale tanks. Field-screening techniques are being developed and field tested for site investigations of service stations. The "monitoring only" option of remediation is being demonstrated in the field with guidance for this alternative being developed.

INDUSTRY-SPECIFIC MONITORING PARAMETERS FOR GROUND-WATER MONITORING

The EMSL-LV is conducting research into indicator parameters that will give a reliable indication of subsurface leakage on an industry-by-industry basis. For cost-effective monitoring, a short list of parameters, which will be reliable and inexpensive to measure is desired. Indicator parameters are measured during the detection monitoring phase. A more complete assessment of hazardous chemicals is done in the compliance monitoring phase.

Among the factors to be considered in specifying parameters to be monitored are the following: (1) the mobility, stability, and persistence of waste constituents or their reaction products in the unsaturated zone beneath the facility; (2) the detectability of the parameters in the ground water; and (3) the concentrations and amount of variation of the proposed monitoring parameters in the ground-water background.

The objectives of this project are: (1) Identify process chemicals and waste products for specific industries (source profile); (2) Identify hydrologic contamination typical of industry-specific activities (contamination profile); (3) Assess the effect of hydrologic and hydrogeologic parameters, as appropriate, on the contamination profile; and (4) Identify analytes that may be used as direct or indirect indicators of industry-specific chemical releases.

QUALITY ASSURANCE/FIELD METHODS STANDARDIZATION

The EMSL-LV is working towards the development of standards in the area of ground-water monitoring. These standards are needed for the quality assurance of field investigations being performed at RCRA and Superfund sites. Standards are needed in the areas of: (1) borehole geophysics; (2) vadose zone monitoring; (3) monitoring well drilling and soil sampling practices; (4) determination of hydrogeological parameters; (5) monitoring well design and construction; and (6) ground-water sample collection, handling, and field analysis.

The Laboratory is in the process of setting up a cooperative agreement with ASTM to have voluntary consensus standards written in these areas. ASTM has set up a new subcommittee, D-18.21 on Ground-Water Monitoring, to write standards in this area. The cooperative agreement is designed to accelerate the development of standards in this area, to support RCRA and Superfund in this area as quickly as possible.

TECHNICAL SUPPORT CENTER

The EMSL-LV developed a program to provide assistance to the Superfund program. A facility will be developed at Pittman, Nevada, to serve as a staging area for the Technical Support Center and to store equipment to be used for ground-water research. Principal activities include the development and distribution of training materials, technical transfer of new technologies through field programs, and technical support in areas of specialized expertise.

GEOPHYSICAL RESEARCH PROGRAM

In research programs funded under RCRA, SDWA, and CERCLA, geophysical techniques for determining subsurface structure and detecting and mapping ground-water contamination are being developed, tested, and applied in field investigations. The use of geophysical and geochemical methods for detecting and mapping underground contamination is part of a cost-effective approach to ground-water monitoring.

Geophysical and geochemical methods can be used to ensure proper placement and completion of monitoring wells for detection and compliance monitoring to meet RCRA Land Disposal Regulations. CERCLA requires the assessment of ground-water contamination at uncontrolled hazardous waste sites for remedial action. The UIC Regulations promulgated under the SDWA requires surveys of the zone of influence of proposed new injection wells prior to granting permits for the construction of the wells.

Research in geophysical and geochemical methods will demonstrate and evaluate these techniques for detection and mapping of subsurface properties and ground-water contaminant plumes. In the area of downhole sensing, the research objectives are to survey, develop, test, and evaluate downhole sensors and methods which can be used for hazardous waste site monitoring and for pre-construction hydrogeologic investigations, principally using small-diameter, shallow-depth boreholes. In the area of mapping fluids from injection wells, several techniques are being evaluated for use on the detection of deeply buried contaminant plumes. Magnetometers along with aerial photography have been evaluated for locating abandoned wells in the vicinity of proposed new injection wells.

GEOPHYSICAL TECHNICAL SUPPORT FOR SUPERFUND HAZARDOUS WASTE SITE ASSESSMENT

Much of the EMSL-LV geophysical research is directly applicable to CERCLA site investigations. To take advantage of these benefits, the EMSL-LV has initiated a program to provide technical support in the use of geophysical methods in hazardous waste site investigations. Support will be provided through the Emergency Response Branch (ERB) of the Office of Emergency and Remedial Response (OERR) to the 10 EPA regional offices. The primary program goal is to assist field teams from OERR/ERB and the regional offices in performing hazardous waste site assessments, with emphasis on better utilization of the geophysical capabilities that these groups already have. First priority is given to developing EMSL-LV products which will be of immediate use to field teams already possessing some geophysical capability. Quality

assurance services for geophysical measurements will also be provided to regional office teams on request.

ADVANCED FIELD MONITORING METHODS

Rapid field x-ray fluorescence (XRF) analytical techniques are being developed for screening Superfund sites that may be contaminated with toxic metals. These results will optimize Superfund field efforts from the initial investigation through the remediation steps by being able to readily provide on-site data.

When site screening requires a "contour" plot of contaminant intensity over the actual site coordinates there is recently-developed instrumentation that uses the XRF spectrometer in combination with an ultrasonic ranging and data system (USRADS). Speed in developing contour plots is increased about one to two orders of magnitude, over that of conventional methods.

With the XRF-USRADS system, data points are gathered, typically at a frequency of one intensity point per second, as the site is walked in a criss-cross pattern by the technician. The points are sent ultrasonically from the back-pack that contains the transmitter to an array of ultrasonic receivers. The signals are used in a surveyor's "triangulation" calculation to determine the exact geographical position. Each position or point in this "grid" is coordinated with an XRF value. Under computer control, a plot is rapidly made that gives a contour perspective, with the highest points being those of the strongest signals. Such capability will save much time and cost and enable

Superfund site managers to make better and much more timely decisions while on-site. This is an important technological tool that should greatly speed up the site remediation process.

Surface geophysical surveying is also available as a rapidly developed plot using an electromagnetic induction instrument linked to the USRADS. Other geophysical devices have the potential to be linked to the USRADS. Any device that emits a measurement, and that needs to be coordinated with geographical positioning can be adapted.

In addition to fluorescence measurements from x-rays, there are also relatively new technologies that use other types of fluorescence. Ultraviolet-visible (UV-vis) fluorescence of organic molecular compounds is a phenomenon that is now being developed into field instruments for detection and quantitation of polychlorinated biphenyls (PCBs) and for polyaromatic hydrocarbons (PAHs). Small portable, or mobile-van instruments, as they become widely available in the 1990s, will enable determination of this class of contaminants on-site. Quality decisions will follow for remediation work on hazardous waste sites that might contain these contaminants.

TITLE: Evaluation of a Multi-Layer Ground-Water Sampler

GOAL: Provide a fully evaluated ground-water profiler for simultaneous collection of water from various depths.

RATIONALE: The need for new methods to help characterize and monitor ground water at RCRA and Superfund sites is increasing as the number and knowledge of the complexity of the sites is increasing. RPM's, OSC's and EPA remediation contractors have had problems characterizing the hydrologic properties of their sites. The development of new methods to provide insight into the hydrological properties of sites should greatly decrease the remediation process, which would then decrease the cost of remediation.

APPROACH: This project will use the data and field experience acquired during the previous testing phase of the Ronen/Magaritz (R/M) sampler at Brookhaven National Laboratory. The initial testing of the R/M sampler proved to work well for inorganics, but cannot be generally applied to organics. The sampler was constructed out of rubber, PVC and other material that adsorbed the organics. The new ground-water profiler will be constructed of optimum materials (stainless steel, teflon and glass) so as to not contaminate the sample or adsorb contaminants during the sampling procedure. This sampler will be tested at the same well that the R/M sampler testing was performed.

EPA Coordinator: K. R. Scarbrough FTS 545-2645
(702) 798-2645

TITLE: "In-Soil" Diffusion Coefficient (UST)

GOAL: 1) To determine the "in-soil" diffusion coefficients of trichloroethylene and butane. 2) Try to establish a functional relationship between concentration levels, location of contaminants and time of contamination. The results will be used to predict concentration levels at depths and the time sequence of contamination associated with spills or leaking tanks from contaminant releases at the soil surface. 3) Attempt to scale down the apparatus and define the barrier effects.

RATIONALE: The Office of Underground Storage Tanks (OUST) is now placing emphasis on remediation of UST sites. This study will provide valuable information for remediation as well as monitoring.

APPROACH: Six small-scale cylindrical containers will be constructed for test chambers. These cylinders will be filled with a mixture of sand and silt to produce a porosity of .25 to .40. Then, a constant source of chemical contaminate (vapor) will be placed at the bottom of each cylinder. The cylinders will be equipped to measure the diffusion rate of the gas through them using ports in the side of the cylinder. During these experiments external factors (i.e., temperature, humidity and soil moisture) will be controlled. Once the initial test are completed we will build a smaller scaled versions to test the barrier effects.

EPA Coordinator: K. R. Scarbrough FTS 545-2645
(702) 798-2645

TITLE: Free Product Thickness in a Shallow Aquifer

GOAL: To develop and field test a device that can measure accurately and quickly the thickness of a free product plume on a shallow aquifer. To test methods for measuring free product thickness.

RATIONALE: The Office of Underground Storage Tanks (OUST) is placing their emphasis on remediation of UST sites. This project would support that emphasis by providing a quick screening tool for site characterization of an UST site. It also would help determine the progress of remediation efforts.

APPROACH: A prototype device will be designed and constructed. This device will consist of two tubes, one inside the other. The outer tube will be stainless steel with a longitudinal slot. It also will have a resistivity device to detect when the device contacts the saturated zone. The inner tube will be made of plastic. This tube will be rotated inside the outer tube to expose the detectors (dye material or electric sensors) that will indicate fuel thickness. This device will be field tested at the Oregon Graduate Institute sand tanks and appropriately characterized contaminated UST sites. Research also will be conducted to evaluate the influence of hydrophobic well-construction materials in free-product monitoring.

EPA Coordinator: K. R. Scarbrough FTS 545-2645
(702) 798-2645

TITLE: Use of Peat for Adsorption of Hydrocarbons from UST

GOAL: This study will be concerned with laboratory testing of a permeable peat barrier to remove petroleum contaminants from the ground water. Once the laboratory testing is complete, EPA will field test this technology.

RATIONALE: There is a need to study passive methods of remediation at UST sites. The conventional practices (i.e., pump and treat, injection, excavation and removal) are usually effective in porous/high yield soils but are not in tight formations with low hydraulic conductivities. This study will investigate the use of a permeable peat barrier as a remediation tool.

APPROACH: The physical and chemical characteristics of three different peats will be identified. These peats will then be tested to determine quantitatively the equilibrium sorption characteristic of each peat. The peats will then be placed in a column to assure that kinetic problems will not limit the effectiveness of peat as a sorbent for organic constituents. The second phase will be to field test this technology at a contaminated abandoned gas station. It is proposed to construct a peat barrier (trench) and monitor the influent and effluent water for hydrocarbons.

EPA Coordinator: K. R. Scarbrough FTS 545-2645
(702) 798-2645

TITLE: Ground-Water Monitoring in Karst Terrain

GOAL: To develop a Karst map of the United States; this map would be used to assist in the siting of new RCRA facilities.

RATIONALE: Much of the Agency's efforts concerning ground-water monitoring have focused on hydrogeologic environments comprised of unconsolidated materials. New and existing RCRA facilities may be located in or near Karst terrains, therefore, monitoring strategies unique to this type of hydrogeologic environment are being developed and guidelines prepared for use by the regulator and the regulated community. *This map would complement the monitoring strategies and guidelines presently being prepared for Karst environments.

APPROACH: The approach to this problem would be to map into two existing sources of information and get these to produce the map. First would be to access Dr. James Quinlan (formerly U.S. National Park Service) to compile the information or the different zones of Karst Hydrology in the U.S. Then we would access a map manufacture or a GIS Service (possibly EMSL-LV) to manipulate this information into the finished product.

EPA Coordinator: K. R. Scarbrough FTS 545-2645
(702) 798-2645

TITLE: Industry-Specific Monitoring Parameters

GOAL: Primarily, to provide recommendations of ground-water monitoring parameters for each of the two specific industries: (1) Municipal/Sanitary Landfills, and (2) Incinerated Municipal Waste Ash Monofills. Secondarily, source profiles and contamination profiles will subsequently be developed for seven additional industries: aerospace, chemical manufacturing, metal manufacturing, military, oil refining, wood treatment, and hazardous waste disposal.

RATIONALE: RCRA subtitle D landfill disposal regulations require the continual monitoring of ground water at most facilities for both detection and compliance monitoring. Most landfills, as they leak, release volatile organic compounds (VOCs) as principal contaminants. Many of the VOCs are chlorinated compounds. For detection monitoring to be cost-effective, a short list of low-cost parameters is desired.

APPROACH: A data base of RCRA, Superfund, and DOD monitoring data has been developed, from information supplied by Waste Management, Inc. (WMI), one of the largest operators of municipal landfill sites in the U.S. Additional data

will be gathered to link specific chemicals with the specific industries noted above. Chemicals will then be identified that may be used as direct or indirect indicators of chemical contamination in ground water. The FY89 effort focused on the organic contaminants at wood treatment hazardous waste. The FY90 emphasis will be on possible inorganic indicators for all seven of the above industries. Temporal variability of the indicator and contaminant chemicals will also be studied through charting the variances, with time, of each contaminant concentration to determine seasonal changes in concentration.

EPA Coordinator: W. H. Engelmann FTS 545-2664
(702) 798-2664

TITLE: Information Integration Software for Ground-Water Quality Assessments

GOAL: To provide a "toolbox" of software packages and methods for extracting useful information from data bases of ground-water monitoring information. To disseminate this methodology among ground-water professionals, researchers, and policy makers.

RATIONALE: Under the Resources Conservation and Recovery Act, as amended in 1984, and The Safe Drinking Water Act Amendment of 1986, many state and local agencies routinely collect environmental data to meet a variety of objectives. Many large data bases are being compiled by the EPA, other federal agencies in the Department of Defense, and state and local governments. A need exists for a methodology to cost effectively extract knowledge from the vast amount

APPROACH: The University of Iowa has implemented several major ground-water quality data bases at the University of Iowa Computing Facility. These data bases include several million chemical (analytical) measurements from thousands of wells at ambient locations, public water supply systems and hazardous waste sites. They have acquired additional hardware and software resources to process, analyze, and interpret the data in these data bases. With the assistance of existing software, they have developed procedures to create several transformed data bases from each original data base. They have also written numerous macro-procedures to produce plots, charts, tables, statistical tests, and analyses of data from these data bases. What is missing is the documentation for this step-by-step process by which data from diverse data bases have been brought together to answer specific analytical questions. As a part of this effort, an information-integration document will be developed based on findings published in the open literature as well as the results of research from the last five years of effort at the University of Iowa, Iowa Department of Natural Resources, and the US EPA.

EPA Coordinator: S. P. Gardner FTS 545-2580
(702) 798-2580

TITLE: Ground-Water Monitoring Methods Standardization

GOAL: To produce voluntary consensus standards for field methods in the area of environmental monitoring of ground water.

RATIONALE: Subtitle C of the Resource Conservation and Recovery Act requires ground-water monitoring at licensed hazardous waste sites. There is an ongoing EPA program for the quality assurance of chemical analyses produced from these monitoring systems, but no program to assure samples are collected correctly, or that field data gathering is performed according to a set protocol. Field data must be comparable and consistent, these standard methods help assure that they are. This program will provide the scientific basis to standardize the EPA approach to subsurface monitoring.

APPROACH: Six task groups have been set up under ASTM guidelines to write draft standards in the areas of 1) borehole geophysics, 2) vadose zone monitoring, 3) monitoring well drilling and soil sampling, 4) determination of hydrogeologic parameters, 5) monitoring well design and construction, and 6) ground-water sample collection, handling and field analysis. A person affiliated with EMSL-LV with expertise in the field, has been assigned to each task group. These task groups meet concurrently and develop draft standards for delivery to ASTM for balloting. At the same time, they are delivered to EPA as internal reports for dissemination and comments by the laboratories, program offices, and regional offices. These standards will provide a means of quality assurance of ground-water quality monitoring and are a method of transfer of knowledge and technology from experts in various phases of ground-water monitoring.

EPA Coordinator: S. P. Gardner FTS 545-2580
(702) 798-2580

TITLE: Wellhead Protection Technical Assistance/Technology Transfer

GOAL: To provide technical assistance and technical transfer of information developed during monitoring and GIS research supported by C104/F89/01 Projects 01 and 02 and C104/F81/01 Project 03. The recipients of this information will be state and local managers and technical staff working in wellhead protection.

RATIONALE: As a result of the passage of the 1986 amendments to the Safe Drinking Water Act a nationwide program to protect ground-water resources used for public supplies was established - the Wellhead Protection Program. EPA is responsible for providing guidance to the states to implement and manage well-head protection programs. This task will provide the vehicle to transfer information developed in other Wellhead Protection research projects to the local managers of Wellhead Protection Areas. This will help them make informed decisions regarding ground-water monitoring and information management at the local level.

APPROACH: EMSL-LV operates a Technology Support Center for Monitoring and Site Characterization, which provides assistance to EPA Regional personnel working with sites regulated under CERCLA and RCRA. This assistance includes geophysical, ground water, and vadoze-zone investigations. Questions pertaining to hydrogeology, contaminant chemistry, and ground-water monitoring are also addressed. The EMSL-LV Geographic Information System Research Group is currently providing support to the Regions for delineating WHPAs by coupling ground-water models with a GIS system. EMSL-LV will increase its level of technical support to include state and local agencies through:

- Technical review of site-specific WHP plans, monitoring network designs, sampling plans, delineation methodology, and source identification and characterization documents.
- Site visits to participate in routine field work, implement and test laboratory-developed technologies, and document case-studies research.
- Preparation of educational materials to facilitate information dissemination in such forms as electronic bulletin boards, technical assistance documents (TADs), brochures, pamphlets, and short courses.

EPA Coordinator: S. P. Gardner FTS 545-2580
(702) 798-2580

TITLE: Ground-Water Monitoring Strategies for Wellhead Protection

GOAL: The purpose of this effort is to prepare a guidance document concerning monitoring strategies for wellhead protection areas (WHPA). Monitoring is a type of management strategy that can be used in wellhead protection areas along with land use controls for early warning and pollution prevention.

RATIONALE: As a result of the passage of the 1986 amendments to the Safe Drinking Water Act a nationwide program to protect ground-water resources used for public supplies was established - the Wellhead Protection Program. EPA is responsible for providing guidance to the states to implement and manage wellhead protection programs. Guidance for delineating WHPAs has already been provided, the next step is to develop guidance for the design of monitoring networks. Elements of the Wellhead Protection Program include delineation of a Wellhead Protection Area, identification of contaminant sources, selection of management approaches, and development of contingency plan. Monitoring networks in Wellhead Protection Area can provide hydrogeologic information to support area delineation, detection of unknown contaminant sources, and be used as a management approach.

APPROACH: This project will include four tasks. These include contacting state and local agencies which are implementing or trying to implement a WHP program, develop the background information for monitoring network design, develop and discuss case studies and prepare a guidance document for distri-

bution to the states. Case studies will be funded with 4 to 6 small co-operative agreements to municipalities. These municipalities will design a monitoring network for their wellhead protection area based on their unique hydrogeology and contaminant distribution. These case studies will be tracked by LESC and included in the monitoring strategy document. Municipalities funded in FY89 include Littleton, MA; Dover, NH; Stevens Point, WI; Springfield, MO; and Souix Falls, SD. A case study in Monterey County, California may be funded to design a monitoring system in a confined hydrogeology. Funding for GIS support in Monterey County may come from Region 9.

EPA Coordinator: S. P. Gardner FTS 545-2580
(702) 798-2580

TITLE: Innovative Monitoring Devices for Wellhead Protection

GOAL: To provide guidance to state and local managers of Wellhead Protection Areas regarding innovative and cost effective methods of monitoring large areas.

RATIONALE: As a result of the passage of the 1986 amendments to the Safe Drinking Water Act a nationwide program to protect ground-water resources used for public supplies was established - the Wellhead Protection Program. EPA is responsible for providing guidance to the state to implement and manage wellhead protection programs. Guidance for delineating WHPAs has already been provided, and guidance for the design of monitoring networks is currently being developed under C104/F81/01/03. Monitoring is one type of management strategy that can be used alone, or in conjunction with land use controls, to prevent new pollution of an aquifer and provide early detection of contamination. Wellhead Protection Areas are areally extensive and innovative and more cost effective ways of monitoring for contamination must be found. All types of information, not just chemical analyses, must be integrated by the Wellhead Protection Area Manager to make decisions regarding aquifer management.

APPROACH: Literature and laboratory surveys will assess continuous monitoring and sample extraction devices for WHPA monitoring. Devices that can quantify *in situ* analyte concentrations could have particular applicability in monitoring the large areas of WHPA's. These devices could provide a screening method for early detection of contaminants and may provide a large cost savings over the traditional methods of monitoring well sampling and laboratory analysis. This research would assess the current and emerging technology related to innovative monitoring devices applicable to WHP program. Various thermal, mass, electrochemical, and optical sensors will be evaluated in terms of their development and the immediate needs of the WHP community. A guidance document will be prepared on the use of innovative monitoring devices in WHPA's for delivery to state and local managers implementing monitoring in their WHPA's. An internal report identifying promising new technologies deserving further research and development will be delivered to EPA.

EPA Coordinator: S. P. Gardner FTS 545-2580
(702) 798-2580

TITLE: Well Construction

GOAL: To provide information regarding state-of-the-art equipment, materials, and methods for the design, installation and completion of monitoring wells in various regions and hydrogeologic settings to ensure that the wells provide representative ground-water samples and do not themselves contribute to contamination of water.

RATIONALE: SDWA, CERCLA, and RCRA require that underground drinking water sources be protected from contamination. Assurance that protection is being attained is provided by water quality data from monitoring wells. These wells should provide representative water samples and should not themselves produce contamination. EPA Program Office and Regional personnel as well as others involved with ground-water monitoring have expressed concern regarding well construction materials and methods, and their questions are addressed in the "Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells."

APPROACH: Literature has been reviewed, and drilling and well construction methods typically used have been assessed from publications and inquiries. Interviews with professionals from the EPA Regions were conducted to determine well construction techniques and to discuss problems and potential solutions. The Project's Advisory Committee, composed of members from private industry and U.S. EPA staff from Headquarters Program and Regional offices and the R. S. Kerr Lab reviewed draft documents. Products included the journal article, "Drilling and Constructing Monitoring Wells with Hollow-Stem Augers" and the "Handbook" which is in final review.

EPA Coordinator: J. E. Denne FTS 545-2655
(702) 798-2655

TITLE: Site Characterization, Spatial and Temporal Variability

GOAL: To provide a practical, field-tested methodology for site characterization which will allow consistent collection, analyses, and interpretation of site data and to provide current monitoring information regarding spatial and temporal variability for assessment of volatile organic contamination in a large urban, industrialized area with a sub-humid environment.

RATIONALE: RCRA regulations require a ground-water monitoring program at most facilities, and volatile organic compounds (VOCs) are commonly found in contaminated ground water. Therefore, the temporal and spatial behavior of these chemicals and site characterization of a VOC-contaminated area are important factors to be considered when designing a monitoring system as well

as evaluating and interpreting data. State-of-the-art monitoring information is needed to make scientifically valid and cost-effective decisions for investigating and monitoring subsurface and ground-water conditions at RCRA and Superfund sites. Temporal variability and site characterization research results from this project, together with those from other EMSL-LV studies in areas with different climatic and hydrogeologic conditions, may be applied throughout the country to improve the consistency and comparability of ground-water monitoring data. Region 5 is also very interested in site-specific results of this study.

APPROACH: An approximately 10-square mile area of southeast Rockford, IL was selected because it overlies an extensive sand and gravel aquifer (typical of many hazardous waste sites) contaminated with volatile organic compounds. Both public water supply and private wells have been contaminated by a number of industrial sources. State-of-the-art hydrogeologic and chemical data collection and interpretive methods will be used in the project which will be conducted in three phases. The first is reconnaissance (including compilation of existing data and use of field contamination survey techniques) and development of hydrologic and geochemical monitoring systems. Survey methods will include analyses of soil gas, ground-water headspace, and aquifer core materials. Results will be integrated with hydrologic and chemical data collected during well tests to estimate spatial variability in contaminant sources. A real-time meteorologic and hydrologic data measurement system will be installed to maintain continuous records. The second phase will include use of a GIS and modeling for refinement of sampling well and piezometer arrays. Monitoring of the temporal variability of the spatial distribution of the principal organic contaminants will be initiated. Synoptic experiments under pumping and nonpumping conditions will be designed to estimate the effects of transient flow regime. Results will be reported in an article comparing sampling and surveillance methods. The third phase will consist of data analysis, refinement and repetition of the synoptic experiment, and provision of a conceptual model. A guidance document for methods to characterize sites and assess contamination will be prepared based on study results.

EPA Coordinator: J. E. Denne FTS 545-2655
(702) 798-2655

TITLE: Temporal Variability (Arid) and Sampling Procedures

GOAL: To provide an understanding of the statistical nature and temporal variability of ground-water quality (especially volatile organic compounds) in an arid environment and to provide an assessment/validation of elements of ground-water sampling protocols.

RATIONALE: RCRA regulations require a ground-water monitoring program at most facilities. Results of both major parts of this research project (evaluation of temporal variability and validation of selected elements of sampling protocol) have the potential of increasing the quality and consistency and reducing the cost of hydrogeologic data gathered in RCRA and Superfund site

investigations and monitoring. Behavior of volatile organic compounds (VOCs, a major source of ground-water contamination) in the natural environment must be studied in order to design better monitoring networks and sampling frequencies to detect contamination. Results of this arid zone temporal variability research together with those of other EMSL-LV studies in areas with different climatic and hydrogeologic conditions may be applied in varied settings across the nation. Evaluation of elements of sampling protocols (well purging in low-permeability materials, field filtration methods for ground-water samples, and equipment decontamination procedures) should allow determination of appropriate methods to collect representative samples in a consistent manner.

APPROACH: For evaluation of temporal variability of ground-water quality in an arid environment, sampling points will be selected in a VOC-contaminated aquifer and in an uncontaminated area of southern Nevada. Four wells will be instrumented and monitored. Data will be analyzed to determine their statistical nature and the temporal variability of water quality. Cross-correlation between chemical indicator parameters and dissolved constituents of the water will be evaluated for use of indicator parameters as predictors of water chemistry. For assessment of sampling protocol elements, experiments will include purging in low permeability materials, field filtering, and decontaminating equipment. Field purging studies in a monitoring well will address the extent of draw-down during purging, time of sampling during well recovery, and location of sampling device with respect to the screened interval; *in situ* devices that do not need to be purged will be evaluated and compared to monitoring well results. Filtering experiments at the field site will include a monitoring well and *in situ* devices; in-line, barrel-type, vacuum-type, and internal filters; and varied pre-filtration holding times. Laboratory investigation of decontamination will involve a bladder pump exposed to a tracer fluid and the use of several types of rinses and cleansers for varying times.

EPA Coordinator: J. E. Denne FTS 545-2655
(702) 798-2655

TITLE: Technology Transfer and Hands-On Demonstration

GOAL: To provide technology transfer and hands-on demonstration of current, rapidly evolving, state-of-the-art ground-water monitoring technology to EPA, State, and other professionals involved with ground-water monitoring.

RATIONALE: SDWA, CERCLA, and RCRA require that underground drinking water sources be protected from contamination. Ground-water monitoring data provide assurance that protection is being attained and may be used in assessment or remediation of ground-water contamination. As new technology and methods are developed and properly applied, the quality, comparability, and cost-effectiveness of hydrogeologic data gathered in RCRA and Superfund site investigations and monitoring, as well as in other EPA-related activities, should be significantly improved. This project will allow a wide range of monitoring professionals to keep abreast of state-of-the-art equipment and

methods that will enhance their ability to effectively monitor and protect ground water.

APPROACH: Four activities are to be performed for technology transfer. They are: 1) videotaping of hands-on demonstrations and conferences, 2) coordination of hands-on demonstrations, 3) publication of a biannual bibliography/newsletter, and 4) ground-water technology transfer for hazardous waste sites. Videotapes and demonstrations will emphasize topics of current concern to practicing professionals. Monitoring topics to be covered include, but are not limited to, unsaturated and saturated zone monitoring (e.g., soil gas monitoring, drilling, and well design and installation); surface geophysical methods; site characterization; aquifer tests; and ground-water sample collection, handling, and field analyses. The bibliography/ newsletter will describe current monitoring literature, legislation, and the Technology Support Centers and will be submitted for publication in Ground-Water Monitoring Review. Technology transfer activities will include research into the best methods for quickly and cost-effectively providing information to those who need it. One example includes computerization of parts of the Monitoring Well Handbook together with updated references.

EPA Coordinator: J. E. Denne FTS 545-2655
(702) 798-2655

TITLE: Comparative Testing

GOAL: To provide information regarding monitoring-well sampling equipment and procedures for obtaining representative water samples and to provide standard test procedures for evaluating water quality sampling devices.

RATIONALE: RCRA regulations require a ground-water monitoring program at most facilities. Good and cost-effective ground-water monitoring methods are very important not only for RCRA sites but also Superfund and other programs that address water-quality issues. Durable sampling devices that provide reproducible results and do not degrade the integrity of the sample are needed. For QA, standardized procedures also are needed to assure that the various methods used are comparable. This research program is of great interest to EPA Program and Regional Office personnel as well as other monitoring professionals who have raised questions regarding ground-water sampling methods and equipment and who need guidance. Several techniques exist for samples to be collected from ground-water monitoring wells (e.g., bailing, pumping, and *in situ* samplers). *In situ* samplers are significant because they generally avoid the need for well purging. Results of this research will be useful for the selection of equipment and methods that ensure cost-effectiveness and the representativeness of collected samples to the actual water quality.

APPROACH: Ground-water monitoring literature was reviewed, and an annotated bibliography and a sampling device matrix were prepared. Selected sampling devices have been compared in the field at the Pittman site in Henderson, NV; a thorough QA/QC plan was written before sampling began. Early results of the

study have been reported, and quarterly sampling and evaluations of data are continuing. A literature search for information dealing with sampling artifacts was completed, and a simulated well environment is being constructed for development and testing of the ground-water sampler testing protocol. Purging and sampling experiments will be conducted in a controlled laboratory environment (equipment designed for this study) to evaluate well purging procedures appropriate to low-permeability conditions. Results of research will be included in reports and presentations described below which will be used by EPA Program and Regional Office, state, and other ground-water monitoring professionals.

EPA Coordinator: J. E. Denne FTS 545-2655
(702) 798-2655

TITLE: Well Casing Material Comparison

GOAL: To provide guidance on the effects of various well casing materials on water quality sample integrity for varying hydrogeochemical conditions.

RATIONALE: SDWA, CERCLA, and RCRA require that underground drinking water sources be protected from contamination. Assurance that protection is being attained is provided by water quality data from monitoring wells. These wells should provide representative water samples and should not themselves produce contamination. EPA Program Office and Regional personnel as well as others involved with ground-water monitoring have expressed concern regarding the effects of well casing and screen materials on the validity of water quality samples. At least one Region is currently being challenged over its well casing materials position. The combination of field and laboratory research should provide effective answers to questions about appropriate well casings and screens for various hydrogeochemical conditions.

APPROACH: Laboratory and field studies will be conducted that go beyond the preliminary EMSL-LV research efforts with the Illinois State Water Survey and National Water Well Association. A field comparison of 304 and 316 stainless steel, fiberglass, PVC, and PTFE casing for low level volatile organic and metallic parameters is to be done at a former, permitted hazardous waste disposal facility near Wilsonville, IL. A long-term PVC casing field test will be done to evaluate casing integrity in ground water with low levels of organic contaminants. Laboratory studies will compare different casing and screen materials under a variety of conditions. Frequency and timing of sample collection will be selected with consideration of field ground-water sampling procedures. Results will be compiled in a guidance document.

EPA Coordinator: K. R. Scarbrough FTS 545-2645
(702) 798-2645

TITLE: Ground-Water Monitoring for Municipal Waste Combustion Ash Disposal

GOAL: Identify key ground-water monitoring issues pertaining to municipal waste combustion (MWC) ash disposal facilities. Provide technical guidance to regulators of MWC ash units on monitoring well sampling and leachate characterization.

RATIONALE: Legislation is pending in Congress that would exempt MWC ash from RCRA, Subtitle C (Hazardous Waste) and require EPA to develop special regulations for MWC ash under Subtitle D (Non-Hazardous Waste). Technical information will be required to support the development of regulations for monitoring of ground water at Subtitle D ash disposal facilities.

APPROACH: Data on leachate characteristics from various types of existing Subtitle D facilities which receive MWC ash have been collected and evaluated. This initial effort has indicated that only a small number of constituents (sodium, calcium, magnesium, potassium, chloride, sulfate, and bicarbonate) account for 99 percent of the readily mobile contaminant mass associated with MWC ash. In order to verify these results, ash samples from several active MWC ash generators will be obtained and subjected to laboratory leaching experiments. The objective will be to characterize the behavior of MWC ash in standardized laboratory test procedures and to evaluate the sensitivity of leaching results to controllable factors such as solid-liquid ratio, leaching time, replicate analysis, and sampling frequency. In addition, the laboratory results will be substantiated by comparison with leachate data and ground-water monitoring data generated by each of the facilities included in the study. The results will provide the technical basis for a cost-effective ground-water monitoring strategy and the necessary implementation guidance that is appropriate for RCRA Subtitle D MWC ash monofills.

EPA Coordinator: W. H. Engelmann FTS 545-2664
(702) 798-2664

TITLE: Surface/Surface to Borehole Geophysical Methods

GOAL: To provide surface and surface to borehole geophysical methods and strategies for monitoring at RCRA hazardous waste sites.

RATIONALE: RCRA Land Disposal Regulations require the establishment of a ground-water monitoring program at most facilities, including detection and compliance monitoring, involving the saturated and vadose zone. Surface and downhole monitoring techniques are required. Site characterization of the area is of prime importance in the location of the monitoring wells and vertical location of the screens. Geophysical methods have proven effective in delineating subsurface contamination and properties. A number of new instruments and techniques have been developed recently. The capabilities of these techniques have not been evaluated fully for hazardous waste site investigations. This research task is to evaluate these new methods for monitoring and hazardous site investigations.

APPROACH: A new research proposal has been submitted by DRI and is undergoing external review. Three tasks were outlined in the original proposal. One task involves technology transfer and is covered and funded under Y105/F06. The other two tasks, involving seismic and electromagnetic research, are covered under this Task Description. The first task involves the development of seismic tomography techniques using the full wave signal and diffraction theory. This technique will be evaluated for hazardous waste site investigations. In a recent review, it was pointed out that some of the proposed tomography research already has been performed at the Oak Ridge National Laboratory with good success. This work was funded by DOD and DOE. Discussions are currently underway with the Oak Ridge scientists to coordinate with their research efforts and provide technology transfer of their recent research. The second DRI task involves electromagnetic research. A new transient electromagnetic (TEM) sounding instrument has recently been developed for very shallow soundings. In addition, a number of theoretical TEM interpretation programs have been developed and new field data acquisition procedures have been proposed. Recently, a LBL and University of Utah research proposal has been partially funded by DOE on evaluating these interpretation procedures. Coordination with these researchers is currently underway for a joint field data evaluation program applicable for hazardous waste site investigations. Field evaluation of these programs and procedures require a site where the complete geological structure is known down to a depth of 50 meters. This will be done by using a number of standard surface, borehole, and surface to borehole geophysical techniques along with coring of the wells. Once a site has been characterized, a change in the subsurface physical properties will be induced by fluid injection and monitored with the geophysical techniques, such as TEM and seismic tomography. Ground truth would be established by the monitoring wells in the area.

EPA Coordinator: A. T. Mazzella FTS 545-2254
(702) 798-2254

TITLE: Seismic Shear-Wave Source Development

GOAL: To provide better seismic shear-wave sources for hazardous waste site investigations.

RATIONALE: Superfund (CERCLA) as amended in 1986 requires a national program to protect human health and environment from the hazards of inactive waste sites and spills or releases of hazardous substances. Regional OSCs and RPMs require monitoring techniques that quickly and effectively assess the degree of hazard posed at waste sites. Seismic techniques have proven effective for determining the subsurface site characterization at many locations. In particular, seismic shear-wave methods in combination with compression-wave surveys have proven very effective. A good three-dimensional shear-wave source for use in an urban environment does not exist. This research task is to design, develop, test and evaluate a three-dimensional shear-wave source to conduct high resolution seismic surveys at hazardous waste sites.

APPROACH: Based upon a number of shallow seismic studies conducted in the past three years under another project, it became evident that a good three-dimensional shear-wave source for shallow seismic studies was needed. The concept of such a source exists. The USGS is developing such a source for borehole surveys. This project will take advantage of the experience gained in the development of the borehole source. The design of the surface source and the software for the data acquisition system for the surface surveys will be developed with FY89 funding, project starting date 8/89. A prototype will be constructed, initial testing will start, and working drawings plus instructions for its operation will be written with FY90 funding. Acceptance criteria of the source will involve the following field testing: Evaluate the non-destructive aspects of its use. It should be usable on pavements without destroying the surface. The amplitude level and repeatability of the signal output should be sufficiently good that standard stacking techniques can be used. The source performance will be compared to the best non-destructive sources currently in use. The third year of the project, with FY91 funding, will involve completion of the testing and conducting field investigations at the Sand Creek CERCLA site in Denver, CO.

EPA Coordinator: A. T. Mazzella FTS 545-2254
(702) 798-2254

TITLE: Evaluation of Ground Penetrating Radar

GOAL: To provide better ground penetrating radar systems for hazardous waste site investigations.

RATIONALE: Superfund (CERCLA) as amended in 1986 requires a national program to protect human health and environment from the hazards of inactive waste sites and spills or releases of hazardous substances. Regional OSCs and RPMs require monitoring techniques that quickly and effectively assess the degree of hazard posed at waste sites. Ground penetrating radar (GPR) surveys have proven successful in some cases in providing high resolution data for delineating subsurface properties at hazardous waste sites. Existing systems could be improved to increase their range of application, and provide better resolution and interpretation. This research task is to investigate, evaluate and conduct testing of new radar systems designs at Superfund sites.

APPROACH: EPA Region 5 has been funding Dr. Jeff Daniels at Ohio State University to evaluate the GPR system for investigations in the Mid-west portion of the country. In the first year of this project, ORD funding was added to Region 5 funds to start a basic investigation into improving the GPR system for hazardous waste site surveys. Specific items that will be investigated are 1) new antenna designs, 2) fiber optics cables for low noise, 3) a method for improvement of data acquisition, and 4) an evaluation of a USGS processing program for enhancement of data interpretation. In the first year of this project, efforts are being concentrated on the new antenna designs and their evaluation. The best designs will be field tested in the second year along with the fiber optics transmission cable modifications. The USGS is behind on their processing program development (item (4) above). This

is not being funded by the EPA. The exact status of this work will be studied and possible modifications to the coop may be required. Full evaluation of the system is not expected until the third year along with investigations at Superfund sites.

EPA Coordinator: A. T. Mazzella FTS 545-2254
(702) 798-2254

TITLE: Surface to Borehole Geophysical Surveys for the UIC Program

GOAL: To provide geophysical methods to delineate and monitor deep subsurface contamination associated with injection well disposal.

RATIONALE: The Underground Injection Control Regulations require the assessment of the potential for contamination of ground water from the disposal of contaminants through injection wells. This project addresses the monitoring of inorganic contaminants disposed of in Class 1 or Class 2 wells. Injection zones for these contaminants are usually at depths greater than 700 meters (2000 feet). Surface geophysical electrical methods have proven effective in detecting inorganic contamination in the subsurface, usually at fairly shallow depths (100 meters). The surface methods lack the resolution and sensitivity necessary for monitoring at great depths. Borehole geophysical methods can provide the necessary resolution and sensitivity, however, the borehole methods are limited to a zone of detection that is very close to the borehole (2 meters). Borehole to surface geophysical methods provides a technique than combines the characteristics of the two methods. Depth resolution and detectability will be improved over the surface method and the zone of measurement can cover hundreds of meters laterally. This research task is to evaluate the use of the borehole to surface d.c. resistivity methods to delineate the deep subsurface structure, site characterization, and monitor the deep inorganic contamination.

APPROACH: Previous work on this project has developed a new method of treating borehole to surface d.c. resistivity data in order to provide better deep subsurface resolution. Theoretical treatment for the effects of metal well casings has also been developed. The equipment for conducting field surveys at depths to 2000 feet has been developed and has successfully undergone extensive field calibration tests. An extensive effort has been devoted to getting permission to conduct a field experiment at a Class 1 injection well facility. This has been met with limited success. Approval has been tentatively granted to conduct an experiment in a Dupont test well near a Class 1 injection facility. The FY90 task will be to conduct this field experiment and interpret the results.

EPA Coordinator: A. T. Mazzella FTS 545-2254
(702) 798-2254

TITLE: Airborne Geophysical Surveys

GOAL: To provide geophysical methods to monitor brine contamination of near surface aquifers resulting from underground injection well disposal.

RATIONALE: The Underground Injection Control Regulations require the assessment of the potential for contamination of ground water from the disposal of contaminants through injection wells. This project addresses the disposal of brine in Class 2 wells. Near-surface brine contamination in most oil fields can arise from a number of sources. For example, even though the practice of disposal of brine in surface pits was banned around 1976, a brine contaminant plume from this past practice still could be spreading throughout a region. Contamination can also arise from the present brine disposal practice due to poor integrity of the injection wells, improperly plugged abandoned wells, and vertical fractures. For a typical oil field, this region can cover a 40 square mile area. Geophysical methods have proven effective in detecting brine contamination in the subsurface. In order to distinguish between the past and current contamination, and between different possible sources, geophysical data must be acquired at fairly close spacing. Many areas are inaccessible for surface based surveys and to cover large areas can be very expensive. Airborne geophysical methods, electromagnetic induction (EM) and magnetometer methods, can cover large areas in a cost effective manner. This research task is to evaluate the use of the airborne EM and magnetometer methods to delineate the subsurface structure, the brine contamination plumes, and to identify the possible contamination sources.

APPROACH: Under a previous project, an airborne EM and magnetometer survey was conducted over the Brookhaven oil field, MS. This previous project established that usable airborne data could be obtained in this oil field production environment. The first phase of this task (FY89), which has just started, is to put the data into a GIS system, start a detailed interpretation of the airborne EM and magnetometer data, evaluate the need for ground and additional existing airborne EM surveys, and correlate the data with the location of all the wells and old surface brine pits. A discrepancy has been observed between the location of wells from the Petroleum Information data base and USGS topographic maps for this area. Historic and present air photographs also are being studied. Resolving these location discrepancies and correlating the well locations with the magnetic data may take more effort than was initially planned. Modelling interpretation of the EM data has just started. However, plans are being made with FY90 funds to conduct ground based geophysical surveys to "ground truth" these interpretations. At the same time it is proposed to fly a new prototype 60 HZ airborne system developed by the USGS. The first survey provided information about the contamination of the upper aquifer. This new system will sense deeper and should provide information about the brine contamination of the second, deeper aquifer in the area. Because of the problems locating all the wells in the area, airborne magnetic data will be obtained simultaneously with the EM data. In this case, it is proposed to use a high resolution 3 component fluxgate magnetometer to provide better lateral resolution than what was obtained in the first survey. These data will be incorporated into the GIS system and preliminary evaluation and interpretation will be performed. Detailed interpretation and modelling will be conducted in FY91.

EPA Coordinator: A. T. Mazzella

FTS 545-2254
(702) 798-2254

TITLE: Geophysics Expert System

GOAL: To provide a geophysics advisor expert system for hazardous waste site investigations.

RATIONALE: Superfund (CERCLA) as amended in 1986 requires a national program to protect human health and environment from the hazards of inactive waste sites and spills or releases of hazardous substances. Regional OSCs and RPMs require monitoring techniques that quickly and effectively assess the degree of hazard posed at waste sites. Many geophysical techniques have proven effective in locating and mapping contamination and in determining subsurface characterization at hazardous waste sites. The techniques are not necessarily successful at all sites and in all cases. There are many things, such as cultural interferences, that can influence these results and these should be considered. A competent geophysicist is aware of these problems, however, most OSCs and RPMs do not have this level of background. In order to check whether a proposed geophysical survey from a contractor had reasonable merit, a considerable amount of effort in literature search or consultation from an additional outside geophysicist would be required. By the development of a geophysics advisor expert system computer program, this research task is designed to aid the non-geophysicist in the decision-making process of which geophysical techniques should be considered for the different types of targets and environments. This would allow the manager a simple check on whether the proposed geophysical methods had merit, and a point for further discussions with the contractor.

APPROACH: An IBM-PC compatible computer program, Geophysics Advisor Expert System, Version 1.0, has been developed to advise on the use of different geophysical techniques for hazardous waste site investigations. The program generates a list of questions and answers, which are matrixed against the characteristics of the different geophysical techniques to produce a weighted recommendation of which geophysical methods to consider. This program is currently in use. The present, second phase of this project is to introduce a database of the physical and chemical properties of 100 toxic organic and inorganic chemicals into the computer program. These properties have been compiled from an extensive literature search and are currently undergoing review. The second version of the program then will provide to the user a menu of contaminants, and the program will have the necessary answers to determine the best geophysical method for monitoring. Information on additional geophysical methods that were not included in the first version are currently being researched. If sufficient data are available, these methods will be added in the second version. The program will be reviewed against known case studies and the results of current research, such as the geophysical studies for chlorinated solvents, will be incorporated.

EPA Coordinator: A. T. Mazzella FTS 545-2254
(702) 798-2254

TITLE: Electromagnetic Methods Development

GOAL: To provide better electromagnetic methods for hazardous waste site investigations.

RATIONALE: Superfund (CERCLA) as amended in 1986 requires a national program to protect human health and environment from the hazards of inactive waste sites and spills or releases of hazardous substances. Regional OSCs and RPMs require monitoring techniques that quickly and effectively assess the degree of hazard posed at waste sites. Electromagnetic induction (EM) and ground penetrating radar (GPR) surveys have proven effective in some cases for hazardous waste site investigations. The EM methods operate below 20 KHz and give good penetration into the earth, however they suffer from resolution. GPR (80 MHz) provides good resolution, but in many situations has poor penetration. Little work has been done in the intervening frequency band. This research task is to investigate the possibility of an electromagnetic system in this intervening frequency band. Such a system could provide an exploration method with a better combined resolution and penetration depth capability that could be used at hazardous waste sites.

APPROACH: In the frequency band of 100 KHz to 30 MHz, the EM response will be dependent upon the dielectric constant and electrical conductivity. In the first phase of this work computer programs were developed to study the EM response at these frequencies. These programs then were used to study the response of design parameters to different earth models. It was shown that a transmitted loop - receiver loop system, operating in the frequency range of 100 KHz to 30 MHz, could detect changes in the dielectric properties of a layered earth, simulating the presence of such contaminants as gasoline. The transmitter-receiver separation was shown to be critical, operating from one to tens of meters separation. However, the optimum separation for a particular model was not easily determined. This would have to be determined using multiple loop-loop separations on an actual survey. The modelling results indicated that the most significant response occurs at the high frequency end of the spectrum, 1 to 30 MHz. Based on these studies, a prototype system is currently being developed. In order to check the computer models and the prototype system, analog scale tank model experiments are being developed. These experiments will compare the theoretical computer model results to the tank model measurements for a homogenous half space with various dielectric constants. Additional experiments for a two-layer case also will be compared with various conductivities, dielectric constants, and thicknesses. This work is in progress. Field testing of the prototype system is scheduled for the third year of the project. These experiments will test the system against standard EM and GPR methods under actual cultural noise environments.

EPA Coordinator: A. T. Mazzella FTS 545-2254
(702) 798-2254

TITLE: Borehole Geophysical Methods

GOAL: To provide borehole geophysical methods and strategies for monitoring at RCRA hazardous waste sites.

RATIONALE: RCRA Land Disposal Regulations require the establishment of a ground-water monitoring program at most facilities, including detection and compliance monitoring, involving the saturated and vadose zone. Surface and downhole monitoring techniques are required. Understanding the hydrological characteristics of the area is of prime importance in the location of the monitoring wells and vertical location of the screens. Borehole geophysical tools to determine subsurface properties have been in use many years in the petroleum industry, however their use for hydrologic studies has not been evaluated fully. This research project is to develop and evaluate a strategy using borehole geophysical tools to determine the vertical hydraulic conductivity, hydraulic anisotropy and hydrogeological characterization of an area.

APPROACH: In a previous project, a strategy was developed to determine the hydraulic anisotropy of an area with borehole flowmeters. Evaluation of an existing thermal flowmeter indicated that it did not have the sensitivity needed for the strategy. Further testing of other flowmeter methods led to limited success, hence, the original strategy to determine anisotropy of the hydraulic conductivity could not be performed. Therefore, efforts were devoted to evaluating an EM borehole tool and testing a field procedure using it to determine the vertical distribution of the hydraulic conductivity. This was successfully tested in the field and the results were reported in the literature. Many of the interpretations of borehole data are influenced by the presence of clay. The present efforts are being devoted to an evaluation of borehole gamma and induced polarization tools to delineate thin clay lenses in the subsurface. This work is in the final stages and should be completed by 3/90. The remainder of the FY90 activities will be devoted to the completion of the final project report.

EPA Coordinator: A. T. Mazzella FTS 545-2254
(702) 798-2254

TITLE: Geophysical Technical Support

GOAL: To provide geophysical technical support to the Regions for hazardous waste site investigations.

RATIONALE: Superfund (CERCLA) as amended in 1986 requires a national program to protect human health and environment from the hazards of inactive waste sites and spills or releases of hazardous substances. Regional OSCs and RPMs require monitoring techniques that quickly and effectively assess the degree of hazard posed at waste sites. Many geophysical techniques have proven

effective in locating and mapping contamination and in determining subsurface characterization at hazardous waste sites. There are a wide variety of techniques and applications. Many of these are not known to Regional personnel. The Geophysics Advisor Expert System computer program can help solve some of the problems, particularly those that are routine. However, some sites may require a higher level of expertise, more than that which the Regional support contractor can provide. This task is to assist the Regions with this higher technical level of support.

APPROACH: Geophysical support to conduct surveys will be provided through the USGS, LESC, DRI, COE, Ohio State, and EPA EMSL-LV personnel. Research projects with some component of technical support are in place with these organizations. This task is to provide some base level support for these support activities. The funding to DRI and COE is to partially support co-located personnel from those organizations at EMSL-LV. They provide the basic support for the organizational aspect of the program. Funding to Ohio State is for partial support for site specific investigations in Region 5 using a number of geophysical methods to evaluate the GPR system. The research aspect of this coop is funded under Y105/A04/01/05, Evaluation of Ground penetrating Radar Systems. The funding to LESC is for base level maintenance and support of the geophysical equipment and initial site specific visits. A number of different organizations are involved in the geophysical technical support to take advantage of specialized expertise that lies in the different organizations. This is necessary because of the large number of different geophysical techniques that could be considered in an investigation. Some of the surface geophysical techniques are as follows: ground penetrating radar, EM, d.c. resistivity, magnetometer, refraction and reflection seismic (includes both P and S wave studies), gravity, and electrokinetic methods. In addition to these there are a number of marine, borehole, surface to borehole, cross borehole, and airborne geophysical methods that can be considered for a specific site problem.

EPA Coordinator: A. T. Mazzella FTS 545-2254
(702) 798-2254

TITLE: Geophysical Studies for Chlorinated Solvents

GOAL: To provide better geophysical methods to detect chlorinated organics in the subsurface.

RATIONALE: Superfund (CERCLA) as amended in 1986 requires a national program to protect human health and the environment from the hazards of inactive waste sites and spills or releases of hazardous substances. Regional OSCs and RPMs require monitoring techniques that quickly and effectively assess the degree of hazard posed at waste sites. This problem is particulary difficult if the contaminants are buried or are migrating in the subsurface. Geophysical methods can provide useful information for these subsurface problems. Such geophysical methods as ground penetrating radar and complex resistivity have detected organic contamination in the subsurface. Little work has been

conducted under controlled field experiments to study these responses and fully evaluate the methods.

APPROACH: This project will fund the USGS to participate in a multi-year (a total of 5 years) field experiment with the University of Waterloo, Oregon Graduate Center, and Colorado State University. These other institutions are being funded at a level of $1,000,000 per year from private corporations. At a site in Canada, a number of experiments with controlled spills of chlorinated solvents, such as TCE, will be conducted. A single solvent will be studied at a time and its fate, transport, and remediation investigated. This area will be monitored by geophysical techniques before and after the contamination is released and after final remediation. The site characteristics, hydrology, and ground truth will be evaluated by the other researchers. For example, the addition of a dye to the chlorinated solvent will permit photographic documentation of the lateral distribution of residual liquid in the subsurface exposed by excavation. By previously evaluating any natural occurring temporal variations, these experiments will indicate the detection limits and resolution abilities of geophysical methods such as GPR and complex resistivity to detect and delineate areas of subsurface contamination.

EPA Coordinator: A. T. Mazzella FTS 545-2254
(702) 798-2254

TITLE: Effects of Drilling Methods on Water Quality

GOAL: To determine temporary or permanent geochemical changes in monitoring well sampling zones resulting from both drill type and method used in monitoring well-bore development.

RATIONALE: Compliance with RCRA regulations depends on reliable water quality data from monitoring wells for detection and assessment monitoring phases, yet there is a considerable lack of information on the significant geochemical disturbances that occur as wells are drilled. Some changes near the well bore are permanent, while others are temporary, pending re-establishment of the ionic equilibria within the sampling volume of the well. This study will eventually provide for closer control of drilling methods and sampling protocol to ensure meaningful water quality data from monitoring wells.

APPROACH: This study will initially be run in-house, until the approach can be clearly defined and an appropriate research direction formulated. The characterization of geochemical disturbances will be reached through two pathways: 1) drilling technology literature and 2) conferring with other workers in the field, for latest trends in geochemical research. The task will then be advertised in the CBD, calling for Letters of Interest from groups who might conduct the research. A further step of formal selection RFP route suggested of the contractor will follow.

EPA Coordinator: W. H. Engelmann FTS 545-2664
(702) 798-2664

TITLE: UST Sensor Evaluation

GOAL: Development of preliminary test criteria document and standard test procedures that presumably will become ASTM standards. To provide validated test methods/ASTM standards for evaluating UST monitoring devices.

RATIONALE: As the new UST regulations are implemented, a variety of monitoring devices will become available. The performance characteristics of external leak detection monitoring systems need to be understood and test protocols developed. The essential characteristics of this hardware should be identified and the response function characterized. Standard test procedures need to be established so that tests and comparisons can be made on existing and future devices. Such tests and the resulting comparisons will help consumers select devices best suited to their needs.

APPROACH: 1) To develop minimum preliminary performance criteria for instrument manufacturers to aid in their development and testing of external leak detection monitoring methods; 2) to develop standard test methods to allow external leak detection instruments to be evaluated on a common basis and to promote the reporting of instrument specifications against a common test method; 3) to establish the response function for the hardware that will be useful in evaluating the total response of a monitoring system; 4) to validate the test procedures by conducting interlaboratory tests; and 5) to develop ASTM standard test procedures.

EPA Coordinator: P. B. Durgin FTS 545-2623
(702) 798-2623

TITLE: Geophysics Technical Support

GOAL: To provide geophysical technical support for Regional hazardous waste site investigations.

RATIONALE: Superfund (CERCLA), as amended in 1986, requires a national program to protect human health and environment from the hazards of inactive waste sites and spills or releases of hazardous substances. Regional OSCs and RPMs require investigative and monitoring techniques which are able to provide information on subsurface pollutants at Superfund sites. Geophysical techniques, generally employed early in the overall investigative program, have proven to be effective in detecting and defining subsurface wastes quickly and economically. However, geophysics is a highly technical field having a wide variety of individual techniques and applications not generally known to Regional personnel. While the Geophysics Advisor Expert System (developed by AMW) and the Regional support contractor can often handle routine geophysical applications, some problems require a higher level of expertise. This task provides the Regions with that higher level of geophysical support needed in such circumstances and/or QA/QC for Regional geophysical activities.

APPROACH: Geophysical support to assist in planning, conducting special geophysical surveys, or to provide QA/QC assistance is provided through LESC, DRI, USGS, COE, and EPA EMSL-LV personnel. Research projects, with some component of technical support, are in place with these organizations. This task is to provide some base level support for these activities. The funding to DRI and CoE is to partially support co-located personnel from those organizations at EMSL-LV who provide the basic support for the organizational aspects of the program. Funding to Ohio State is for partial support for site specific investigations in Region 5 using a number of geophysical methods to evaluate the GPR system. The research aspect of this coop is funded under Y105/A04/01/05, Evaluation of Ground penetrating Radar Systems. The funding to LESC is for base level maintenance and support of the geophysical equipment and initial site specific visits. Mechanisms, to provide technical support, are in place with all of these organizations to take advantage of specialized expertise that lies in each. This is necessary due to the large number of different geophysical techniques that could be considered in an investigation. Some of the geophysical techniques are as follows: ground penetrating radar, EM, d.c. resistivity, magnetometry, seismic studies, and electrokinetic methods. In addition to these, there are a number of marine, borehole, and airborne geophysical methods that can be considered for a specific site problem.

EPA Coordinator: A. T. Mazzella FTS 545-2254
(702) 798-2254

TITLE: Geophysics Technical Support (SCAP funded)

GOAL: To provide geophysical methods for the detection and assessment of contamination at Superfund sites, through geophysical technical support.

RATIONALE: Regional OSCs and RPMs require investigative and monitoring techniques which are able to provide information on subsurface pollutants at Superfund sites. Geophysical techniques have proven to be effective in detecting and defining subsurface wastes quickly and economically, and are generally employed early in the overall investigative program. However, geophysics is a highly technical field having a wide variety of individual techniques and applications not generally known to Regional personnel. While the Geophysics Advisor Expert System (developed by AMW) and the Regional support contractor can often handle routine geophysical applications, some problems require a higher level of expertise. This task provides the Regions with that higher level of geophysical support needed in such circumstances, QA/QC for Regional geophysical activities, and the presentation of the geophysics training course as requested.

APPROACH: Geophysical support to assist in planning, conducting special geophysical surveys, or to provide QA/QC assistance is provided through LESC, DRI, USGS, COE, and EPA EMSL-LV personnel. Mechanisms, to provide technical support, are in place with all of these organizations to take advantage of specialized expertise that lies in each. This is necessary due to the large

number of different geophysical techniques that could be considered in an investigation. Some of the geophysical techniques are as follows: ground penetrating radar, EM, d.c. resistivity, magnetometry, seismic surveys, and borehole geophysical loggers. This task provides for the overhead, workplans, assistance, and reports for these SCAP technical support activities. Other tasks under this project provide for related activities. To insure Regional personnel are familiar with geophysics, an introductory course has been developed which is presented periodically in the Regional offices. FY-90 funding levels are estimates; all FY-90 funds will be from regional offices requesting the technical support (SCAP funds estimated at $100K) or OSWER (Technical Support Center funds, also estimated at $100K).

EPA Coordinator: J. L. Jack FTS 545-2373
(702) 798-2373

TITLE: Cone Penetrometer Evaluation

GOAL: To provide methods for the detection and assessment of contamination at Superfund sites, using a cone penetrometer tool.

RATIONALE: CERCLA as amended in 1986 requires a national program to protect human health and environment from the hazards of inactive waste sites and spills or releases of hazardous substances. Regional OCSs and RPMs require monitoring techniques that quickly and effectively assess the degree of hazard posed at waste sites. Traditional borings require significantly more time and expense to complete and may result in uneven holes or masking of actual bore wall materials. Geophysical techniques using a cone penetrometer, a probe pushed into unconsolidated sediments with various logging devices, may prove effective in locating and mapping contamination at depth without the expense and delay of drilling boreholes. However, methods of equating geophysical measurements made using cone penetrometers with more traditional tools need to be developed and/or validated prior to wide implementation. Cone penetrometers can provide logs of natural parameters not obtainable via conventional drilling and eliminate some of the deleterious effects of rotary drilling and drill mud.

APPROACH: The primary requirement is being able to make direct comparisons between geophysical measurements made with older methods and those made with the cone penetrometer (CPT). Essentially, electrical resistivity logs acquired using CPT need to be compared to similar resistivity logs from a conventionally drilled and logged hole. During FY-89 work began on the Quality Assurance Plan while FY-90 will see completion of that and the actual acquisition of CPT data taken in close proximity to an existing borehole used as a standard for traditional logging equipment. During these tests various multiple electrode array spacings will be evaluated, as will various surface to borehole resistivity configurations. Should reliable correlation be obtained at the initial calibration hole, there will need to be similar testing done adjacent to other well-logged holes which penetrate different geologies/soils. Once reliable correlation to traditionally obtained data and actual sample material is achieved and reported, this technique will be

available to be used and further verified via the SCAP funded, Geophysics Technical Support (Y105, Project 02, Task 01).

EPA Coordinator: L. A. Eccles FTS 545-2385
(702) 798-2385

TITLE: Seismic Noise Studies to Detect Contaminant Migration

GOAL: To provide geophysical techniques to delineate subsurface contamination movement associated with underground injection wells.

RATIONALE: The Underground Injection Control Regulations require the assessment of the potential for contamination of ground water from the disposal of contaminants through injection wells. This means fully understanding where the injected contaminants are going. This project addresses the monitoring of contaminants disposed of in Class I or Class II wells. Injection zones for these contaminants are usually at depths greater than 700 meters (2100 feet). Surface geophysical methods have proven effective in monitoring contamination in the subsurface, usually at fairly shallow depths (100 meters). Previous surveys, under a separate task, have concentrated upon the evaluation of borehole to surface electrical methods for the detection of deep inorganic contamination. Detection of organic contamination by these electrical methods is not highly probable. The movement of the contaminant fluids in the subsurface should generate microseismic noise. This task is to evaluate whether this microseismic noise can be detected over background noise at UIC sites.

APPROACH: The movement of injected fluids in the subsurface generates microseismic noise. A considerable amount of attention and research has been devoted to detecting this passive seismic noise for geothermal exploration and hydrofracture monitoring over the past 15 years. The first phase of this task will be to investigate whether this microseismic noise can be detected over the background noise at UIC sites. An array of seismic geophones will be placed down a fairly shallow borehole (less than 50 feet) near the injection wells and the signals monitored over a period of time (about a week). Spectral analysis of these signals will indicate whether fluid migration was detected. This experiment will be conducted at five different injection sites around the country under different geological and background noise conditions. In the second phase of the project, additional experiments will be conducted at those sites where microseismic noise associated with fluid migrations was detected. Multiple geophone arrays in boreholes around the injection well will be monitored in order to fully evaluate the ability of the passive seismic method to detect and delineate the fluid movement associated with the underground injection process.

EPA Coordinator: A. T. Mazzella FTS 545-2254
(702) 798-2254

TITLE: In Situ Fiber Optic Field Spectrofluorimeter (Luminoscope)

GOAL: Provide advanced-design portable UV-visible spectrofluorometic (luminoscope) capability for in situ screening for polynuclear aromatic (PNA) contaminants in water, oils, and waste materials. Provide improved luminescence analytical methods, including synchronous scanning capability for less spectral overlap and improved PNA "fingerprints". Provide technology transfer to commercial manufacturer and methods acceptable for eventual standardization by ASTM.

RATIONALE: Subtitle C of RCRA requires EPA to promulgate regulations for protecting ground water from releases of hazardous waste. Development of rapid on-site analytical spectroscopic capability will support RCRA remediation efforts enabling more timely on-site decision making. This will also provide a method for rapid screening by luminescent techniques; also for screening samples at abandoned waste storage, treatment, and disposal facilities; and rapid evaluation of RCRA sites and personnel for potential exposure to hazardous materials in emergency response situations. Therefore, luminescence screening of waste materials and samples at abandoned sites is a highly-desired rapid spectroscopic method and is an essential method to keep analysis costs down and to shorten the time before implementing RCRA remediation procedures.

APPROACH: Develop and modify a portable UV-vis spectrofluorometer (luminoscope), adding a remote fiber-optic probe to detect polynuclear aromatics (PNAs) in water, soils, and in municipal and industrial incinerator residues. The luminoscope will be modified for synchronous scanning capability for improved PNA "fingerprint", resulting from less spectral overlap. In this mode of operation the excitation beam and the fluorescent beam are tuned with a constant small wavelength difference (usually 3-7 nanometers). Correlation with GC-MS data is expected to be sufficient to eventually allow this advanced spectroscopic technology to replace the need for GC-MS analysis. The analytical methods and system support software that are developed will be demonstrated. Methods also will be presented to appropriate ASTM committees for acceptance. The versatile capability of the instrumentation and the analytical methods for screening personnel for exposure to PNAs will be evaluated. Finally technology transfer to a commercial manufacturer will also be provided.

EPA Coordinator: W. H. Engelmann FTS 545-2664
(702) 798-2664

TITLE: RCRA Rapid Field Screening Techniques for Hazardous Waste Sites

GOAL: Provide field portable luminescence analytical methods for detecting and characterizing PNAs and PCBs in water and soil samples and for in situ analysis for PNAs in soils.

RATIONALE: Subtitle C of RCRA, as amended by HSWA in 1984, requires EPA to promulgate regulations for owners and operators of hazardous waste storage,

treatment, and disposal facilities. These regulations are contained in 40 CFR, Part 264. Many RCRA and Superfund sites contain PNAs and PCBs from heavy petroleum oils, tars, and creosotes; and from both incinerated and nonincinerated organic refuse. PNAs are of concern since many are carcinogenic (example - benzo(a)pyrene). PCBs are also of concern because of their ubiquity, chemical inertness, and relatively high toxicity at low ppm levels. Further, if PCBs are incinerated without complete combustion, they can be transformed into even more toxic compounds, such as chlorinated dibenzodioxins. Field methods of luminescence spectroscopy, as planned to be developed here, will allow rapid RCRA-site analytical capability, in addition to *in situ* field screening for many other hazardous compounds. This will save both time and money and enable more timely on-site decision-making during remediation of RCRA sites. Luminescence methods present the potential for very fast analytical times in the following cases: (1) rapid-screening of field samples, (2) sample screening in the laboratory, and (3) "standard" laboratory spectro-analytical methods, once accuracy and precision are perfected for

APPROACH: Portable instrumentation utilizing luminescence appears to be the most promising route to on-site RCRA screening data for PNAs and PCBs. Two approaches will be taken under this task. In one case, advanced analytical protocols for field PNA methods, starting with existing ASTM and U.S. Coast Guard methods, will be improved and submitted to ASTM. A draft ASTM method for PCBs based on previous feasibility studies will also be developed. This will allow a beginning of standardization in spectrochemical testing of hazardous waste, sensitivity and detection limits, which should be commensurate with RCRA regulations applicable to specific contaminants. Methods for data interpretation and spectral pattern recognition will be developed to simplify rapid spectro-analytical work on pollutant identification. The other approach involves using luminescence in combination with chemical sensors (such as those based on fiber optics). The technology barrier in this case is the development of coatings for the chemical sensors. These coatings are needed to provide specific interactions with the analytes of interest in order to achieve selectivity and sensitivity. Success in the coatings development should allow considerable choice in the selection of the sensor itself. Polymer films with immobilized indicator molecules will be examined initially for various RCRA pollutants.

EPA Coordinator: W. H. Engelmann FTS 545-2664
(702) 798-2664

TITLE: Rapid Soil-Gas Field Screening Methods

GOAL: Provide and demonstrate the utility of rapid soil-gas field screening techniques and instrumentation for Superfund site assessments for volatile and semi-volatile contaminants.

RATIONALE: Section 311c of SARA authorizes research for detecting hazardous substances in the environment. The development of these rapid screening methods will optimize field efforts from initial investigation through

remediation by providing on-site data. This will save time and money and enable Superfund site managers to make better and more timely decisions in the field. These methods are intended to aid in making initial determination as to whether or not soil and ground water at sites are contaminated with either volatile or semi-volatile organic compounds and, if so, determine the extent. These methods will also aid in reducing the cost and time to perform subsequent detailed investigations by providing an abundance of rapid and inexpensive screening data, as well as have applicability to monitoring active and passive site bioremediation processes.

APPROACH: Rapid soil-gas field screening techniques and instrumentation will be developed and demonstrated in the following way: the instrumentation components planned for this task are portable vapor analyzers, sensors, and field gas chromatographs modified for rapid analysis. Commercially-available equipment that can be used directly, or easily modified for the intended application will be evaluated. This includes soil-gas probes, probe installation equipment, and analysis systems. Methods and equipment for rapid data handling and interpretation will be demonstrated, including portable computers and associated hardware and software for modeling, mapping, and data transmission. Field screening will be demonstrated and an evaluation will be prepared. Measurement of soil-gas carbon dioxide (CO2) levels as an indicator of (CO2) subsurface hydrocarbon contamination will be emphasized. Under aerobic conditions, CO2 is the ultimate degradation product of many petroleum hydrocarbons. As a result, CO2 measurement may be of value in 1) detection of volatile compounds in the subsurface (not present in the overlying soil gases because of rapid degradation), 2) indirect detection of low-volatility organic compounds (not otherwise detected in the soil gases due to low partitioning to the gas phase), and 3) monitoring active or passive in situ bioremediation. The first two potential applications will be field tested, followed by tests at both Superfund and Air Force sites. Concurrently, the system and methods will be made available through the Tech Support/Tech Transfer Center, as was done with the development and application of the XRF field-screening system. A commercial vendor for the equipment developed under these tasks will be sought, possibly through a FTTA Cooperative Agreement.

EPA Coordinator: W. H. Engelmann FTS 545-2664
(702) 798-2664

TITLE: Development/Demonstration/Evaluation of Field Monitoring Systems

GOAL: (1) Demonstrate and evaluate x-ray/UV-visible fluorescence and fiber optic chemical sensor (FOCS) technologies at Superfund sites; (2) Communicate effectively the results and advantages to the regulators and the regulated community; (3) Transfer the new technology to the user community by encouraging the commercial licensing of the technologies; (4) Identify technically superior field monitoring methods that currently lack cost-effectiveness and undertake developmental work on advancing the technology to achieve cost-effectiveness to the degree necessary to facilitate commercialization.

RATIONALE: Section 311(b) of SARA requires EPA to establish . . ."a program of research, evaluation, testing, development, and demonstration of alternative or innovative treatment technologies . . .". Accordingly, the "SITE" program (Superfund Innovative Technology Evaluation) was developed. The Monitoring and Measurement Technologies phase of SITE addresses this requirement. The magnitude of environmental screening potentially required by the swelling number of Superfund sites is staggering. Development of rapid field screening devices that are embodied as compact spectroscopic instrumentation and sensitive chemical sensors shows great promise to be the highly useful tools to respond to this accelerating need for Superfund site screening. EMSL-LV has supported early development of FOCSs and has also successfully facilitated their commercialization. The task remains to demonstrate further and evaluate improved FOCSs, as well as related technical improvements in chemical sensor films.

APPROACH: Technological innovation in field monitoring systems has generally occurred as advances in electronic design, featuring faster speed, miniaturization, increased sensitivity, more computer control of the data management, as well as substantial innovations in the instrument's detector. Likely new candidates for advancing field monitoring systems are novel chemical films and coatings on the sensor that respond to UV-Visible light when contracting PCBs on PNAs. Advances in field screening detectors or instrumentation will be pursued closely (1) in the literature, (2) through attendance at technical conferences where late-breaking innovations are presented, and (3) through the RFP route to R and D contracts, or Cooperative Agreements, all for picking up on the latest detector innovations or associated instrumentation design improvements, including: sensitivity, selectivity, accuracy, precision, broader operating temperature, ruggedness, and reduced size. When new technology or innovations favorable for Superfund site screening are uncovered, and there appears to be a need for seed, or developmental funding, to bring it to a useful state faster, then negotiations, if appropriate, will be started with the parties with the intellectual property, protecting their possible patent rights, along with those of the U.S. Government, as the inventions move toward reduction-to-practice and interest grows toward licensing for manufacture (full Technology Transfer).

EPA Coordinator: W. H. Engelmann FTS 545-2664
(702) 798-2664

TITLE: Field Screening Methods for PNAs and PCBs

GOAL: Provide molecular spectroscopic (UV-vis-near IR) fieldable and portable instrumentation and methods for characterizing and semiquantitating PNAs in water and soil and PCBs in soil.

RATIONALE: Section 311c of SARA authorizes research for detecting hazardous substances in the environment. Advanced *in situ* screening and monitoring methods and instrumentation allow major savings in time and analysis costs and more efficient selection of samples if confirmation by other methods is desired. Many Superfund sites contain hazardous PNAs from heavy petroleum

oils, tars, creosotes, and both PNAs and PCBs from incinerated and non-incinerated organic refuse and from discarded heavy-duty electrical equipment. Development of spectroscopic techniques such as luminescent-based methods will permit rapid on-site and possibly *in situ* analysis, enabling more timely on-site decision making and cost savings. These methods may also be used for rapidly screening samples sent to the laboratory. Application of such methods in the laboratory, upon meeting the assurance and quality control requirements of laboratory testing, should also result in time and cost savings.

APPROACH: Two approaches are being evaluated for pollutants, such as PNAs and PCBs. One involves luminescence, with portable instrumentation to obtain data on site. Major classes of luminescing chemicals or even individual compounds can be distinguished through wavelength selectivity or phosphorescence lifetimes. Luminescence is especially applicable to PNAs and PCBs since they have relatively high quantum yields of luminescence and spectral structure. More portable, sensitive and selective instruments suitable for screening applications are now available and they will be used for PNAs and PCBs in soil and water. Protocols for luminescence analysis of PNAs and PCBs for detection, classification and quantitation for screening will be refined for possible ASTM tests. The other approach involves luminescence (or color changes) of sensor films coated with pollutant-specific reagents. The technology barrier is the coating chemistry that provides selectivity and sensitivity. Success here should allow considerable choice in the physical sensor itself (fiber optics or portable UV lamp). Spectroscopic techniques also include fluorescence, phosphorescence and synchronous fluorescence. Other spectroscopic "read outs" such as infrared, UV-visible absorption, and surface-enhanced Raman techniques might also be applicable.

EPA Coordinator: W. H. Engelmann FTS 545-2664
(702) 798-2664

TITLE: Support for Field Screening Methods - XRF

GOAL: Provide rapid field x-ray fluorescence (XRF) analytical techniques for screening Superfund sites contaminated with metals. Provide rapid *in situ* measurement techniques that will reduce sample handling. Provide comprehensive field analytical capability resulting in complete elemental analysis at the low pm level and fundamental parameters ("standardless") calibration. Provide techniques for preparing calibration standards for field portable XRF while on site.

RATIONALE: Section 311c of SARA authorizes research on detection methods for hazardous substances in the environment. Regulations promulgating CERCLA or SARA require the detection and quantitation of particular pollutants from hazardous waste or Superfund sites. The development of these rapid screening methods will optimize Superfund field efforts from initial investigation through remediation by providing on-site data. These *in situ* XRF methods will allow for site coverage not feasible with traditional sampling and analytical

methods. This will save time and money and enable Superfund site managers to make better and more timely decisions in the field.

APPROACH: Develop *in situ* XRF measurement techniques for rapid screening and demonstrate at sites in various stages of investigation or remediation. Develop methods for preparing site specific calibration standards suitable to carry out field screening tasks. Develop methods for *in situ* homogenization of contaminated soils. Develop a field method for analysis of contaminated soils at the low ppm level for highly toxic elements, such as cadmium. Develop specifications for an advanced field portable XRF analyzer system for making *in situ* measurements. Prepare a comprehensive Project Report which will include field data analysis and mapping methods developed under the associated work of this project (task 02).

EPA Coordinator: W. H. Engelmann FTS 545-2664
(702) 798-2664

TITLE: Development of Prototype USRADS to Portable XRF

GOAL: Ultrasonic Ranging and Data Systems (USRADS) to field-portable XRF screening equipment for rapid field screening of sites contaminated by metals. This will enable us to transmit data along with auto-location to an off-site (beyond exclusion area) base station and feed it directly into a field computer to process and map the data. Provide this capability for soil gas portable instrumentation for sites contaminated with volatile organics and for portable fluorescence analyzer systems used to screen for PNAs and PCBs in soils as they become available. Provide capability for surface geophysical surveying with the EM-31 electromagnetic induction surveying instrument used for locating buried objects and covered trenches.

RATIONALE: Section 311c of SARA authorizes research on detection for hazardous substances in the environment. The most time-consuming steps in using data generated in the field by portable XRF and other sensing technologies is often determining the location of the measurement and loading it, along with measurement data, into a computer for processing. The adaption of the USRADS will enhance rapid screening methods and further optimize field efforts from initial Superfund site investigation through remediation by quickening the process of loading site analytical data into field computers used to process the data into usable information. This will save time and money and enable site managers to make better and more timely decisions in the detailed surveys by providing an abundance of screening data that can be handled rapidly and inexpensively.

APPROACH: USRADS was developed at ORNL and licensed for manufacture to ChemRad, Inc. It is suitable for adaption to a number of advanced field portable sensing systems, as well as to a number of the more conventional analytical system. Through development of a computer interface module, the USRADS will be able to receive data from new, rapid field-screening systems (Columbia X-Met portable XRF and EM-31 electromagnetic induction tool). A

computer will be adapted for managing and displaying all the outputs from the instrumentation. This capability will be demonstrated on site.

EPA Coordinator: W. H. Engelmann FTS 545-2664
(702) 798-2664

TITLE: Data Management for Rapid Field Screening Methods

GOAL: Provide data management techniques to support the large volume of data generated under field screening development efforts.

RATIONALE: Section 311c of SARA authorizes research for detecting hazardous substances in the environment. The rapid XRF screening methods are designed to optimize field efforts from the initial Superfund investigation stage through final remediation and to rely on computer conversion of data into information usable by the site managers. This includes data produced both on and off site. These computer-managed techniques will save both time and money and enable the site managers to make better and more timely decisions and minimize the data tracking, cataloging, interpretation, and retrieval efforts.

APPROACH: Data management techniques for field screening will be developed with computer control and demonstrated at Regional Superfund sites. A series of site investigation reports also will be produced in conjunction with task 01 under this Project. This will include interfacing data acquired through telemetry techniques with automated mapping techniques done in the field. A bar code system, applied to the sample container for inputing and tracking XRF-generated data directly into computers for subsequent manipulation, will be developed and demonstrated. Additional automated methods to support the production of interpretative reports in the field will be developed, including standardized pages for site information, instrument calibration, and quality control procedures.

EPA Coordinator: W. H. Engelmann FTS 545-2664
(702) 798-2664

TITLE: Bioremediation Monitoring Around UST

GOAL: Evaluate the important factors to monitor during both active and passive bioremediation. Determine and develop inexpensive monitoring techniques and promote protocols that use these techniques. Establish demonstration projects that provide visibility for passive bioremediation.

RATIONALE: There is a tremendous number of contaminated underground storage tank sites in this country with plumes of petroleum hydrocarbons that are not moving nor causing a serious threat. The contaminants are undergoing natural biodegradation but regulators are hesitant to allow the owner/operator to simply monitor the situation without initiating cleanup procedures. This

research would provide guidance on what only needs monitoring and provides help on monitoring procedures. Active bioremediation is being pursued at many sites but improvements in monitoring procedures could make the process more efficient and cost effective. Bioremediation has the potential ;of being a low-cost cleanup alternative however in reality it has been one of the most expensive. This work will be accomplished in conjunction with the Ada Lab.

APPROACH: Study sites will be selected at the Sleeping Bear Dunes National Lakeshore in northwestern Michigan. Investigations related to passive remediation will be initiated in cooperation with the National Park Service and RSKERL. The two service-station study sites at the University of Connecticut will also be used for this research. The commercial station will be the site of active bioremediation while the motor pool will be monitored for passive bioremediation. LUST Trust Fund sites in Connecticut may also be monitored if they are undergoing bioremediation. Prior to the start of the UCONN project the microbial populations will be characterized. Changes in the microbial population will be monitored as the sites are cleaned up and easily-measured surrogate parameters will be chosen to help people monitor their cleanup progress. Protocols for monitoring bioremediation will be developed and provided to ASTM for standards development.

EPA Coordinator: P. B. Durgin FTS 545-2623
(702) 798-2623

TITLE: Detection and Monitoring of Subsurface Gasoline

GOAL: To continue to develop an understanding of vapor and ground-water monitoring problems around UST and devise practical solutions. To develop and provide technology transfer of field-screening techniques. To further characterize the site in preparation for bioremediation.

RATIONALE: This is work to be conducted during the third year of a co-operative agreement with the University of Connecticut. This co-op has been tremendously successful and should be continued because many of the projects have not been completed. For example, a manual for field screening around UST will be delivered in November. The monitoring will continue in order to answer some questions about changes over time. The sites will soon undergo bioremediation. In preparation for that, the microbiological conditions of the site will be characterized. Work is continuing related to the impact of well purging on hydrocarbon concentrations. The results of this research is expected to impact RCRA and CERCLA as well as the UST program.

APPROACH: Studies will continue at the two service station study sites at the University of Connecticut (UCONN). Soil-gas and ground-water monitoring will continue as the sites undergo bioremediation. The sites have undergone extensive physical and chemical characterization but a postdoc in microbiology now will characterize the sites biologically. Vapor monitoring has not been very successful at these sites because of high ground water. As a result, the research has focused on ground-water monitoring. One aspect of that is purging and the PI is working on the theory and practice of purging at UCONN

and the Oregon Graduate Center. Several field-screening techniques have been compiled into a manual. The efforts during FY90 will be to have technology transfer of this information through courses and a video.

EPA Coordinator: P. B. Durgin FTS 545-2623
(702) 798-2623

TITLE: Field Screening Techniques Evaluation

GOAL: To determine the usefulness and value of a variety of field screening techniques employed by trained technicians. To compare field results with samples sent to the laboratory. To provide field validation of a guide to UST field-screening techniques. To identify UST sites on Indian reservations of Region 8 that need further site characterization and possible remediation.

RATIONALE: There is a strong need nationwide for quick, accurate, cheap, and easy methods to determine if a tank has leaked. A set of protocols is being developed at the University of Connecticut to conduct site assessments using field-screening techniques, however it needs field validation. There is also a need to identify problem UST sites on Region 8 Indian Reservations where EPA is solely responsible for program implementation. The revised field-screening protocols resulting from this work is expected to be extensively used by consultants and regulators.

APPROACH: The first phase (RARE funds) will be for Midwest Research Institute to prepare a "scoping" document that integrates the concerns of Region 8, OUST, and EMSL-LV into a plan that will fulfill the technical questions which need to be answered. The second phase will include conducting the study on the Indian Reservations of Region 8. The field-screening guide that is being prepared by the University of Connecticut will be used in addition to any other methods that may seem appropriate. These methods will be revised and refined. A data base will be developed during this study to compare variables in differing environments.

EPA Coordinator: P. B. Durgin FTS 545-2623
(702) 798-2623

TITLE: UST Technology Transfer

GOAL: To provide products to the public that will help to transfer the research findings of EMSL-LV to UST problems. The goal will be to produce issue papers that focus on practical information needs of regulators and practitioners.

RATIONALE: There is a need in the UST program to provide information to a wide range of people involved with tanks. There are a huge number of owner-operators, consultants, and regulators that have an interest in these problems. Most of these people are new to the field and there is a variety

of information related to ground water, soils, hydrocarbon chemistry etc. that they would benefit from learning about.

APPROACH: A series of papers will be produced through ERC entitled "Tank Issues". The concept has been approved by OUST and they will be printed by CERI. These issue papers will be based on field experience as well as research and will be the result of a variety of specialists brought together to hammer out answers to pressing issues based on the best available knowledge. These papers will undergo thorough review.

EPA Coordinator: P. B. Durgin FTS 545-2623
(702) 798-2623

TITLE: Porous Glass Suction Lysimeter

GOAL: To provide a prototype porous glass element for a suction lysimeter that has increased efficiency for collecting target contaminants with an acceptable operating capability over an adequate range of soil moisture content.

RATIONALE: RCRA regulations under Subtitle C currently require vadose zone monitoring at land treatment facilities to detect and remediate hazardous constituents in leachates before they reach and contaminate ground water. Currently available suction lysimeters that are used to collect soil-pore liquid samples utilize a porous ceramic element which has a very poor efficiency with respect to the collection of hydrophobic organic compounds. Several researchers have attempted to overcome this problem with modest success by applying coatings to available ceramic elements or by using sintered metals, however, those options compromise other operational characteristics. Advances in vitreous (glass) materials could be used to develop a porous material especially designed to optimize the efficiency with respect to the collection of hydrophobic organic contaminants in the vadose zone and possibly be useful for ground-water monitoring well screens. Development of a porous glass suction lysimeter element could have advantages over those currently in use: (1) small pore size easily attainable, (2) can be made strong and durable, (3) can control interaction with many target contaminants, (4) can optimize operating range with respect to collection of hydrophobic organic contaminants, (5) can be mass produce inexpensively, and (6) quality

APPROACH: An updated review of the theory of operation of suction lysimeters will be performed along with a review of applicable elements of multiphase flow relevant to collecting hydrophobic, hydrocarbon contaminants in unsaturated porous media. The information developed from this review will be used to make a preliminary determination of optimum pore size and surface properties that will be necessary to provide the desired operational characteristics for porous element material. A review of literature for possible existing glass formulations applicable to producing the desired properties for the porous element will also be performed. From these reviews, possible formulations will be selected from which to produce the desired material. The

materials produced will be tested and evaluated for the desired properties. If early results indicate that the desired material for a prototype porous element is obtainable, the research will focus on materials development. If no reasonable expectation of success is indicated at this time, termination of the project at the end of the first budget period, which is one year, will be considered. If indications are that a suitable material or combination of materials can be developed, fabrication into a form suitable for use as an experimental suction lysimeter will be performed. This will be followed by testing at properly equipped laboratory facilities and in collaboration with expertise in vadose zone monitoring; e.g., L.G. Everett at U.C. Santa Barbara or J.C. Parker at Virginia Polytech. If laboratory testing indicates that the material is suitable for use in making a useful suction lysimeter, an operational prototype will be fabricated and demonstrate in the field.

EPA Coordinator: L. A. Eccles FTS 545-2385
(702) 798-2385