

APPENDIX A

CMST PROGRAM SELECTED HIGHLIGHTS AND TECHNOLOGY PROJECTS

FISCAL YEAR SUMMARIES

The following CMST Program Highlights and Technology Projects are presented by Fiscal Year (FY) in chronological order.

FY 1990 Highlights

- Former Secretary of Energy Watkins established the Office of Environmental Restoration and Waste Management (ERWM) on November 1, 1989. The citation pertaining to the need for a characterization, monitoring, and sensor technology development program follows:

“DOE’s goal is to solve and prevent the recurrence of its essential environmental problem: actual or threatened migration to the biosphere of 40 years of radioactive and hazardous chemical pollutants dispersed through large volumes of soil and groundwater. These pollutants are often difficult to access for treatment and to reduce to regulatory standards. DOE must strive to transcend current methods and tools, replacing them with more effective and efficient means. When needed methods are not currently available, [the Office of] Technology Development must seek to provide them, either through adaptation from other fields or through development in concert with industry and academic institutions.”

- In FY 1990, Characterization, Monitoring, and Sensor Technology (CMST) research and development activities began as part of the ERWM Integrated Program (IP). Los Alamos National Laboratory served as the primary ERWM support organization to HQ for CMST development. The early focus of the emerging CMST program was to identify environmental restoration and waste management technology needs of DOE sites and to conduct a research and development program to satisfy those needs.

FY 1990 Technology Projects

Projects Outside Program – Related to CMST

- *In Situ* Characterization by Ion Trap Mass Spectroscopy (*Tech ID 1297)
- Laser Spark Analysis of Soils for Contaminants (Tech ID 434)
- Remote Handled Non-Destructive Assay Development
- Mobile Inductively Coupled Plasma Optical Emission Spectroscopy (Tech ID 602)
- Improvements in Inductively Coupled Plasma Mass Spectroscopy (Tech ID 133)
- Portable Infrared Analyzer (Tech ID 711)
- Characterization of Underground Storage Tanks
- Sensor System Development for Remote Sensing (Tech ID 208)
- Electromagnetic Underground Imaging - Electrical Resistance Tomography (Tech ID 17)

*DOE OST Technology Management System (TMS) Tech ID Number; see DOE Office of Environmental Management Internet site [<http://ost.em.doe.gov/IFD/OSThome.htm>] for accessing TMS and other information sources. Since the TMS did not exist from the inception of CMST, the corresponding TMS numbers have been added retroactively.

FY 1991 Highlights

- ❑ Ames Laboratory prepared a Technology Task Plan covering the formation and coordination of an Integrated Program for Characterization, Monitoring, and Sensor Technologies. This was the beginning of Ames Laboratory's role in the formation and field coordination of the CMST program. Jim Coronas, Ames Laboratory Deputy Director, and Bill Haas, Ames Laboratory, met with Stan Wolf and Steve Lien at DOE HQ on March 13, 1991 to discuss the formation of the new Program. The plan outline was presented on March 21, 1991 to the Applied Research and Development Division of the DOE Office of Technology Development (OTD).
- ❑ Convened a Characterization and Sensor Technologies Expert Panel Workshop in Dallas, TX, on May 20, 1991 to assess site characterization, monitoring, and sensor technology (CMST) needs, assess the current state of the art in CMST, identify technology gaps and opportunities, and provide technical recommendations to DOE management.
- ❑ Participated in the Buried Waste/Mixed Waste Landfill Integrated Demonstrations Program Development meeting on June 17-19, 1991 in Salt Lake City, UT; the National Underground Storage Tanks Characterization Workshop on June 25-27 in Richland, WA; and began participation in the Characterization Technical Support Group for the Plutonium in Soils Integrated Demonstration by reviewing protocols for soil characterization in September 1991.
- ❑ Provided Input to DOE OTD in August 1991 on five CMST needs areas to be addressed by the October 1991 Program Research and Development Announcement issued by the Morgantown Energy Technology Center. The PRDA was the first large attempt to involve industry and universities in addressing OTD needs.
- ❑ Convened a Mixed Waste Landfill Integrated Demonstration Characterization Technical Advisory Group to evaluate and rank proposals on August 28, 1991 in Dallas, TX; and a Workshop on Geophysics for Noninvasive Waste Site Characterization, on August 29-30, 1991, in Dallas, TX.

FY 1991 Technology Projects

CMST Projects

- *In Situ* Characterization by Ion Trap Mass Spectroscopy (Tech ID 1297)
- Improvements in Inductively Coupled Plasma Mass Spectroscopy (Tech ID 133)
- Sensor System Development for Remote Sensing (Tech ID 208)

Projects Outside Program – Related to CMST

- Defense Low-Level Waste Technical Support - Lysimeters: Groundwater Studies (Tech ID 715, 2365)
- Portable Infrared Analyzer (Tech ID 711)
- Analysis of a Plume at INEEL: Commercial, Airborne Thermal and Electromagnetic Flyovers and Soil Characterization Activities (Tech ID 733, 2946)

FY 1992 Highlights

- ❑ Completed an independent review of characterization technologies pertinent to volatile organic compounds (VOCs) in arid soil and groundwater and produced a report on the findings. On October 30-November 1, 1991, participated in a meeting of the Characterization Technical Support Group for the VOCs in Non-Arid Soils and VOCs in the Arid Soils Integrated Demonstrations in Augusta, GA. On November 6-8, 1991, also participated in the work of the VOC-Arid Integrated Demonstration Workshop in Seattle, WA; this workshop focused on the characterization technology needs at the demonstration site.

- ❑ Conducted an independent Review of Non-Destructive Assay (NDA) Technologies on the Buried Waste Integrated Demonstration Technologies on November 25-27, 1991 in Dallas, TX.
- ❑ Participated in the work of the Characterization Technical Support Group for the Underground Storage Tanks Integrated Demonstration on January 16-17, 1992 in Richland, WA. The principal work was to perform a characterization needs assessment in support of underground single-shell tanks. Also participated in the work of the Characterization Team at the Tank Waste Remediation System Workshop on February 11-12, 1992 in Richland, WA.
- ❑ Convened a workshop on the Contributions of Remote Sensing to Environmental Characterization of DOE Facilities to ascertain what agencies, assets, and technologies would be utilized on March 11, 1992. Also convened a second workshop on this subject addressed classified material on May 12-14, 1992.
- ❑ Ames Laboratory completed a Draft Strategic Plan, Implementation Plan, and Applied Research and Technology Development Plan for the Characterization, Monitoring, and Sensor Technology - Integrated Program (CMST-IP) and submitted the Drafts to Steve Lien, OTD, on February 19, 1992. The CMST-IP Strategic Plan document was distributed at the OTD Midyear Review, Gaithersburg, MD, the week of March 16, 1992. This marks the official establishment of the Field-coordinated CMST-IP.
- ❑ Completed and delivered expert panel assessment and prioritization of characterization and monitoring technologies for VOCs in the vadose zone and groundwater in support of the VOCs at the Arid Sites Integrated Demonstration on March 26, 1992.
- ❑ Formed Technology Focus Groups to identify customer needs, make selections from available technologies, and to solve problems. The two main criteria for selecting members of the Technology Focus Groups were (1) awareness of customer needs and (2) expertise in at least one of the following technical areas:
 - Data Quality Objectives (establishing characterization requirements) and statistically guided adaptive sampling (quantitatively optimizing sampling strategies)
 - Geophysical and Hydrologic Characterization
 - Organic Compounds Characterization (volatile and semi-volatile organic compounds)
 - Inorganic Chemicals Characterization
 - Sampling and Sensor Placement Technologies
 - Radiological and Radioisotope Characterization
 - Chemical Sensors (linked to DOE ERWM Robotics Program)
 - Remote Sensing
- ❑ Completed the establishment of Integrated Program Technology Focus Groups by April 1992, and conducted a meeting of the CMST-IP Technology Focus Groups on April 29-30, 1992 in Dallas, TX. The Technology Focus Groups prepared draft statements of work for future applied research and development needed to address EM needs identified through the DOE/Geotech Technology Needs Assessment and other means.
- ❑ Participated in the work of the Characterization Technical Support Group meeting in support of the VOC-Non-Arid and VOC Arid Integrated Demonstrations on July 12-13 in Golden, CO, and on July 17, 1992 in Dallas, TX. The principal work was reviewing and prioritizing proposed projects.
- ❑ Conducted a meeting of the CMST-IP Technology Focus Groups for the evaluation and ranking of proposed projects received in response to the call for proposals on August 5-6, 1992. Approximately 280 proposals were received of which about 55 were selected for funding.

FY 1992 Technology Projects

CMST-IP Projects

- Non-Invasive Site Characterization Phase I (Meeting, Study)
- Improvements in Inductively Coupled Plasma Mass Spectroscopy (Tech ID 133)
- Portable Infrared Analyzer (Tech ID 711)
- Volatile Organic Compounds in Vadose Zone Groundwater Characterization
- Cone Penetrometer Truck Vadose Zone Testing for Subsurface Contaminants (Initial Studies with Commercial CPT Before Building SCAPS) (Tech ID 243)
- *In Situ* Secondary Ion Mass Spectroscopy Analysis (Tech ID 135)
- Martin Marietta Energy System Corp. Thermal Measurements – Flyover (Thermal Anomaly Found) (Tech ID 733, 2946)
- Sensor System Development for Remote Sensing (Tech ID 208)
- Associated Particle Imaging (Tech ID 413)
- Defense Low-Level Waste Technical Support - Lysimeters (Water Sample Collections) (Tech ID 715, 2365)

FY 1993 Highlights

- Assembled teams of technical experts to compare CMST needs submitted by EM organizations against their knowledge of existing commercial and CMST-developed technologies. These comparisons led to the generation of a needs statement written primarily by the technical experts; these needs formed the core of the first Program Research and Development Announcement (PRDA) and CMST-IP Calls for Proposals. The CMST-IP staff coordinated the review of over 300 technical task proposals submitted by DOE and other federal proposers. Technical experts who were members of CMST-IP Technology Focus Groups evaluated the proposals. The Ames Laboratory CMST-IP staff teamed with the CMST-IP Program Manager and DOE/HQ EM staff in preparing and implementing CMST-IP research and development program for FY 1993.
- Provided technical leadership to Characterization Technical Support Groups for chemical waste landfill/mixed waste landfill, underground storage tanks, and buried waste. and participated in Characterization Technical Support Groups for plutonium in soil, volatile organic compounds in saturated soil and groundwater, and volatile organic compounds in arid soil and groundwater.
- Produced and distributed several Technology Data Sheets:
 - Centrifuge Technology for Vadose Zone Transport Measurements
 - Tensor Magnetic Gradiometer Integrated Borehole Geophysical Systems
 - Three-Dimensional Site Characterization Using Broadband Electromagnetics
 - Crosshole Borescope: Assessment of Colloidal-Size Particle Movement and Groundwater Velocity in Monitoring Wells Using Video-Optic Techniques
 - Supercritical Fluid Extraction/Optical Detection System
 - Site Characterization and Analysis Cone Penetrometer
 - Photoacoustic Field Deployable Volatile Organic Compound Analyzer
 - On-Line Transient Infrared Spectrometer
 - Fourier Transform Infrared Photoacoustic Spectrometer
 - Direct Sampling Ion Trap Mass Spectrometry
 - Portable Vapochromic/Fiber-Optic Detector for Volatile Organic Detector in Air and Water
 - Fiber-Optic Sensors for the Detection of Volatile Organic Compounds

FY 1993 Technology Projects

Projects for Expedited Site Characterization

- Expedited Site Characterization: Application and Continued Development of Rapid, Focused Site Characterization Methodology for Federal Facilities (Tech ID 77)
- Innovative Directional and Position Specific Sampling Technique (Tech ID 8)
- Direct Sampling Ion Trap Mass Spectrometry Instrumentation for Organics in Water, Soil, and Waste (Tech ID 69)
- Field-Deployable Volatile Organic Compound (VOC) Analyzer: On-Site, Real-Time VOC Analyzer Systems for Air, Soil, and Water (Tech ID 711)
- Field-Usable Portable Analyzer for Chlorinated Organic Compounds (Tech ID 313)
- Improvements in Inductively Coupled Plasma Mass Spectrometry (Tech ID 133)
- Direct Measurement of Strontium-90 in Surface Soils (Tech ID 70)
- Road Transportable Analytical Laboratory System (Tech ID 292)
- *In Situ* Secondary Ion Mass Spectrometry (SIMS) Analysis: Development and Evaluation of a Transportable Ion Trap SIMS Instrument for the Direct Analysis of Low Volatile Organic Compounds (Tech ID 135)

Projects for Contaminants in Soils and Groundwater

- Spectroelectrochemical Sensors for DOE Site Characterization (Tech ID 744)
- Improved Reversible Carbon Tetrachloride Sensor for On-Line and Down-Well Measurements (Tech ID 103)
- Chlorinated and Aromatic Hydrocarbon Thin Film Chemical Sensors (Tech ID 16)
- Remote Sensing Systems Development (Several Technologies at DOE/STL)

Projects for Geophysical and Hydrogeologic Measurements

- Zero-Tension Lysimeters: An Improved Design to Monitor Colloid Facilitated Contaminant Transport in the Vadose Zone (Tech ID 715)
- A New Generation Pulsed-Neutron Induced Gamma-Ray Multi-Spectral Logging System for *In Situ* Mapping of Contaminants (Tech ID 382)
- High-Resolution Subsurface Imaging and Neural Network Recognition: Non-Intrusive Buried Substance Location (Tech ID 314)
- Geophysical Data Fusion For Subsurface Imaging (Tech ID 290)
- Data Fusion Workstation (Tech ID 290)
- Historical Imagery Applications for Environmental Restoration and Waste Management

Projects for Mixed Wastes in Drums, Burial Grounds, and Underground Storage Tanks

- Associated Particle Imaging Development (Tech ID 413)
- Field Raman Spectrograph for Environmental Analysis (Tech ID 1544)

Projects for Remediation, Deactivation and Decommissioning, and Waste Process Monitoring

- Novel Mass Spectrometric Instrument for Gaseous and Particulate Characterization and Monitoring
- Air Quality Site Boundary Monitoring for Volatile Organic Compounds by Preconcentration/Membrane (Tech ID 670)
- Ion Trap Mass Spectrometry (Tech ID 69)
- Continuous Emission Monitor for Incineration (Tech ID 18, 411, 1564, 2029, 2305)
- Infrared Analysis of Wastes: Novel Lab and On-Line Measurements by Photoacoustic and Transient Infrared Spectroscopies (Tech ID 215)
- Development of a Long-Term Post-Closure Radiation Monitor (Tech ID 288)
- *In Situ* Vitrification Field Data Collection at Arnold Air Force Base and Parsons Superfund Site (Tech ID 749)

FY 1994 Highlights

- ❑ Issued Calls for Proposals, the Research Opportunity Announcement (ROA), and the FY 1994 DOE EM Small Business Innovative Research (SBIR) Solicitation for FY 1995 projects. Prepared two draft characterization technology need statements as part of the Tank Waste Remediation System FY 1994 Technology Development Plan.
- ❑ Evaluated over 280 technical task proposals submitted by DOE and other federal proposers by teams of technical experts as members of CMST-IP Technology Focus Groups.
- ❑ Coordinated the review of 117 SBIR chemical and radiochemical sensor proposals prepared by over 50 technical experts.
- ❑ Participated in the Characterization Technical Support Group activities for nearly all of the Integrated Demonstrations of the Office of Technology Development:
 - The Characterization Architecture Group of the Hanford Tank Waste Remediation System activity.
 - Hanford Single-Shell Tank Instrumentation Program Review.
 - Hanford Tank Vapor Characterization Activities.
 - Office of Environmental Restoration's Field Area Technology Representatives Group in support of the Technology Information Exchange Workshops.These activities contribute to the effective coordination and integration of CMST applications and Research and Development/Demonstration, Testing, and Evaluation efforts and help the CMST-IP team and others stay up to date regarding EM needs and lessons learned.

FY 1994 Technology Projects

Projects for Contaminants in Soils and Groundwater

- Expedited Site Characterization at DOE Facilities (Tech ID 77)
- Ames Laboratory Expedited Site Characterization Project (Tech ID 77)

Projects for Sensors and Field Analysis Equipment

- Ames Mobile Laboratory Project (Tech ID 717)
- Site Characterization and Penetrometer System (Tech ID 243)
- Time Domain Reflectometry and Fiber Optic Probes for the Cone Penetrometer (Tech ID 141)
- Airborne Miniature Platforms (Tech ID 76)
- Development of Screening and Quantitative Field Methods Coupled to the Cone Penetrometer (Tech ID 219)
- Secondary Ion-Mass Spectrometry Analysis: Development and Evaluation (Tech ID 135)
- Miniaturized Chemical Flow Probe Sensor Development (Tech ID 218)
- Multi-analyte, Single-Fiber Optical Sensor (Tech ID 383)
- Sol-Gel Indicator Program (Tech ID 384)
- Portable, Real-Time Monitoring Systems for Volatile Organics (Tech ID 711)
- Chlorinated and Aromatic Hydrocarbon Thin Film Chemical Sensors (Tech ID 16)
- Air Quality Site Boundary Monitoring for Volatile Organic Compounds by Preconcentration/Membrane (Tech ID 670)
- Direct Sampling Ion Trap Mass Spectrometry Instrumentation (Tech ID 69)
- Multisorbent Arrayed Sampler for Collection of Vadoze Zone Organic Contaminants (Tech ID 461)
- Multi-Spectral Neutron Logging (Tech ID 382)
- *In Situ* RCRA Metals Analysis (Tech ID 434)
- Air-Quality Monitoring for Alpha Contamination - Long Range Alpha Detector (Tech ID 596)
- Direct Measurement of Strontium-90 in Surface Soils in Real Time (Tech ID 70)
- LA-ICP-AES Using a High-Resolution Fiber Optic Interferometer (Tech ID 430)

Projects for Characterization Decision Support Tools

- Data Fusion for Characterization and Monitoring (Tech ID 290)

Projects for Geophysical and Hydrogeologic Measurements

- Three-Dimensional/Three-Component Seismic Reflection for Site Characterization (Tech ID 174)
- Crosshole Compressional and Shear Wave Seismic Tomography (Tech ID 623)
- Zero-Tension Lysimeters: An Improved Design to Monitor Colloid-Facilitated Contaminant Transport in the Vadoze Zone (Tech ID 715)
- Analog Site for Characterization of Fractured Rock (Tech ID 216)
- Rabbit Valley Geophysics Performance Evaluation (Tech ID 427)
- International Environmental Assessment of Contaminant Transport Studies of Russian Sites (Tech ID 775)
- Electrical Resistance Tomography for Subsurface Imaging (Tech ID 17)

Projects for High-Level Waste Tanks

- Moisture Measurement by Electromagnetic Induction (Tech ID 398)
- In-Tank Interface Detection Using Time Domain Reflectometry (Tech ID 401)
- Transuranic Elements and Moisture Measurement in High-Level Waste Tanks by Neutron Activation (Tech ID 771)
- Sensing of Head Space Gases: Continuous *In Situ* Monitoring of Gaseous Components in Underground Storage Tanks Using Piezoelectric Thin Film Resonator Sensors (Tech ID 396)
- Raman Probe Radiation Study (Tech ID 1544)
- Infrared Analysis of Wastes: Novel Laboratory and On-Line Measurements by Photoacoustic and Transient Infrared Spectroscopies (Tech ID 215)
- Laser Ablation Mass Spectrometry Scanning of Waste Tank Core Samples (Tech ID 127)
- Imaging Through Obscuration During Sluicing (Tech ID 405)

Projects for Characterization, Treatment, and Disposal of Mixed Waste

- Development of a Continuous Emission Monitor for Incineration (Tech ID 1564)
- Associated Particle Imaging (Tech ID 413)

Projects for Remote Sensing

- Remote Sensing Systems Development (Tech ID 208)
- Laser-Induced Fluorescence Imaging (Tech ID 78, 1999)

FY 1995 Highlights

- ❑ Supported technology development projects in all five Focus Areas. CMST Need Statements in the solicitations for ROA and SBIR grant applications were developed by Characterization, Monitoring, and Sensor Technology - Crosscutting Program (CMST-CP) team members who worked closely with representatives of Focus Area Management Teams and other customer representatives to discern and describe Focus Area needs. The needs statements were subsequently reviewed and validated by Site Technology Coordination Groups (STCGs) and DOE authorities.
- ❑ Conducted expert technical and customer review of all FY 1994 CMST-CP projects. It evaluated 165 Technical Task Plans (TTPs) proposed for funding in FY 1995. Each was assigned for review by three persons from one of six Technical Focus Groups comprising 28 technical experts and Focus Area representatives. Forty TTPs were also sent to other EM Programs. Evaluation information was transmitted to the PIs through Technical Program Officers (TPOs) and Technical Program Managers (TPMs).
- ❑ Participated in the expert technical evaluation of 53 CMST proposals received in response to the ROA solicitation entitled, "Applied Research and Development of Technologies for Environmental Restoration and Waste Management;" the CMST-CP staff also coordinated the review of 115 SBIR

grant applications received in response to the FY 1994 solicitation topic entitled, "Expedited Site Characterization." In addition, they either provided or arranged for expert technical review for numerous Phase I ROA and SBIR reports and Phase II extension proposals.

- ❑ Sponsored Expedited Site Characterization at an industrial site, the DOE Pantex site, and the St. Louis Airport site.
- ❑ Participated in:
 - Characterization Technical Support Group or Program Review activities for all of the former EM-50 Integrated Demonstrations.
 - Program Review for the former *In Situ* Remediation Integrated Program.
 - Characterization Architecture Group of the Hanford TWRS activity
 - EM-40 Steering Group in support of Technology Information Exchange Workshop sessions on Expedited Site Characterization, DNAPL Characterization, and Treatment of Secondary Waste.
- ❑ The Principal Investigators of four CMST-CP projects championed their technologies to more than 100 managers from companies participating in the November 1994 Sponsor Meeting of the Center for Process Analytical Chemistry.
- ❑ Developed and posted an online "Characterization, Monitoring, and Sensor Technology - Crosscutting Program, Technology Catalogue" on the CMST-CP website in September 1995. The address is: [http://www.cmst.org/cmst/Tech_Cat.text/toc.html].

FY 1995 Technology Projects

Projects for the Contaminant Plume Containment and Remediation Focus Area

Expedited Site Characterization

- Expedited Site Characterization - Application to Federal Facilities (Tech ID 77)
- Ames Laboratory's Expedited Site Characterization Demonstrations (Tech ID 77)

Field Analysis and Instrumentation

- Time Domain Reflectometry and Fiber-Optic Probes for the Cone Penetrometer (Tech ID 141)
- Site Characterization and Analysis Penetrometer System (Tech ID 243)
- *In Situ* Measurement of Volatile and Semi-Volatile Organic Compounds in the Subsurface: Development of Screening and Quantitative Field Methods Coupled to the Cone Penetrometer (Tech ID 219)
- Miniature Pumps in the Cone Penetrometer Tip for Groundwater and Soil Gas Sampling (Tech ID 381)
- Nuclear Borehole Logging: Passive and Neutron-Induced Spectral Gamma-Ray Techniques for Mapping Contaminants *In Situ* (Tech ID 382)

Sensors

- Multi-Analyte Single Fiber-Optical Sensor (Tech ID 383)
- Sol-Gel Indicator Program (Tech ID 384)
- Miniaturized Chemical Flow Probe Sensor Development (Tech ID 218)
- Flow Probe Sensor Development - Center for Process Analytical Chemistry (Tech ID 218)
- Portable Acoustic Wave Sensor Systems for Volatile Organic Compounds (Tech ID 282)
- Surface Acoustic Wave Array Detectors (Tech ID 16)

Contaminant Transport

- Analog Site for Characterization of Contaminant Transport Through Fractured Rock (Tech ID 216)
- Integrated Geophysical and Hydrological Characterization of Transport Through Fractured Media (Tech ID 290, 2944)

Projects for the High-Level Tank Waste Remediation Focus Area

- Safe Storage
- Sensing of Head Space Gases: Continuous In Situ Monitoring of Gaseous Components in Underground Storage Tanks Using Piezoelectric Thin Film Resonator Sensors (Tech ID 396)
- Electrical Resistance Tomography for Subsurface Imaging (Tech ID 17)
- Moisture Measurement by Electromagnetic Induction (EMI) (Tech ID 398)
- In-Tank Interface Detection Using Time Domain Reflectometry (Tech ID 401)

Waste Retrieval

- Acoustic Characterization of Wastes in Double Shell Underground Storage Tanks (Tech ID 175)
- Imaging Through Obscurations During Sluicing Operations (Tech ID 405)

Waste Sampling/Analysis

- Moisture Sensor in Cone Penetrometer for In-Tank Characterization (Tech ID 86)
- Infrared Analysis of Wastes (Tech ID 215)

Projects for the Mixed Waste Characterization, Treatment, and Disposal Focus Area

Waste Process Monitoring and Controls

- Diagnostic Instrumentation and Analysis Laboratory (Tech ID 207)
- Support for RCRA Metal and Air Stream Characterization

Off-Gas and Effluent Monitoring

- Continuous Emission Monitor for Thermal Treatment Systems (Tech ID 411, 2932)
- Metal Emissions Monitor for DOE Mixed Waste Thermal Treatment (Tech ID 18, 1564)

Projects for Decontamination and Decommissioning Focus Area

- Associated Particle Imaging Development (Tech ID 413)
- A Robust Radiation Detector for Rapid Waste Characterization (Tech ID 19)
- Development of a Portable Heavy Metal Detector Using X-Ray, K-Edge Analysis (Tech ID 134)

Projects for Landfill Stabilization Focus Area

- Buried Waste Location/Characterization
- Remotely Piloted Vehicles and Miniaturized Sensors (Tech ID 76)
- Remote Sensing Systems Development and Application (Tech ID 208)
- Laser-Induced Fluorescence Imaging for Surface Uranium (Tech ID 1999)
- Rabbit Valley Geophysics Performance Evaluation Range (Tech ID 427)
- Three-Dimensional/Three-Component Seismic Surveys for Site Characterization (Tech ID 174)

Containment

- Laser Ablation-ICP-AES Using a High Resolution Fiber-Optic Interferometer (Tech ID 430)
- Inductively-Coupled Plasma - Mass Spectrometry (ICP-MS) for Analysis of Microliter Samples and Solids (Tech ID 133)
- Secondary Ion-Mass Spectroscopy Analysis: Development and Evaluation (Tech ID 135)
- RCRA Metals Analysis by Laser-Induced Breakdown Spectroscopy (Tech ID 434)

FY 1996 Highlights

- ❑ Conducted expert technical and customer reviews of 27 FY 1995 CMST-CP projects. Each project was reviewed by three technical experts and two to four Focus Area representatives. The review team consisted of 21 technical reviewers and 10 Focus Area representatives. About 110 people attended the meeting. Evaluation information was transmitted to the PIs through their TPOs and TPMs.
- ❑ The Tanks Focus Area (TFA) and CMST-CP jointly evaluated 54 proposals received in response to the August 1995 joint Call for Proposals for CMST Development. CMST-CP provided technical evaluators; the TFA provided evaluators representing user needs at the Savannah River Site and Hanford Site. Three representatives of the Mixed Waste Focus Area (MWFA) also served as user

needs evaluators. The evaluation produced a consensus recommendation of five proposals for FY 1996 funding.

- ❑ Conducted an expert technical and customer review of CMST-funded FY 1995 and proposed FY 1996 characterization/monitoring work at the Diagnostic Instrumentation and Analysis Laboratory (DIAL) at Mississippi State University (MSU), Starkville, Mississippi. The projects and proposals were evaluated September 13 and 14, 1995, at MSU by technical peers and Focus Area customer representatives.
- ❑ Provided technical input for review of 26 new CMST-CP tasks proposed for funding by the Landfill Stabilization Focus Area (LSFA) and MWFA. Input was provided to the Landfill and Mixed Waste Implementation Teams.
- ❑ Participated in expert technical evaluation of 40 CMST-CP proposals received in response to the Morgantown Energy Technology Center (METC) ROA solicitation entitled "Applied Research and Development of Technologies for Environmental Restoration and Waste Management." CMST-CP staff also participated in the expert technical evaluation of 52 CMST-CP proposals received in response to the METC PRDA solicitation entitled "Characterization, Monitoring, and Sensor Technology (CMST) Development."
- ❑ Coordinated the review of 20 SBIR grant applications received in response to the FY 1995 solicitation topic entitled, "Characterization, Monitoring, and Sensor Technologies for Radioactive and Hazardous Waste." In addition, they either provided or arranged for expert technical reviews of numerous Phase I ROA and SBIR reports and Phase II extension proposals.
- ❑ Served on the Rapid Commercialization Initiative (RCI) peer review panel for the monitoring and assessment technology category and reviewed 10 proposals submitted in response to the RCI Announcement issued August 16, 1996.
- ❑ Sponsored Expedited Site Characterization (ESC) at the DOE Pantex Plant, Zone 12 Groundwater Investigation, and Savannah River D-Area Oil Seepage Basin sites.
- ❑ Developed a CMST-CP Technology Transfer Roadmap consisting of six main sections:
 - Needs Assessment
 - Identification of Technologies for Transfer
 - A Managing-Technology-for-Development (MTD) Process
 - A Technology De-Risking Process
 - A Technology Verification and/or Certification Process
 - A "Hands-On" Technical Assistance ProcessThrough the use of this Technology Transfer Roadmap process, many barriers that impede acceptance of new technologies have been identified and mitigated.
- ❑ Organized a workshop and forum on Chemical Sensors for Environmental Applications. Preliminary results of a market study on existing technologies and user needs were presented. The workshop was held immediately prior to the Pittsburgh Conference in Chicago. More than 80 users, developers, and manufacturers of chemical sensors and field deployable analytical instrumentation participated, dealing with issues concerning developing, adapting, and commercializing analytical instrumentation technologies for environmental analysis.
- ❑ The CMST-CP, jointly with the EPA Consortium for Site Characterization Technologies (CSCT), sponsored the "RCRA and Other Heavy Metals in Soils Demonstration." Four technology developers participated in field demonstration activities during September 1995 in Butte, Montana. Split samples were archived and sent to two EPA laboratories for confirmatory analyses. The final evaluation would detail the performance (and cost of performance) of demonstrated technologies against individual

developer or vendor claims and comparatively evaluate these field performance data with results gained from using baseline EPA laboratory methods.

- ❑ The Diagnostic Instrumentation and Analysis Laboratory (DIAL) supported the shakedown test of the Transportable Vitrification System (TVS) at the Westinghouse Savannah River Co. Clemson facility. Measurements were made with laser induced breakdown spectroscopy (LIBS), Fourier transform infrared spectrometry, laser Doppler velocimetry, optical pyrometry, and multicolor imaging systems. A chlorine analyzer was also evaluated; testing consisted of measuring background levels of chlorine present in the TVS offgas and the detection of chlorine in the offgas system.
- ❑ In February 1996, DOE EM-40 at SRS requested that the Ames ESC team assist in incorporating ESC into the site characterization activities there. The Bingham Pump Outage Pits, a suite of trenches with low-level radioactive waste, was identified as the first set of ESC candidate sites. A Phase I site-specific contaminant characterization plan was reviewed and will be implemented this spring. ESC is being integrated at SRS into a complete cleanup planning initiative that will expedite all phases of remediation.
- ❑ Convened an American Society for Testing and Materials (ASTM) task force on April 18 in conjunction with the Technology Information Exchange (TIE) meeting in Santa Fe, New Mexico. This task force is charged with developing an ASTM preliminary standard guidance document on ESC to be used by contractors and regulators to identify essential characteristics of the ESC methodology. A second meeting involving knowledgeable ASTM members of the D18 Committee on Soil and Rock on April 29 resulted in generation of a second version of the document outline. Follow-up visits to each laboratory by the task force chair, Russell Boulding, were conducted in May. In July 1996, the Nevada Division of Environmental Protection (NDEP) accepted the ESC methodology.
- ❑ Demonstrated the prototype Road Transportable Analytical Laboratory (RTAL) three-module system in January 1996 at the Fernald Environmental Management Project (FEMP) site in January. The RTAL's three modules (a radioanalytical laboratory, an organic chemical analysis laboratory, and an operations control center) became fully operational on January 2 to demonstrate the system's sample analysis capabilities. In all cases, the analyses performed were in excellent agreement with FEMP analyses. All contaminants of concern were identified at the correct concentrations. Costs for performing the same analyses in the RTAL system were about 40 percent less than current Fernald Environmental Management Project (FEMP) costs. In addition, the sample turnaround time in the RTAL system was one to four days as compared to 21 days in the FEMP laboratory. A paper documenting the RTAL system and its performance was accepted for presentation at the Spectrum '96 conference.
- ❑ Convened a workshop at Pacific Northwest National Laboratory (PNNL) from June 17 to 28, 1996 to compare initial results of a cooperative Russian-American modeling study related to the Lake Karachai contaminant plume at the Mayak Site. Initial efforts were to develop two numerical models of a test problem defined by the Russian team members, based loosely on their studies of density-dependent groundwater flow and transport around Lake Karachai. Modeling results of the first test problem were compared; this problem involved a steady state simulation used as initial conditions for all subsequent problems. Calculated water fluxes from the lake, river, model boundaries, infiltration, and evapotranspiration agreed within seven percent between the models.
- ❑ Completed testing of a new inverse code for the Electrical Resistance Tomography (ERT) for Subsurface Imaging technology in May 1996. For the first time the complex resistivity field data can be processed without resorting to approximations about the magnitude of the out-of-phase voltage. The latest tests suggest that the code is ready to use on field data. Three noise tests were conducted to determine the effect of a cathodic protection system and other cultural electrical noise sources on ERT data. The conclusion is that cultural noise of the tank farms should not limit the use of ERT as a leak detection method.

- ❑ Began developing a neural network for the Raman Cone Penetrometer Signal Extraction and Enhancement project collaboratively with Physical Optics Corporation (POC), an industrial partner. In August 1996, POC analyzed a blind data set from Lawrence Livermore National Laboratory with 100 percent accuracy both in terms of component identification and noise and system artifact rejection.

FY 1996 Technology Projects

Projects for the Contaminant Plume Containment and Remediation Focus Area

- Integration of Innovative Expedited Site Characterization Techniques (Tech ID 77)
- Cone Penetrometer Support: Operation, Maintenance, and R&D Activity Conducted on the DOE Office of Technology Development Cone Penetrometer Vehicle (Tech ID 243)
- *In Situ* Measurement of Volatile and Semi-Volatile Organic Compounds in the Subsurface
- Flow Probe Chemical Analyzer (Tech ID 219, 237)
- Portable Acoustic Wave Sensor Systems for Volatile Organic Compounds (Tech ID 282)
- Surface Acoustic Wave Array Detectors (Tech ID 16)
- Analog Site for Characterization of Contaminant Transport Through Fractured Rock (Tech ID 216)
- International Environmental Assessment/JCCEM Contaminant Transport Studies (Tech ID 775)

Projects for the Radioactive Tank Waste Remediation Focus Area

- Electrical Resistance Tomography For Subsurface Imaging (Tech ID #140)
- Acoustic Characterization of Wastes in Double-Shelled Underground Storage Tanks (Tech ID 175)
- Infrared Analysis of Wastes (Tech ID 215)
- Neural Network Raman Cone Penetrometer Signal Extraction and Enhancement (Tech ID 242)
- In Situ Sensor Development: Ultrasonic Density Measurement Probe (Tech ID 214)
- Ultrasonic Sensors For In Situ Monitoring of Physical Properties (Tech ID 214)
- *In Situ* Viscosity and Density Monitoring Using Quartz Resonators (Tech ID 213)
- Process Monitoring and Control: Ammonia Measurements in Offgases (Tech ID 212)

Projects For Mixed Waste Characterization, Treatment, and Disposal Focus Area

- Diagnostic Instrumentation and Analysis Laboratory (Tech ID 207)
- Support for RCRA Metal, Forensic Geophysics, and Air Stream Characterization
- Metal Emissions Monitor for DOE Mixed Waste Thermal Treatment (Tech ID 18)

Projects for Decontamination and Decommissioning Focus Area

- A Robust Radiation Detector for Rapid Waste Characterization (Tech ID 19)
- Portable X-Ray, K-Edge Heavy Metal Detector (Tech ID 134)

Projects for Landfill Stabilization Focus Area

- Remotely Piloted Vehicles and Miniaturized Sensors (Tech ID 76)
- Airborne and Ground-Based, Laser-Induced Fluorescence Imaging (Tech ID 78, 1999)
- Three-Dimensional, Three-Component Seismic Imaging for Site Characterization (Tech ID 174)
- Inductively Coupled Plasma-Mass Spectrometry for Analysis of Microliter Samples and Solids (Tech ID 133)
- Secondary Ion Mass Spectroscopy Analysis (Tech ID 135)

FY 1997 Technology Highlights

- ❑ Began integrating position location capability into the new Environmental Measurement While Drilling (EMWD) package. Sandia National Laboratories (SNL) Technology Transfer is proceeding to offer the coaxial cable coil for licensing to other interested parties. A SNL report documenting the EMWD-gamma ray spectrometer demonstration at the Savannah River Site F-Area Retention Basin was published. Field testing of the magnetometer at the Sandia pipe farm was successful.

- ❑ Tested the laser-induced breakdown spectroscopy (LIBS) based metals continuous emissions monitor (CEM) during March 1997 at Balboa Pacific which demonstrated significant improvements made available by the conditional analysis approach. All data analysis and data reporting procedures were fully automated and performed in real-time. Overall, this test demonstrated that a LIBS-based metals CEM can provide accurate data in actual treatment facilities at metal effluent levels of a few ppb. A formal SNL report (SAND 97-8270) was published on the demonstration. In August 1997, the LIBS-based metals emissions monitor was mounted directly to the stack of the Toxic Substances Control Act Incinerator located at the DOE K-25 site in Oak Ridge, Tennessee. Eighteen two-hour reference methods tests were conducted over seven test days, with the LIBS system on-line 100% of the time. Real-time measurements were recorded for arsenic, beryllium, cadmium, chromium, iron, mercury, manganese, nickel, lead, and silicon. The monitor performed flawlessly during the entire test, and real-time multimetals analysis was accomplished for the targeted metals.
- ❑ Set up the X-ray, K-edge heavy metal detector system at the Oak Ridge K-25 Site at the Materials and Chemistry Lab User Facility. Pipes containing uranium deposits ranging from a thin coating to a layer nearly half of the pipe diameter was inspected. Began discussions with Oak Ridge National Laboratory regarding application of the K-edge technique at the K-25 Site as part of the Deposit Removal Program.
- ❑ Began the comparative evaluation of the performance of slurry monitoring instruments with actual slurries on June 1, 1997 at Oak Ridge National Laboratory and completed the evaluation in August 1997.
- ❑ Tested monitoring a molten glass stream at the Savannah River Site during the week of August 4, 1997. The glass used was the frit developed at the Savannah River Site for plutonium vitrification.
- ❑ Field tested the Multi-Element Metal Continuous Emissions Monitor system for monitoring metals at EPA Research Triangle Park. The report detailing operation of the system was issued.
- ❑ Participated in the Emissions and Process Monitoring Workshop on December 10-11, 1996 at EPA Research Triangle Park, North Carolina. The CMST-CP teamed with the Mixed Waste Focus Area and Westinghouse Savannah River Company to encourage CEM developers to participate in the Workshop sponsored by the EPA, DOE, and American Society of Mechanical Engineers. Participation in a developers workshop and team-building meeting on December 10, 1996 at the EPA Environmental Research Center, RTP was also encouraged. The CMST-CP presented a paper entitled "Multi-Metal Continuous Emissions Monitoring Systems: Side-by-Side Performance Testing at EPA Research Triangle Park Rotary Kiln Incinerator Simulator."
- ❑ Continued the field evaluation of the Enhanced Spectral Gamma Probe, developed by the U.S. Army Corps of Engineers Waterways Experiment Station, at R-reactor basins. Completed pushes in Basins 1 and 3. Qualitatively, the areas of high activity corresponded well with laboratory data.
- ❑ Continued work to optimize rapid water sampling methods for technetium-99, polychlorinated biphenyls (PCBs), and lead using 3M's Empore™ membranes. During laboratory testing of the technetium-99 Rad Disk on groundwater from the Paducah Gaseous Diffusion Plant, greater than 99 percent retention of technetium-99 was observed at a flow rate of 370 ml/min (compared to 50 ml/min using the existing method). Testing of the lead membranes showed excellent loading qualities but inefficient elution characteristics. PCB testing is in progress. Sealed and assembled disk holders were designed; prototypes were fabricated and are ready for field evaluation. Feasibility testing of direct-read Empore™ disks was completed. Training on the Empore™ disk sampling and solid-state beta spectrometer analytical methodology was provided to user personnel at the Paducah Gaseous Diffusion Plant.
- ❑ Used Waste Inspection Tomography (WIT) to inspect drums at the Idaho National Engineering Laboratory in October 1996. Three drums were inspected with nondestructive examination (NDE) and nondestructive assay (NDA) and 24 were inspected with NDE only. All matrices were observed

and identified with WIT 2 MeV digital radiography and computed tomography systems, including free liquid identification in the new phantom drum. The WIT trailer final system operating and maintenance manuals were submitted to the METC.

- ❑ Began operating the Active and Passive Neutron Examination and Assay (APNEA) trailer at the Idaho National Engineering and Environmental Laboratory (INEEL) in late October 1996. Assay results were demonstrable in real-time from a printout with slice-by-slice collimated gamma scan and active and passive computed tomography (A&PCT) assay results. WIT was used to inspect Radioactive Waste Management Complex (RWMC) waste drums; several of these drums were also WIT assayed.
- ❑ Deployed the handheld uranium survey tool using Ground-Based Laser-Induced Fluorescence Imaging (LIFI) in November 1996 at Fluor-Daniels Fernald. It was co-sponsored by CMST and the Deactivation and Decommissioning Focus Area for a large-scale integrated test. Strong LIFI signals were observed at dozens of locations. Preliminary small helicopter flight tests using a scaled-down airborne fluorescence imaging system were conducted at the Remote Sensing Laboratory. Digital images of ground targets were collected on samples of uranium-doped glass, trays of motor oil, and cloth fabrics at approximately 250-foot distances from the helicopter. The uranium survey tool was shown at two technology demonstrations in Washington D.C. The LIFI system was installed in a helicopter at Ft. Rucker. Ground operations consisted of full system testing on a laser range with targets at a distance of 350 feet.

FY 1997 Technology Projects

Projects for the Subsurface Contaminants Focus Area

- New Environmental Measurement While Drilling (Tech ID 8)
- A Steerable/Distance Enhanced Penetrometer Delivery System (Tech ID 317)
- Cone Penetrometer Operations & Site Characterization and Analysis (Tech ID 243)
- Tomographic Site Characterization Using Cone Penetrometer, Electrical Resistivity Tomography, and Ground Penetrating Radar (Tech ID 17, 284)
- Internal Reflection Sensor (IRS) for the Cone Penetrometer (Tech ID 1723)
- *In Situ* Permeability Measurements with Direct Push Techniques (Tech ID 307)
- Joint Development of a Membrane-Based Rapid Water Sampler with 3M (Tech ID 1514)
- Field Raman Spectrograph for Environmental Analysis (Tech ID 873)
- Three-Dimensional Integrated Characterization and Archiving System (Tech ID 97)
- Environmental Remote Sensing for Monitoring Plant Health (Tech ID 1900)
- Laser-Induced Fluorescence (LIF) for Heavy Metals in Soils and Plants (Tech ID 78, 208)
- JCCEM Contaminant Transport Studies--Pacific Northwest National Laboratory (Tech ID 775)
- Electrical Resistance Tomography (ERT) for Subsurface Imaging of Barriers (Tech ID 140)
- Neural Network Raman Cone Penetrometer Signal Extraction and Enhancement (Tech ID 242)
- Characterization and Monitoring of Dense, Non-Aqueous Phase Liquids (DNAPLs) (Tech ID 237)
- Analog Site for Characterization of Fractured Rock (Tech ID 216)

Projects for the Radioactive Tank Waste Remediation Focus Area

- Portable Acoustic Wave Sensor Systems for Volatile Organic Compounds (Tech ID 282)
- *In Situ* Viscosity and Density Monitoring Using Quartz Resonators (Tech ID 213)
- Comparative Testing of Pipeline Slurry Monitors (Tech ID 2935, 2936, 2970)
- Ultrasonic Sensors for *In Situ* Monitoring of Physical Properties (Tech ID 214)
- Development of a Magnetic Resonance Monitor for Technetium-99 Column Breakthrough (Tech ID 1513)
- Robotic End Effector for Inspection of Storage Tanks (Tech ID 278)
- Development of an On-Line, Real-Time, Alpha-Radiation Measuring Instrument for Liquid Streams (Tech ID 312)
- Diagnostics and Data Fusion of Robotic Sensors (Tech ID 227)

- Automated Monitoring System for Fluid Level and Density in High-Level Waste Tanks (Tech ID 279)
- *In Situ* Sensor Development - Ultrasonic Density Measurement Probe (Tech ID 214)

Projects for the Mixed Waste Characterization, Treatment, and Disposal Focus Area

- Metal Emissions Monitor for DOE Mixed Waste Thermal Treatment (Tech ID 18, 1564)
- Diagnostic Instrumentation and Analysis Laboratory (Tech ID 207)
- Development of a Multielement Metal Continuous Emissions Monitor (Tech ID 18, 1564)
- Coherent Laser Vision System (Tech ID 94)
- An Advanced, Open-Path, Atmospheric Pollution Monitor for Large Areas (Tech ID 280)
- A Continuous Emission Monitor for Toxic Metals in the Offgases of Thermal Treatment Facilities (Tech ID 1564)
- Demonstration of Emerging Continuous Emissions Monitoring (CEM) Technologies (Tech ID 2034)

Projects for the Deactivation and Decommissioning Focus Area

- Real-Time Monitoring of Alpha Emissions (Tech ID 114)
- Portable X-Ray, K-Edge Heavy Metal Detector
- Characterization of Radioactive Contamination Inside Pipes with the Pipe Explorer™ System (Tech ID 74)
- Waste Inspection Tomography (Tech ID 259)
- Portable Sensor for Hazardous Waste (Tech ID 31)
- Nondestructive Examination and Assay of Drums Containing Transuranic Waste Associated Particle Imaging (Tech ID 413)
- Airborne and Ground-Based Laser-Induced Fluorescence Imaging (Tech ID 78, 1999)
- Radiation Sensors (Long-Range Alpha Detector) for Uranium Cylinders (Tech ID 1560)
- Remotely Piloted Vehicles and Miniaturized Sensors (Tech ID 76)

Projects for the Plutonium Focus Area

Real-Time Plutonium Monitoring (Tech ID 2004)

FY 1998 Technology Highlights

- ❑ Demonstrated the modified Environmental Measurement While Drilling (EMWD) system demonstrated in November 1997 at the Charles Machine Works testing range. Sandia National Laboratories (SNL) received a letter of commitment in April 1998 from the Hanford Vadose Zone Program to support an EMWD 'Hot Site' demonstration at the SX Tank Farm.
- ❑ Co-authored the the EPA Landfill Cover Design Guideline that heavily emphasized alternative technologies being demonstrated in the Alternative Landfill Cover Demonstration (ALCD).
- ❑ Completed a second field test at the Naval Air Weapons Station in China Lake, California during February 1998. The Laser-Induced Breakdown Spectroscopy (LIBS)-based monitor was successful in detecting transient lead emissions ranging from 100 µg/actual cubic meter (acm) to over 50,000 µg/acm. All data were recorded in true real-time with LIBS-based on-line gas analysis performed continuously with a nearly 100% sampling rate.
- ❑ Completed analysis of data from tests on uranium fuel plates in November 1997. K-Edge analysis can provide accurate nondestructive measurements of total uranium content in fuel and can determine characteristics such as enrichment and burn-up. In July 1998 a review committee at SRS recommended that the procurement process proceed for inclusion of the K-edge technology in the 321-M LSDP for use in characterization of uranium holdup in ducts in the fuel fabrication plant. In August 1998 the K-edge system was demonstrated for analysis of thorium contamination in seven drain lines at DOE Ames Laboratory. Preliminary results indicate minimal contamination in two lines, significant thorium contamination in three lines, one line with mercury contamination, and a drain trap

contaminated with uranium, thorium, and mercury. This was the first true *in situ* demonstration of the K-edge system.

- ❑ Completed construction of the Real-Time Plutonium Monitor during June 1998. It was laboratory-tested and found to have the necessary sensitivity and other capabilities required for demonstration at the SRS. During the last week of July 1998, the monitor was tested and demonstrated at SRS on the Cylindrical Induction Melter (CIM). The monitor was set up to view the molten glass stream exiting the CIM and record spectra of the stream. The stream was composed of mixtures of the glass frit developed at SRS for the americium-curium vitrification and the SRS-developed non-radioactive surrogate for the americium-curium tank waste with erbium substituting for americium and curium. The monitor successfully acquired emission spectra from all stream compositions, but the spectrum from the glass with the highest surrogate loading differed from expectations. The principal collaborator at SRS (J. Marra) was "pleased and impressed" with the monitor and is confident that changes could be made to accommodate the high loading.
- ❑ The Southern States Energy Board (SSEB) held a roundtable entitled "Best Practices in Environmental Liability Restructuring, Mechanisms for Privatization of Expedited Site Characterization" on January 22-23, 1997 in Atlanta, Georgia. It brought together more than 40 key decision-makers on environmental issues in a unique roundtable format that promotes open dialog on difficult regulatory and site conversion issues. A key finding was that if ESC were practiced more widely on Superfund and Resource Conservation and Recovery Act sites, the overall liability could conservatively be reduced by 10 percent with savings of nearly \$10 billion for problem holders.
- ❑ Completed the field test plan for the Development of a Long-Term, Post-Closure Radiation Monitor and issued to the Fernald Environmental Management Project (FEMP) site. All five system probes were installed at the predesignated FEMP site locations during December 12 to 19, 1997.
- ❑ Deployed the Pipe Explorer™ in December 1997 to Pacific Gas and Electric (PG&E) to conduct eight surveys in a total of 350 feet of concrete-embedded piping to determine the adequacy of cleaning. It was able to identify piping systems that are suitable for free release without excavation and piping systems that require further cleaning or excavation for disposal as low-level radioactive waste. The use of the Pipe Explorer™ saved PG&E money by releasing a portion of the piping system and avoiding the costly excavation of pipe.
- ❑ Completed the Capability Evaluation Program and Performance Demonstration Program tests of Waste Inspection Tomography (WIT) in October 1997. The testing of active and passive computed tomography assay precision was conducted at the Idaho National Engineering and Environmental Laboratory. Bio-Imaging Research received a letter from the DOE Carlsbad Area Office (CAO) that as of December 18, WIT was approved by CAO for nondestructive assay of TRU waste drums using A&PCT based on cycle 4 testing of the PDP.
- ❑ Integrated the Three-Dimensional Integrated Characterization and Archiving System (3D-ICAS) in October 1997 with mobility platforms at Oak Ridge National Laboratory (ORNL).
- ❑ Several customers have expressed an interest in cone penetrometer/fast gas chromatography sampling tools being developed. Dover Air Force Base (AFB) is considering using this technology to conduct characterization of an area thought to be impacted by chlorinated hydrocarbons. The Bernalillo County Environmental Health Department in Albuquerque, New Mexico is also considering its use to characterize an area thought to be contaminated with tetrachloroethylene (PCE). The field evaluation and demonstration were completed during June 1998 at the Groundwater Remediation Field Laboratory (GRFL) at Dover Air Force Base. The demonstration at GRFL brings this project to a close.
- ❑ Conducted field testing of the laser-induced breakdown spectroscopy (LIBS) penetrometer system in Albuquerque, New Mexico, during October 1997. In November 1997 LIBS was used for surface analysis using a prototype backpack and van-mounted system at the Formerly Utilized Sites

Remedial Action Program (FUSRAP) at Luckey, Ohio. At FUSRAP it was used to measure beryllium concentrations, *in situ* and in real time, in contaminated soil at the 40-acre site. Deployment during a six-week field project in October and November 1997 led to the successful identification of beryllium hot spots. Preliminary benefit analysis indicated a cost reduction estimate of 30 to 50 percent and a schedule reduction estimate of 30 percent, compared to selected baseline technologies. The technology is being considered for use during a six-month-long remediation phase scheduled for 1998 in which detailed beryllium characterization will guide abatement of the soil contamination.

- ❑ Deployed the Electrical Resistance Tomography (ERT) For Subsurface Imaging and Ground Penetrating Radar (GPR) prototype equipment and survey crew in October 1997 at the Savannah River Site where cross-hole measurements and preliminary cross-hole images were made.
- ❑ Completed a field demonstration at SRS in January 1998 that resulted in the integration of the cone penetrometer (CPT) with ERT for tomographic imaging of the subsurface. Studies reveal the importance of the CPT resistivity profile in improving the numerical tomographic imaging process convergence to an accurate optimal solution. Planning of another field demo will involve numerical simulation to help determine appropriate electrode spacing and appropriate scheduling of the ERT data acquisition equipment.
- ❑ Delivered a cone penetrometer deployed probe, trade named Cone Permeameter™ to SRS in March 1998. The system, which was designed to measure subsurface soil permeability, was demonstrated during April 1998 at SRS at the D-Area Coal Pile Runoff Basin and the A/M area at the 321 M Solvent Tank pad.
- ❑ Completed the final report on the Nevada Test Site Associated Particle Imaging (API) field demonstration in October 1997. The results of the Area 5 tests on both known and unknown waste drums were encouraging. The "Lynchburg standard" drum survey showed distinct objects. The survey of the unknown drum showed a strong distributed signature of the expected material in the lower section of the drum, but no resolvable shapes. A strong oxygen signature was also detected. The conclusions are that the contents are in the form of small pieces, are distributed through the lower part of the drum, and are probably highly oxidized.
- ❑ Prepared a purchase requisition for an Endress+Hauser Promass Coriolis meter in March 1998 for the Comparative Testing of Pipeline Slurry Monitors (Oak Ridge National Laboratory). The Promass instrument was evaluated during FY 1997 activities and was judged as providing the best on-line determination of slurry density of the density-measuring instruments evaluated.
- ❑ In the Joint Coordinating Committee for Environmental Restoration and Management (JCCEM) Contaminant Transport Studies (Pacific Northwest National Laboratory), the possibility of using contaminant-migration data from Lake Karachy at Mayak in support of the Hanford Vadose Zone effort was evaluated during April 1998. The initial data needed to evaluate the relevance of Lake Karachay's plume and sediment chemistry to the Hanford tank-leak question and the steps necessary to achieve the evaluation have been identified jointly with the Russian collaborators. The integration of the new Mayak site characterization data and our model grids into the final 3D site hydrogeologic model will be completed in preparation for the U.S.-Russian model calibration workshop to be held at Pacific Northwest National Laboratory, July 11 to 25, 1998.
- ❑ Conducted the fourth and final pulse of the infiltration test at the Box Canyon analog site In October 1997 for characterization of fractured rock. Site characterization, hydrologic, and geophysical data from infiltration and tracer tests provided a comprehensive picture of liquid infiltration in a fractured medium using time domain reflectometry, tensiometry, electrical resistivity probes, water and tracer sampling, and cross-borehole radar. Such data support characterization, monitoring, and remediation activities in fractured rock vadose zones. A user-interactive computer program was developed in August 1998 to provide three-dimensional visualization and analysis of the geometry and airflow connectivity in the fractured formation derived from cross-borehole interference tests.

- ❑ Conducted a field trial of an EIC-developed Raman probe for the Site Characterization and Analysis Penetrometer System (SCAPS) in the Savannah River Site A/M area during the week of February 2, 1998. Dense nonaqueous phase liquid contamination was detected using cone penetrometer-based Raman spectroscopy.
- ❑ Detected dense nonaqueous phase liquid (DNAPL) contamination, specifically PCE, using cone penetrometer based Raman spectroscopy. In April 1998, a team of researchers from EIC Inc., Fugro Geosciences, and the Savannah River Technology Center identified PCE in clay-rich sediments in the A/M area vadose zone during three pushes in two different locations. High concentrations of PCE in these zones were previously identified by conventional coring and laboratory analyses. Formal confirmation of cone penetrometer-based Raman spectroscopy for DNAPL was completed at the Savannah River Site in June 1998. Preliminary analysis of the soil core samples and the Raman data indicates a strong correlation of the spectrally indicated chlorinated solvent hits to high contaminant concentrations in the soil core. Increased fluorescence intensity also correlates well to soil core data adjacent to the M area basin.
- ❑ Completed the design of the hydrophobic ribbon from a form of Tyvek in April 1998 by FLUTe Ltd. and was approved for construction. The ribbon dusted with Sudan IV dye will cause the Dense, Non-Aqueous Phase Liquids (DNAPLs) to turn red and leave a visible stain on the ribbon.

FY 1998 Technology Projects

Projects for the Subsurface Contaminants Focus Area

- Sonic Cone Penetrometer Technology Testing (Tech ID 1686)
- Site Characterization and Analysis Penetrometer System Sensor Evaluation (Tech ID 243)
- JCCEM Contaminant Transport Studies (Tech ID 775)
- Environmental Monitoring While Drilling Sensor Delivery System (Tech ID 8)
- Alternative Landfill Cover Demonstration (Tech ID 10)
- Environmental Remote Sensing for Monitoring Plant Health (Tech ID 1900)
- Barrier Monitor Using Electrical Resistance Tomography (Tech ID 2120)
- Characterization and Monitoring of Dense Non-Aqueous Phase Liquids (Tech ID 237)
- Integrated Geophysical and Hydrological Characterization of Contaminant Transport Through Fractured Rock (Tech ID 216)
- Analog Site for Characterization of Contaminant Transport Through Fractured Rock (Tech ID 216)
- *In Situ* Permeability Measurements with Direct Push Techniques (Tech ID 307)
- Subsurface Barrier Validation with the SEAtTrace™ Monitoring System (Tech ID 308)
- Specialized Sampling and Separations Using 3M Membrane Technology (Tech ID 1514)

Projects for the Radioactive Tank Waste Remediation Focus Area

- SEALevel™ System for Monitoring Waste Levels in Tanks (Tech ID 279)
- Integrated Raman pOH Sensor for In-Tank Corrosion Monitoring (Tech ID 2015)
- Comparative Testing of Pipeline Slurry Monitors (Tech ID 2935, 2936, 2970)
- *In Situ* Monitoring of Physical Properties of High-Level Waste Slurries (Tech ID 213, 214)
- Magnetic Resonance Monitor for Technetium-99 Column Breakthrough (Tech ID 1513)
- Process Monitors for Cesium-137 Column Breakthrough (Tech ID 1515)

Projects for the Mixed Waste Characterization, Treatment, and Disposal Focus Area

- Multi-Element Metal Continuous Emissions Monitor for Compliance Monitoring (Tech ID 1564)
- Metal Emissions Monitor for Mixed Waste Thermal Treatment (Tech ID 18)
- Performance Testing of Multi-Metal Continuous Emissions Monitors (Tech ID 1564)
- Laboratory/Industry Nondestructive Assay Performance Demonstration (Tech ID 1574)

Projects for the Deactivation and Decommissioning Focus Area

- Portable Uranium Survey Tool Using Laser-Induced Fluorescence (Tech ID 78, 1999)
- Portable X-Ray K-Edge Heavy Metal Detector (Tech ID 134)

Projects for the Plutonium Focus Area

- Real-Time Plutonium, Curium, and Americium Monitor (Tech ID 2004)

Environmental Studies

- Current Practice of Environmental Characterization and Monitoring Technologies (Tech ID 712)
- Privatization Pilot Project for Expedited Site Characterization (Tech ID 77)

FY 1999 Technology Highlights

- ❑ Presented data on the Alternative Landfill Cover Demonstration (ALCD) to a group of about 100 regulators from the states of California, Arizona, and New Mexico in February 1999. These regulators were interested in using data received from the ALCD to determine whether they should permit alternative covers in their respective jurisdictions.
- ❑ Presented the latest K-edge results to attendees at the Sixth Nondestructive Assay (NDA) Waste Characterization Conference, November 17 to 19, 1998. During the conference, several people inquired about applications of the K-edge method to specific problems.
- ❑ A contract for demonstration of the X-ray K-edge technology in the 321-M Large-Scale Demonstration and Deployment Project at SRS was awarded to Ames Laboratory by Westinghouse Savannah River Co. on December 7, 1998. Phase one of a Large-Scale Demonstration and Deployment Project (LSDDP) of the K-edge system at SRS was completed in February 1999. Holdup of highly enriched uranium (HEU) in exhaust ducts on the roof of the 321-M facility was measured. No problems with radiation exposure were encountered during four nights of operation.
- ❑ Completed the FY 1998 year-end report on the identification of DOE EM post-closure monitoring needs and requirements in December 1998. This report includes post-closure needs and requirements for the Fernald, Savannah River, and Hanford sites.
- ❑ Tests were performed in January 1999 to corroborate previous Surface Acoustic Wave Mercury Vapor Sensor data showing responses to concentrations of gaseous elemental mercury. These tests were run on a different sensor with identical parameters to the first, and the results were similar to those presented before. Once again, the device responded quickly and sensitively to concentrations below 1 ppb. Additionally, tests were begun to assess the sensor's response to approximately 50 ppb mercuric chloride in dry nitrogen.
- ❑ Conducted a field evaluation of the sonic cone penetrometer (CPT) during the weeks of April 12 and April 19, 1999 at the Hanford Site. Results of the testing indicate that the sonic CPT is highly beneficial in very gravelly to cobbly soils, but its utility is reduced as the soil changes to silts and clays. In the 200-East area, application of the sonic CPT was able to reduce some rod friction and permit additional static pushing. Although the sonic CPT showed limited benefit in the 200-West area, discussions with contractors familiar with that area indicate there is a very difficult layer at this depth that also thwarted some pile driving activities in the same area.
- ❑ In cooperation with the Westinghouse Savannah River project team, Applied Research Associates deployed several DOE-developed DNAPL characterization tools on June 21, 1999 including:
 - The FLUTE™ membrane system used to identify TCE™ contamination *in situ*.
 - The GeoVis™ downhole video system that allows visual observation through a downhole microscope/video camera of soils as the cone penetrometer sounding is advanced.

- Raman spectroscopy that uses an uphole laser and spectrograph in conjunction with fiber-optic cables to detect chlorinated solvents *in situ*.
- Field-tested the Thermo Alpha Monitor during October 1998 at Oak Ridge using a number of sample sources. The testing, which is part of tested the On-Line, Real-Time, Alpha-Radiation Measuring Instrument for Liquid Streams project, ran without incident and demonstrated that the instrument is capable of alpha detection down to 10-ppb uranium-equivalent while being operated on a portable generator and compressor in the field.
- Field-tested the Internal Reflection Sensor (IRS) for the Cone Penetrometer in Jacksonville, FL using the DOE Site Characterization and Analysis Penetrometer System (SCAPS) truck. The test site (Sage Dry Cleaning) has Non-Aqueous Phase Liquid (NAPL) contamination stemming from its use as a dry cleaning facility and later as a gas filling station. The IRS cone penetrometer module was pushed twice at the site; the first push showed sensor response at 14 feet and 16 feet, while the second push showed a response at 20 feet. Archived data from the Jacksonville test site indicate that NAPLs are present at the depths where response from the IRS sensor was observed.
- Completed the Hanford Area 200 Cone Permeameter™ measurements for the *In Situ* Permeability Measurements with Direct Push Techniques project, in support of the Hanford ER program, during October 19 to 24, 1998. Six pushes were completed to a maximum depth of 60 feet. The data report will be included in the Phase 3 topical report. The Cape Canaveral Cone Permeameter™ measurements, in support of the characterization activities being conducted by Savannah River Site staff with the Site Characterization and Analysis Penetrometer System truck, are planned for the week of December 14, 1998.
- Completed sample port installations at the Waldo test site in October 1998 for the Subsurface Barrier Validation with the SEAtrace™ Monitoring System. The field test plan was modified and delivered to FETC. The first two tracer injections were completed, and monitoring data were collected. The SEAtrace™ system is identifying leaks at the approximate known locations of the engineered leaks.
- Completed a preliminary design of the SEALevel™ deployment system for the Automated Monitoring System for Fluid Level and Density in High-Level Waste Tanks and submitted it to the Savannah River Site and the Tanks Focus Area for review in October 1998. The preliminary design includes the system instrumentation, a mechanism for coupling the deployment system to the tank riser, personnel shielding, mechanisms for *in situ* calibration, and apparatus for probe decontamination.
- Tested Bahia grass for its sensitivity to high levels of copper (up to 100 ppm) in December 1998. Collected the data on slash pine grown under five different levels of zinc. In both plant species, symptoms were observed in all treatments above the control levels. This work is part of the Environmental Remote Sensing for Monitoring Plant Health (Epcot) project.
- Used a laser-induced fluorescence imaging (LIFI) unit produced under a cash order from the Army Corps of Engineers as a mine detection technology at a field exercise in South Carolina. Based on the results of this exercise in October 1998, during which the performance of the LIFI backpack unit was outstanding, a few hardware refinements were made to the CMST unit (primarily with the video displays and with the auto-scaling and gating circuitry).
- Demonstrated a the handheld LIFI system at the Oak Ridge K-27 facility on March 25, 1999. The backpack LIFI system was mobilized, took measurements, and was demobilized in a pre-surveyed contaminated area within four hours. The uranium contamination mapping was overlaid on the visual image and corresponded well to the pre-surveyed contamination map. Discussions on possible applications of the backpack portable LIFI instrument were held with a large group of stakeholders from throughout the Oak Ridge complex.
- Received DOE approval in December 1998 for the Gunite and Associated Tanks (GAAT) project to transfer slurries through the slurry monitoring test loop. Testing with radioactive slurries and the

slurry monitoring test loop began on February 9, 1999. The two-month testing is being conducted by recirculating radioactive supernate and slurries to and from a sludge consolidation tank at the GAAT remediation project at the Oak Ridge National Laboratory. The final project report, "Testing of In-Line Slurry Monitors and Pulsair mixers with Radioactive Slurries," ORNL/TM-1999/111, was published on July 30, 1999.

- ❑ Completed the first phase of characterization using the DOE SCAPS truck in support of the Interagency Dense Non-Aqueous Phase Liquid (DNAPL) Consortium DNAPL evaluation site at Cape Canaveral during December 1998. During this activity, the EIC Raman system and the GeoVis™ downhole video camera were evaluated, and the Cone Sipper™ cone penetrometer sampling system and the Science and Engineering Associates (SEA) Cone Permeameter™ were deployed. The second phase testing of the cone penetrometer truck was completed in January 1999 at the Cape Canaveral Air Station to assist the Interagency Dense Nonaqueous Phase Liquid (DNAPL) Consortium. The evaluation of the FLUTE™ hydrophobic membrane was successful. Two liners were installed successfully in the source area in boreholes spaced approximately three feet apart, and both of the liners indicated the presence of DNAPL. The distribution of NAPL will be compared with depth discrete analyses from sediments previously collected during site characterization.
- ❑ Tested DNAPL sensors (EIC Raman system, GeoVis™, and EIC Internal Reflection Sensor) at a commercial site in Jacksonville, Florida. Fluorescence was observed by the Raman technique in zones where DNAPL has been identified. The method also indicated DNAPL in deeper zones not previously characterized. The GeoVis™ camera saw small, dark globules in zones where DNAPL is suspected.
- ❑ Conducted a DNAPL workshop at the SRS on September 1, 1999. Participants received eight hours of training on DNAPL basics, conceptual model development, and baseline and innovative technologies. In addition, they took a field trip to see the membrane interface probe that was concurrently being deployed on the DOE Site Characterization and Analysis Penetrometer System truck. The participants worked several problems, including an exercise on characterization using actual field data, and received continuing education credits approved by the Professional Engineering and Professional Geologist licensure boards.
- ❑ Completed evaluating the GeoProbe™ Membrane Interface Probe during September 1999. Initial testing was completed the week of August 30, 1999. Dr. William Davis of the Waterways Experiment Station, U.S. Army Corps of Engineers, returned to the site from August 13-17, 1999, to collect additional data. Preliminary comparisons with previously collected sediment samples suggested that the probe was effective at delineating contamination to hundreds of parts per billion in the dissolved phase.

FY 1999 Technology Projects

Subsurface Contaminants Focus Area

- Sonic Penetration Enhancement for Cone Penetrometer (Tech ID 1686)
- Site Characterization and Analysis Penetrometer System Techniques (Tech ID 243)
- Large-Scale Radioactive Contaminant Transport Methodology Validation (Tech ID 775)
- Environmental Monitoring While Drilling Sensor Delivery System (Tech ID 8)
- Alternative Landfill Cover Demonstration (Tech ID 10)
- Environmental Remote Sensing for Monitoring Plant Health (Tech ID 1900)
- Characterization and Monitoring of Dense Non-Aqueous Phase Liquids (Tech ID 237)
- *In Situ* Permeability Measurements with Direct Push Techniques (Tech ID 307)
- Subsurface Barrier Verification with the SEAttrace™ Monitoring System (Tech ID 308)
- Specialized Sampling Using 3M Membrane Technology (Tech ID 1514)

Radioactive Tank Waste Remediation Focus Area

- Raman and Electrochemical Noise Sensors for In-Tank Corrosion Monitoring (Tech ID 2015)
- SEALevel™ System for Monitoring Fluid Levels in Waste Tanks (Tech ID 279)
- Comparative Testing of Pipeline Slurry Monitors (Tech ID 1547)

Mixed Waste Characterization, Treatment, and Disposal Focus Area

- Multi-Element Metal Continuous Emissions Monitor for Compliance Monitoring (Tech ID 1564)
- Environmental Sample Chemical Analysis Automation Project (Tech ID 72)

Deactivation & Decommissioning Focus Area

- Portable Uranium Survey Tool Using Laser-Induced Fluorescence Imaging (Tech ID 1999)
- Portable X-Ray, K-Edge Heavy Metal Detector (Tech ID 134)

Nuclear Materials Focus Area

- Real-Time Plutonium, Americium, and Curium Monitor (Tech ID 2004)