OVERVIEW

Current Program Status

History and Focus

The Carlsbad Environmental Monitoring and Research Center (CEMRC) was established in 1991 with a grant from the U.S. Department of Energy (DOE). The primary goals of the CEMRC are to:

- Establish a permanent center of excellence to anticipate and respond to emerging health and environmental needs, and
- Develop and implement an independent health and environmental monitoring program in the vicinity of the DOE Waste Isolation Pilot Plant (WIPP), and make the results easily accessible to all interested parties.

The Carlsbad Environmental Monitoring & Research Center (CEMRC) is a division of the College of Engineering at New Mexico State University (NMSU). Under the terms of the grant from DOE, the design and conduct of research for environmental monitoring at the WIPP are carried out independently of the DOE, and the production and release of resulting reports do not require DOE review or approval. A brief history of the CEMRC is presented in Appendix A.

The CEMRC is operated as a research institute within NMSU, supported through grants and service contracts. The CEMRC's primary objectives are to:

- Provide for objective, independent health and environmental monitoring;
- Conduct research on environmental phenomena, with particular emphasis on natural and anthropogenic radionuclide chemistry;
- Provide advanced training and educational opportunities;
- Develop improved measurement methods, procedures and sensors; and
- Establish a health and environmental database accessible to all sectors.

Key Activities for Success

The following is a summary of progress and status for nine key enabling activities that are necessary to achieve the goal of establishing and developing the CEMRC. Activities to achieve the second goal of monitoring in the vicinity of the WIPP are presented in the following section (WIPP Environmental Monitoring Project).

1. Assemble a team of highly qualified research scientists and support staff capable of carrying out current and future projects.

At the end of 2002, the CEMRC employed 23 personnel (Table 1). No positions were vacant or in recruitment.

2. Create state-of-the-art laboratory facilities capable of supporting advanced studies in areas of scientific specialization.

In January 1997, the CEMRC was relocated to Light Hall, a new 26,000 ft^2 laboratory and office facility constructed adjacent to the NMSU-Carlsbad campus. The CEMRC's scientific activities are organized into major areas of specialization, with corresponding assignment of staff roles and responsibilities. Although some of the CEMRC's projects involve only one or two of the program areas, all of the program areas collaborate in carrying out the WIPP Environmental Monitoring project, and this type of integrative research is also applied to some newly funded projects. The five scientific program areas include (1) radiochemistry, (2) environmental chemistry, (3) informatics and modeling, (4) internal dosimetry, and (5) field programs. Detailed descriptions of each program area and associated facilities and instrumentation are presented on the CEMRC web site at http://www.cemrc.org.

3. Establish effective liaisons with leading research groups and laboratories to facilitate shared services and collaborative research.

In response to the need for expanding the CEMRC research role, the Center has developed a partnership with Los Alamos National Laboratory (LANL) to conduct actinide chemistry research for WIPP. Program needs for external laboratory services were minimal in 2002, but some subcontractual agreements were maintained to provide specific specialized services or analyses (Appendix B). The NMSU Fishery and Wildlife Science Department also continued to provide support to the CEMRC through part of 2002 with the loan of a boat used in lake sampling activities. With respect to collaborative research, five of the publications and presentations by CEMRC staff during 2002 were co-authored with external colleagues, and four of the CEMRC's proposed and existing projects involve collaboration with other departments or institutions.

4. Establish an independent advisory body of scientists to provide expert guidance and consultation to CEMRC staff in the focus areas of CEMRC research.

The Scientific Advisory Board (SAB) for the CEMRC is composed of one scientific expert in each of the CEMRC's five scientific areas of specialization (Appendix C).

The Program Review Board (PRB) for the CEMRC consists of a minimum of three members selected by the NMSU College of Engineering administration (Appendix C). Members of the PRB are directors or former directors of leading environmental research centers with histories of long-term success in sponsored research.

Because of major changes in direction of CEMRC's science program, as well as a change in its leadership, the annual SAB and PRB meetings have been postponed indefinitely, starting in 2002.

5. Establish a program of administration to ensure effective operation of the CEMRC.

In July 2001, Dr. Marsha Conley, CEMRC director, retired. Dr. George Hidy acted as an interim director during the search for the new permanent director, which concluded in February 2002 when Mr. Joel Webb was appointed Director of CEMRC. Current administrative staff includes a director, an assistant to the director, a buyer specialist, a technical/facility specialist, a quality assurance manager, a word processing specialist, and an administrative secretary.

Formal tracking of CEMRC project schedules and milestones is conducted for current studies, as noted in later sections. Regularly scheduled work sessions for scientific program planning and problem solving are used to define goals and track progress. Administrative and individual program area staff also have regularly scheduled review and planning sessions. During 2002, significant accomplishments and events were reported in quarterly summaries provided to the DOE and NMSU.

6. Publish research results and create a database management system to provide access to information generated by the CEMRC.

CEMRC staff authored or co-authored 10 presentations at international, national and regional scientific meetings and 7 papers were published, are in press, or have been submitted for publication in peer-reviewed scientific journals and books during 2002 (Appendix D). A cumulative list of publications by CEMRC staff since 1996 is presented on the CEMRC web page.

The CEMRC issued a 2001 report that presented extensive data on radionuclides, non-radioactive constituents and other basic environmental parameters from the WIPP Environmental Monitoring project. This report and other CEMRC information are available via the CEMRC web site, and data tables referenced in this report are also presented on the web site at http://www.cemrc.org. Also included as part of the website are samples collected and analyzed since the most recent Center report.

7. Establish regional, national and international outreach and collaboration.

During 2002, the CEMRC hosted 6 colloquia presented by visiting scientists (Appendix E). Each colloquium was advertised locally, resulting in participation by representatives from local scientific, educational, technical and natural resource management organizations, as well as the general public. The CEMRC was involved in many other outreach activities including presentations for local civic and professional groups and exhibits for various school and community events (Appendix F). As described in a later section, over 600 volunteers from the local community have participated in the "Lie Down and Be Counted" project. In addition, CEMRC scientists provided leadership in professional and scientific organizations and meetings (Appendix G).

8. Procure additional research grants and service contracts from external sources.

CEMRC scientists generated 10 new proposals, pre-proposals and contract modifications during 2002 (Appendix H). Important among these is the new contract modification with LANL for $52,420 for actinide chemistry research. The new funding achieved on five projects totaled over $165,000, one proposal is pending, and two proposals were not funded. A total of 13 projects (external to the CEMRC) were in progress during 2002, with a combined value over $2 million. Many of these projects and the funds received include support for external collaborators and cover multiple years of research. These projects represent a wide array of activities, and they have resulted in significant expansion and diversification of the scientific program.

9. Implement programs to offer visiting scientists training in specialized research techniques and methodologies and to involve CEMRC resources and personnel in providing educational opportunities for students nationwide.

During 2002, two undergraduate students worked in laboratory aide positions at the CEMRC; these positions provided training and basic skills development relevant to the position assignments. CEMRC staff presented 10 major presentations and special programs were provided for student groups (Appendix F).

Table 1. Listing of CEMRC Staff as of 31 December 2002

Name	Position
Arimoto, Richard	Senior Scientist-Environmental Chemistry
Brown, Becky	Assistant to the Director
Fraire, Joe	Assistant Scientist-Radiochemistry
Ganaway, David	Assistant Scientist-Field Programs
Khaing, Hnin	Assistant Analyst – Environmental Chemistry/Radiochemistry
Kirchner, Thomas	Senior Scientist-Informatics & Modeling
Lippis, Joe	Technical/Facility Specialist
McCauley, Sharyl	Quality Assurance Manager
McNutt, Damon	Programmer Analyst II
Moir, Deborah	Associate Director
Monk, James	Associate Health Physicist
Nesbit, Curtis	Associate Health Physicist
Sage, Sondra	Assistant Scientist-Environmental Chemistry
Schloesslin, Carl	Assistant Scientist-Radiochemistry
Schloesslin, Cheryl	Assistant Scientist-Environmental Chemistry
Schoep, David	Science Specialist-Internal Dosimetry
Spruiell, Roy	Programmer Analyst II
Stewart, Barry	Associate Scientist-Radiochemistry
Stroble, Carolyn	Buyer Specialist I
Walthall, Mark	Senior Scientist-Environmental Science
Webb, Joel	Director
York, Larry	Technician II-Radiochemistry
Young, Karen	Word Processing Specialist

WIPP Environmental Monitoring Project

Project Concept

As defined in the original grant, the purpose of the WIPP EM project is to establish and maintain independent environmental research and monitoring in the vicinity of the WIPP and to make the results easily accessible to all interested parties. This project was implemented during the WIPP pre-disposal phase, and is now continuing during the operational (disposal) phase. The WIPP EM project is organized and carried out independent of direct oversight by DOE, and the project does not provide data to any regulatory body to meet the compliance demonstration requirements applicable to the WIPP. Analytical results and interpretations from the WIPP EM are published by CEMRC to inform the public and particularly the environmental science community.

A detailed description of the WIPP EM concepts, sampling design and baseline studies is presented on the CEMRC web page. The following is a summary of 2001-2002 activities for each major environmental medium in the WIPP EM. It is important to note that mixed waste was first received by the WIPP on 9 September 2000. The results summarized in this report cover samples collected through October 2002.

Based on the radiological analyses of monitoring phase samples (collected since 26 March 1999) completed to date for area residents and for selected aerosols, soils, drinking water and surface water, there is no evidence of increases in radiological contaminants in the region of the WIPP that could be attributed to releases from the WIPP. In most cases, levels of radiological and non-radiological analytes measured in 2002 were within the range of baseline levels measured previously by CEMRC for the targeted analytes.

In the summer of 2001, the Carlsbad Field Office (CBFO) of DOE requested CEMRC to investigate whether the Center's direction could become more closely aligned with scientific and analytical activities foreseen by the CBFO to support the safe and efficient operation of the U.S. DOE Waste Isolation Pilot Plant (WIPP). To further develop the CEMRC program, during 2002 the Center has been working closely with the CBFO management to define research and analytical tasks that will address such needs. This redirection permits CEMRC to pursue new research avenues aggressively in partnership with (versus independent of) the DOE community in the Carlsbad region.

The tasks requested to be performed by the CEMRC during 2002 included:

- Development of a Center wide quality assurance and control program that complies with and is accountable to CBFO's Quality Assurance Program Document;
- Analytical and scientific support for the LANL Actinide Chemistry and Repository Science Program;
- Characterization of radionuclides in oil and gas from production formations in the vicinity of the WIPP;
- Identification and quantification of Gnome-derived radionuclides;
- Environmental safety and health support for WIPP operations and
- Optimization of the Center's WIPP Environmental Monitoring Project

A summary of the progress made on these tasks is also provided in this report.

Organization and Optimization of Monitoring Program

The scheduling and management of sample analyses collected in the WIPP EM project are based on (1) priorities for providing information to the public in a timely manner, (2) relative risks of human exposure to contaminants among the various media sampled, (3) needs for stringent data validation and verification prior to release and (4) time constraints resulting from sample preparation and analysis procedures.

The management plan for the WIPP EM incorporates milestones representing significant products and progress, including both routine sampling and analyses and special studies. Key performance indicators that integrate groups of milestones are identified and reviewed annually to serve as metrics of the successful progress of the project. Completion of 2002 key performance indicators is summarized in Appendix I.

During 2002, the elements of the monitoring project were reviewed and evaluated as part of the strategic planning for CEMRC activities over the next few years. A re-definition of the scope of the monitoring program has been driven by two factors (1) the diminishing resources available for the monitoring work and (2) the increased emphasis at CEMRC on direct research and technical support of WIPP operations. The challenge that has faced CEMRC during 2002 has been to restructure and optimize the WIPP EM in order to maintain a long-term environmental monitoring program that will contribute to the public's confidence in the safe operation of the WIPP, and identify missing elements in our understanding of the WIPP environment that are not addressed by the ongoing and proposed long-term monitoring studies.

A major reduction in the resources devoted to the WIPP EM has been proposed by CEMRC through a cut back in the frequency of sampling of the various media and by reducing the number of target analytes. The justification for this reduction is based on the fact that to date, there has been no evidence for any perturbation to drinking water, soils, surface water or sediments caused by the WIPP operations. Studies of airborne particulate matter (aerosols) will continue to be a major focus of the CEMRC's monitoring efforts because, in the event that radioactive or chemical contaminants were released from WIPP, these materials could be rapidly dispersed through the atmosphere and spread throughout the environment. In response to a public survey (described in a later section), which indicated that drinking water was the environmental medium of greatest concern, CEMRC proposed annual sampling of the same drinking water sources as in prior years. While it is highly unlikely that any chemical impacts of the WIPP will be detected through analyses of other media, CEMRC considers there is value in continued monitoring of soils, surface water and sediments, and vegetation and biota at least for the remainder of the original grant. Thus, a program has been recommended in which one of the media other than aerosols and drinking water is sampled each year on a rotating basis. The decision was made to halt sampling and analysis for soils, surface water and sediments in 2002 and begin the rotational sampling of media in 2003, starting with soils.

The continuation of the WIPP EM and the optimization plans reflect the Center's commitment to ensuring that the public, workers, and the environment are protected from exposure to contaminants. Also taken into account in developing these plans was the need for the Center to move in new directions, primarily directed research and technical support of WIPP operations. It is likely that additional adjustments to the WIPP EM will be needed as the Center's capabilities continue to evolve and the other programs monitoring the WIPP also move in new directions.

Aerosols

Aerosol particle sampling is conducted at five locations, with samplers operating continuously at each location. The locations include a port inside the WIPP exhaust shaft, a site approximately 0.1 km northwest (downwind) of the WIPP exhaust shaft (On Site station), a site approximately 1 km northwest (downwind) of the WIPP (Near Field station), a site approximately 19 km southeast (upwind) of the WIPP (Cactus Flats station) (Fig. 1), and a site located in Hobbs, NM approximately 75 km northeast of the WIPP.

Continuous sampling of aerosol particles was conducted through December 2002, however, beginning in April 2002 the instruments, frequencies and locations that had been previously established in 2001 and in the baseline phase were changed to address concerns and issues and to make the sampling more efficient. Analyses of all particle samples collected through December 2002 for both radiological and non-radiological constituents were completed and are reported herein. Web site posting of results of radiological and non-radiological analyses of particle samples collected in the WIPP exhaust shaft (FAS) began in July 1999, and are updated weekly. A summary of the 2002 FAS data is also presented herein.

The aerosol particle sampling design underwent major changes in 2002. These changes include (1) sampling for non-radiological aerosol analytes is now done through dicots only; (2) analysis for non-radiological analytes has been limited to trace elements; (3) sampling intervals for the trace elements has been lengthened to one sample per week and (4) sampling at the Hobbs aerosol monitoring station was terminated in April 2002.

Soils

During 2002, no routine soil samples were collected or analyzed.

Surface Water and Sediments

During 2002, no surface water or sediment samples were collected or analyzed.

Drinking Water

The WIPP EM studies of ground water focus on the major drinking water supplies used by communities in the WIPP region because these are often perceived by the public as a potential route for contaminants to reach humans. Five community supplies of drinking water (representing three major regional aquifers) are included in routine sampling, including Carlsbad, Loving/Malaga, Otis, Hobbs and a secondary source for Carlsbad. One private water well (representing a fourth aquifer) that is located within 16 km of the WIPP is also sampled.

During 2002, drinking water samples were collected in the spring at five of the six drinking water supplies, and results of radiological and non-radiological analyses are reported herein. The private water well was dry during the both the 2001 and 2002 sampling periods. The six drinking water supplies will continue to be sampled periodically for selected radiological and inorganic testing.

Biota

During 2002, no vegetation samples were collected or analyzed.

Human Population

The “Lie Down and Be Counted” (LDBC) project serves as a component of the WIPP EM that directly addresses the general concern about personal exposure to contaminants shared by residents who live near DOE sites. As in other aspects of the WIPP EM, *in vivo* bioassay testing was used to establish a baseline profile of internally-deposited radionuclides in a sample of local residents. The sampling design includes solicitation of volunteers from all segments of the community, with sample sizes sufficient to meet or exceed a 15% range in margin of error for comparisons between major population ethnicity and gender categories as identified in the 1990 census. Radiobioassays of the original volunteer cohort have been ongoing since July 1999. New volunteers will continue to be recruited each year, with a target of 100 new volunteers annually to establish new study cohorts and replacement of volunteer attrition.

Results of the LDBC project through 1 October 2002 are reported herein, and are updated quarterly on the CEMRC web site.

Quality Assurance

The CEMRC is subject to the policies, procedures and guidelines adopted by NMSU, as well as state and federal laws and regulations that govern the operation of the University. The management of CEMRC is committed to conducting a well-defined quality assurance program, incorporating good professional practice and focusing on the quality of its testing and calibration in research and service to sponsors. CEMRC technical programmatic areas in 2002 included: Actinide Chemistry, Environmental Chemistry, Radiochemistry, Field Programs, Informatics and Modeling and Internal Dosimetry. The development and implementation of an independent health and environmental monitoring program has been CEMRC's primary activity since establishment. As CEMRC's monitoring activities were to be conducted without direct DOE oversight, review or approval, CEMRC had not been required to comply with DOE orders or quality assurance requirements. Activities conducted at CEMRC were, however, performed in accordance with a formal system, which included a development and implementation of appropriate standards, performance assessment, quality improvement, provision of infrastructure, professional staff development, personal accountability and commitment to compliance.

Beginning in early 2002, however, a significant effort was devoted to refining CEMRC's quality system to meet applicable requirements of the US DOE Carlsbad Field Office (CBFO) Quality Assurance Program Document (QAPD, CAO-94-1012). This effort was in response to the CBFO's request for a change in CEMRC's direction to allow it to become more closely aligned with scientific and analytical activities seen by CBFO to support the safe and efficient operation of WIPP. As a result, CEMRC produced a center-wide Quality Assurance Plan (QAP) CP-QAP-004, which was subsequently submitted to and approved by DOE. In addition, one existing CEMRC document was revised and reissued, five measuring and testing equipment-related documents were written, four safety documents were revised and re-issued and ten implementation procedures, were written to address requirements of the DOE QAPD. All documents were entered into formal document control. In addition forty-five standard operating procedures from the various programmatic areas were written and issued as controlled documents, which means the controlled documents more than doubled in one year's time.

Since implementing a graded approach for conditions adverse to quality under the new QAP, one stop work, one nonconformance and thirty-two non-routine events have been documented. Most of the non-routine events occurred while implementing the QAP. All conditions adverse to quality have been addressed.

Internal surveillances were performed on the following programmatic areas: Environmental Chemistry, Field Programs, Informatics and Modeling, Internal Dosimetry and Radiochemistry. In addition, internal surveillances were performed in the Administrative, Quality Assurance areas as well as on Document Control and maintenance of Scientific Notebooks. To date, all surveillances have been closed.

During the year, external audits were performed on two of the programmatic areas at CEMRC; Internal Dosimetry (also referred to as Radiobioassay) for *in vivo* Radiobioassay, and Environmental Chemistry for Volatile Organic Compounds (VOCs). Washington TRU Solutions (WTS) performed both of these external audits. The Internal Dosimetry Audit resulted in 4 findings and no observations. All findings were adequately addressed by CEMRC. The audit was closed in December 2002, and CEMRC was retained on the WTS Qualified Suppliers List for *in vivo* radiobioassay, lung and whole body counting. As a result of the audit on Environmental Chemistry, CEMRC was included on the WTS Qualified Suppliers List and listed as provisionally approved for VOC analysis and canister cleaning. A follow-up audit has not yet been conducted to reflect full approval for VOC work.

The DOE CBFO performed a center-wide external audit in December 2002. The scope of that audit was to assess the status of the recently issued centerwide QAP against the requirements specified in the CBFO QAPD. This comprehensive audit included all the CEMRC laboratories and programmatic areas. The corrective action report was submitted to DOE for approval and a verification visit will be scheduled in 2003. The following sections describe and summarize the quality assurance/quality control activities of each of the laboratory programmatic areas: Radiochemistry, Environmental Chemistry, Field Programs and Internal Dosimetry.

Quality Assurance/Quality Control for Radioanalyses

Routine quality assurance/quality control activities conducted for radioanalyses include tracking and verification of analytical instrument performance, use of American Chemical Society certified reagents, use of American Society for Testing and Materials (ASTM) Type II water for reagent preparations, use of National Institute of Standards and Technology (NIST) traceable radionuclide solutions and verification testing of radionuclide concentrations for tracers not purchased directly from NIST or Analytics.

Daily (or each time the system was used) control checks were performed on all nuclear counting instrumentation. The type of instrument and methods used for performance checks were as follows. For the Tennelec LB4100 gas-flow α/β proportional counter used for the FAS program, efficiency control charting was performed using ^{239}Pu and ^{90}Sr check sources along with ensuring that α/β cross-talk was within limits. Sixty-minute background counts were recorded daily. Two blanks per week for the FAS program were counted for 20 hours and were used as a background history for calculating results. For the Protean IPC-9025 gas-flow, α/β proportional counter used for other measurements, including ^{234}Th tracer recoveries for isotopic thorium analysis, efficiency control charting was performed using ^{239}Pu and ^{99}Tc check sources along with ensuring that α/β cross-talk was within limits. Sixty-minute background counts were recorded daily.

For the Wallac Guardian 1414 liquid scintillation counter used for ^{241}Pu measurements, efficiency and centroid control charting was performed using ^{3}H and ^{14}C check sources. Fifty-minute background counts were recorded daily. Blanks counted for 12 hours were used as a background history for calculating results. Efficiency, resolution and centroid control charting were performed using ^{152}Eu check sources for the Canberra high purity germanium (HPGe) gamma detectors.

Routine background determinations were made on the HPGe detector systems by counting blank samples, and the data was used to blank correct the sample concentrations.

For the Oxford Oasis alpha spectrometer, efficiency, resolution and centroid control charting was performed using ^{148}Gd check sources on a regular basis. Before each sample count, pulser checks were performed to ensure acceptable detector resolution and centroid. Blanks counted for 5 days were used as a background history for calculating results.

During 2002, CEMRC participated in two rounds of the DOE Environmental Measurements Laboratory Quality Assurance Program (EML QAP), resulting in "acceptable" ratings for 49 individual determinations of 19 analytes in glass fiber filters, soil, vegetation and water samples (Table 2). One "warning" rating occurred for ^{40}K in soil for QAP-56 with a –15% bias. There were no occurrences of "not acceptable" ratings. Due to higher priority commitments to the development of the CEMRC quality assurance program, insufficient time was available to complete the full suite of analyses for samples from QAP-57, and thus many analytes were not reported for this set.

During 2002, CEMRC participated in the NIST Radiochemistry Intercomparison Program (NRIP) for soil, air filter and water analysis. CEMRC did not submit results for synthetic urine due to scheduling conflicts with development of the CEMRC quality assurance program. NRIP 2001 soil results were not available for the 2001 annual report and are included in this report. CEMRC was not traceable for ^{90}Sr in any matrix with approximately –30% biases. Methods for the analysis of ^{90}Sr were still in development at the time these results were obtained. In addition, CEMRC was not traceable for ^{238}U in 2002 soil with a +13% bias and for ^{230}Th in 2002 water with a –10% bias. For all other analytes CEMRC received traceability (Table 3).

Quality Assurance/Quality Control for Environmental Chemistry Inorganic Analyses

The analytical methods employed for inorganic analyses in the environmental chemistry program at CEMRC are based, when applicable, on various standard procedures (EPA/600/4-79-020, 1983; EPA/SW-846, 1997; American Public Health Association, 1981). For some matrix/analyte combinations, appropriate external standard procedures do not exist, and for those cases, specialized procedures have been developed to meet the needs of the WIPP EM and other research projects.

Instrumentation

A DIONEX 500 ion chromatography (IC) system was used to determine the concentrations of a suite of anions, including nitrate, nitrite, sulfate, chloride, fluoride, and phosphate in water samples and aqueous extracts of aerosol samples, soils, and sediments. Configured differently, the same instrumentation was used to determine the concentrations of several cations (calcium, magnesium, sodium, ammonium and potassium). The anion analyses were performed with the use of AS11 and AS14 anion exchange columns and AG11 and AG14 guard columns, with chemical suppression and conductivity detection. The cations were determined using a CG12A guard column and a CS12A analytical column, with the same type of chemical suppression and conductivity detection.

Elemental analyses employed an atomic absorption spectrometer (AAS) with a computer-controlled Perkin-Elmer 5100PC atomic absorption unit with Zeeman background correction. Samples are introduced into the AAS by vaporization in a heated graphite furnace. Additional inorganic analyses were performed using a Perkin-Elmer Elan 6000 inductively-coupled plasma mass spectrometer (ICP-MS). The two instruments used for the elemental analyses are complementary; AAS is more sensitive than the ICP-MS for some elements, especially for the elements As and Se, but compared with the ICP-MS, the AAS has a narrower linear range, requires more operator effort for calibration and operation, and has a much lower sample throughput.

General Quality Control

Independent quality assurance samples are obtained and analyzed to verify the performance of the instrumentation and the proficiency of the analyst. Both blind samples (obtained from an outside source, with true values not known at the time of analysis) and reference samples (obtained from an outside source or prepared internally, with true values known at the time of analysis) are used to perform this function. Regular QC verifications and batch QC provide records of sample performance data. Copies of the analytical data and performance results are maintained by the environmental chemistry group.

In January 2002 the environmental chemistry laboratory participated in the WatR™ Supply Proficiency Testing Study (WS-66) sponsored by Environmental Resource Associates (ERA). All results were within the acceptance limits determined by ERA. Two ions, chloride and ortho-phosphate, results were flagged "Not Acceptable". The IC was recalibrated and the samples reanalyzed. The test sample results obtained in the reanalysis were within acceptance limits.

For all environmental chemistry analyses, QC samples are analyzed with each sample batch as an indicator of the reliability of the data produced. The types, frequencies of analysis, and limits for these QC samples have been established in a set of standard operating procedures. Extraction QC samples include Laboratory Reagent Blanks (LRB) (for aerosol and FAS samples, unused cellulose ester filters were used as LRB samples), Laboratory Fortified Blanks (LFB) (a cellulose ester

CRM, “Trace Metals on Filter Media” from High Purity Standards in Charleston, South Carolina, was used for QC of aerosol sample metals analyses), duplicates and Laboratory Fortified Matrix (LFM) samples. In cases where duplicate aliquots from the original sample were not feasible (such as aerosol filters), separate aliquots of the sample extract were analyzed for the duplicate and LFM analyses. The digestion QC parameters used for the evaluation of constituents in water, soils, and sediments were based on EPA Contract Laboratory Program (EPA 540/R-94013, 1994); and SW-846 methods (EPA/SW-846, 1997). No comparable control parameters presently exist for aerosol samples. For all constituents values were reported relative to the method detection limit as determined by the method outlined in 40 CFR 136, Appendix B.

Quality Assurance/Quality Control for Field Sampling

For the collection of most WIPP EM samples, no external standard procedures are considered completely appropriate for the objectives of the studies. In these cases, customized plans are developed and documented. After the activity is completed, the plan is revised to reflect any departures from the original plan, and documented to file. For most environmental media, the sampling plans combine selected standard procedures with specific adaptations to address scientific objectives of interest. For example, procedures for collection and preservation of samples for compliance with Safe Drinking Water Act requirements are applied to the collection of drinking water and surface water samples, but the locations of sample collection are selected on the basis of other criteria. Likewise, high-volume air samplers are operated to meet an EPA standard of 1.13 m^3min^{-1}, but the frequency of filter replacement is based on optimal loading for radioanalysis.

Sampling procedures used for collection and preparation of environmental samples for the WIPP EM project are described in the individual data summaries that follow. Logbooks are maintained by technical staff in field operations to record locations and other specifics of sample collection, and data on instrument identification, performance, calibration and maintenance. Data generated from field sampling equipment are error-checked by using routine cross checks, control charts and graphical summaries. Most data collected in written form are also entered in electronic files, and electronic copies are crosschecked against the original data forms. All electronic files are backed up daily.

Calibration and maintenance of equipment and analytical instruments are carried out on predetermined schedules coinciding with manufacturer’s specifications or modified to special project needs. Calibrations are either carried out by equipment vendors or by CEMRC personnel using certified calibration standards.

Quality Assurance/Quality Control for Internal Dosimetry

The *in vivo* bioassay program currently participates in, via WIPP, the Department of Energy’s *In Vivo* Laboratory Accreditation Program (DOELAP) and is currently accredited as a service laboratory to perform the following direct bioassays:

- Transuransium elements via L x-ray in lungs
- ^{241}Am in lungs
- ^{234}Th in lungs
- ^{235}U in lungs
- Fission and activation products in lungs including ^{54}Mn, ^{58}Co, ^{60}Co and ^{144}Ce
- Fission and activation products in total body including ^{134}Cs and ^{137}Cs

Under DOELAP, the in vivo bioassay program is subject to the performance and quality assurance requirements specified in *Department of Energy Laboratory Accreditation Program for Radiobioassay* (DOE-STD-1112-98) and *Performance Criteria for Radiobioassay* (ANSI-N13.30). A DOELAP testing cycle was completed in 2002 that included counting phantoms representative of each of the categories listed above.

To evaluate system performance, quality control data were routinely collected throughout the year in order to verify that the lung and whole body counting system was operating as it was at the time the system was calibrated. Quality control parameters that track both overall system performance and individual detector performance were measured. Quality control parameters tracked to evaluate individual detector performance, included:

- net peak area, peak centroid and peak resolution (FWHM) across the energy range of the spectrum,
- detector background

Quality control parameters tracked to assess overall system performance included:

- mean weighted activity of a standard source
- summed detector background

In addition, calibration verification counts were routinely performed using NIST-traceable standards and phantoms.

The Internal Dosimetry program also participated in an intercomparison study program for whole body counting administered by Oak Ridge National Laboratory (ORNL). Under this program bottle phantoms containing unknown amounts of ^{137}Cs, ^{60}Co, ^{57}Co, ^{88}Y and ^{133}Ba were sent to CEMRC, quarterly. The phantoms were counted on the lung and whole body counting system and the measured activities were reported back to ORNL and compared against the known activities. In 2002, the reported values were within –0.9% and +7.3% of the known ORNL values for all radionuclides.

Table 2. Participation in Environmental Measurements Laboratory Quality Assurance Program

Media	Radionuclide	[a]Percent Bias QAP-56	[b] Results QAP-56	Percent Bias QAP-57	Results QAP-57
Air Filter	^{241}Am	+4.2	Acceptable	[c]NR	
	^{60}Co	+1.8	Acceptable	NR	
	^{137}Cs	+4.1	Acceptable	NR	
	^{54}Mn	-0.1	Acceptable	NR	
	^{238}Pu	+6.2	Acceptable	NR	
	^{239,240}Pu	+4.1	Acceptable	NR	
	^{90}Sr	-11.8	Acceptable	NR	
	^{234}U	-0.5	Acceptable	NR	
	^{238}U	-2.0	Acceptable	NR	
Soil	^{228}Ac	-6.0	Acceptable	+1.7	Acceptable
	^{241}Am	+5.2	Acceptable	NR	
	^{212}Bi	-13.2	Acceptable	NR	
	^{214}Bi	-6.4	Acceptable	NR	
	^{137}Cs	-7.4	Acceptable	-0.4	Acceptable
	^{40}K	-15.1	Warning	-5.3	Acceptable
	^{212}Pb	-6.1	Acceptable	NR	
	^{214}Pb	-9.3	Acceptable	NR	
	^{238}Pu	+3.2	Acceptable	NR	
	^{239,240}Pu	+1.0	Acceptable	NR	
	^{90}Sr	-10.1	Acceptable	NR	
	^{234}U	-6.9	Acceptable	NR	
	^{238}U	-3.4	Acceptable	NR	
Vegetation	^{241}Am	+9.5	Acceptable	NR	
	^{244}Cm	-16.1	Acceptable	NR	
	^{60}Co	+6.0	Acceptable	NR	
	^{137}Cs	+3.0	Acceptable	+0.1	Acceptable
	^{40}K	+0.1	Acceptable	-2.2	Acceptable
	^{238}Pu	+7.2	Acceptable	NR	
	^{239,240}Pu	-0.9	Acceptable	NR	
	^{90}Sr	-4.5	Acceptable	NR	
Water	^{241}Am	+7.2	Acceptable	NR	
	^{60}Co	+1.3	Acceptable	-0.2	Acceptable
	^{134}Cs	NR		-2.8	Acceptable
	^{137}Cs	-1.5	Acceptable	+0.6	Acceptable
	Gross Alpha	-2.7	Acceptable	+11.9	Acceptable
	Gross Beta	-16.6	Acceptable	-5.4	Acceptable
	^{238}Pu	+6.0	Acceptable	NR	
	^{239,240}Pu	+3.9	Acceptable	NR	

Table continued on next page

Table 2. Participation in Environmental Measurements Laboratory Quality Assurance Program (cont.)

Media	Radionuclide	[a]Percent Bias QAP-56	[b] Results QAP-56	Percent Bias QAP-57	Results QAP-57
	^{90}Sr	-8.6	Acceptable	NR	
	^{234}U	-5.5	Acceptable	NR	
	^{238}U	-4.4	Acceptable	NR	

[a]Percent bias is calculated as the CEMRC measured value minus the EML known value, expressed as a percentage relative to the known value.
[b]Results for EML QAP "acceptable" are defined in Report EML-617, June 2002 for QAP-56 and in Report EML-618, December 2002 for QAP-57.
[c]NR = not reported, radionuclide was part of the program but not reported.

Table 3. Participation in NIST Radiochemistry Intercomparison Program

Media	Radionuclide	[a]Percent Bias	[b]Results
Soil 2001	^{241}Am	+3.1	[d]Traceable, 7%
	^{238}Pu	+1.8	Traceable, 6%
	$^{239,240}Pu$	+3.4	Traceable, 5%
	^{90}Sr	[c]NR	
	^{238}U	+2.9	Traceable, 16%
Air Filter 2002	^{241}Am	-0.9	Traceable, 5%
	^{238}Pu	-4.1	Traceable, 4%
	^{90}Sr	-26	Not Traceable
	^{230}Th	+3.0	Traceable, 5%
	^{238}U	-0.9	Traceable, 5%
Soil 2002	^{241}Am	+0.5	Traceable, 5%
	^{238}Pu	-3.0	Traceable, 4%
	^{90}Sr	-30	Not Traceable
	^{230}Th	-1.5	Traceable, 12%
	^{238}U	+13	Not Traceable
Water 2002	^{241}Am	-2.0	Traceable, 5%
	^{238}Pu	-1.7	Traceable, 7%
	^{90}Sr	-30	Not Traceable
	^{230}Th	-10	Not Traceable
	^{238}U	+1.1	Traceable, 3%

[a]Percent bias is calculated as the CEMRC measured value minus the NIST known value, expressed as a percentage relative to the known value.
[b]Results and traceability limit (expressed in percent) for NIST Traceablity are defined under ANSI 42.22.
[c]NR = not reported, radionuclide was part of the program but not reported.
[d]ANSI N42.22 defines the acceptance criteria for traceability to NIST for performance testing as:

$$\left|V_C - V_N\right| < \overbrace{3 \times \sqrt{\sigma_C{}^2 + \sigma_N{}^2}}^{\text{Traceability Limit}}$$

V_C = CEMRC Value.
V_N = NIST Value.
σ_C = 1 sigma total uncertainty of V_C.
σ_N= 1 sigma total uncertainty of V_N