THE WASTE ISOLATION PILOT PLANT: AN INTERNATIONAL CENTER OF EXCELLENCE

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ABSTRACT

The United States Department of Energy`s Carlsbad Field Office (CBFO) is responsible for the successful management of transuranic radioactive waste (TRUW) in the United States. TRUW is a long-lived radioactive waste/material (LLRM). CBFO`s responsibilities includes the operation of the Waste Isolation Pilot Plant (WIPP), which is a deep geologic repository for the safe disposal of U.S. defense-related TRUW and is located 42 kilometers (km) east of Carlsbad, New Mexico. WIPP is the only deep-geological disposal site for LLRM that is operating in the world today. CBFO also manages the National Transuranic Waste Program (NTP), which oversees TRU waste management from generation to disposal. As of February 2003, approximately 1500 shipments of waste have been safely transported to the WIPP, which has been operating since March 1999.

Surface and subsurface facilities designed to facilitate the safe handling and disposal of TRU waste are located within the WIPP site. The underground waste disposal area is in a bedded salt formation at a depth of 650 meters (m). Approximately 176,000 m^3 of TRU waste containing up to 17 kilograms of plutonium will be emplaced in disposal rooms 4 m high, 10 m wide, and 91 m long. Magnesium oxide (MgO) backfill will be emplaced with the waste to control the actinide solubility and mobility in the disposal areas. Properties of the repository horizon have been investigated in an underground test facility excavated north of the waste disposal area, and in which seals, rock mechanics, hydrology, and simulated waste emplacement tests were conducted. Thus, in some areas of broad international interest, the CBFO has developed a leading expertise through its 25-year WIPP repository and TRU waste characterization activities.

The CBFO's main programmatic responsibilities during the disposal phase are to operate a safe and efficient TRU waste repository at the WIPP, to operate an effective system for management of TRU waste from generation to disposal, and to comply with applicable laws, regulations, and permits. This responsibility requires maintenance and upgrades to the current technologies for TRU waste operations, monitoring, and transportation. This responsibility also requires the maintenance of scientific capabilities for evaluating the performance of the WIPP repository. Every 5 years, WIPP must be recertified for operations by the regulator, the EPA. Currently, the CBFO is preparing for the 2004 recertification.

The CBFO/WIPP has been designated by the International Atomic Energy Agency (IAEA) as an International Center of Excellence. The IAEA is working with CBFO, other designated centers of excellence, and other member states in the IAEA to foster collaborative training activities and experiments in order to address major radioactive waste disposal issues. As the only operating deep

radioactive waste repository in the world today, CBFO/WIPP is an important participant in this IAEA initiative. In addition to participating in relevant and beneficial experiments, the CBFO is providing the international community convenient access to information by sponsoring and hosting symposia and workshops on relevant topics and by participation in international waste management organizations and topical meetings.

The CBFO has agreed to exchange scientific information with eight foreign radioactive waste management organizations, and other national radioactive waste management and disposal organizations have expressed interest in similar agreements. These activities result in the cost-effective acquisition of scientific information in support of increased WIPP facility operational and post-closure assurance and reliability. It also demonstrates the CBFO's intent and resolve to honor international commitments and obligations.

INTRODUCTION

The CBFO is responsible for operating the WIPP site, which hosts a deep geologic repository for safe disposal of U.S. defense-related TRU waste and is located 42 kilometers (km) east of Carlsbad, New Mexico. WIPP is the only deep-geological disposal site for LLRM that is operating in the world today. CBFO also manages the NTP, which oversees TRU waste management from generation to disposal. The WIPP has operated for four years since March 1999.

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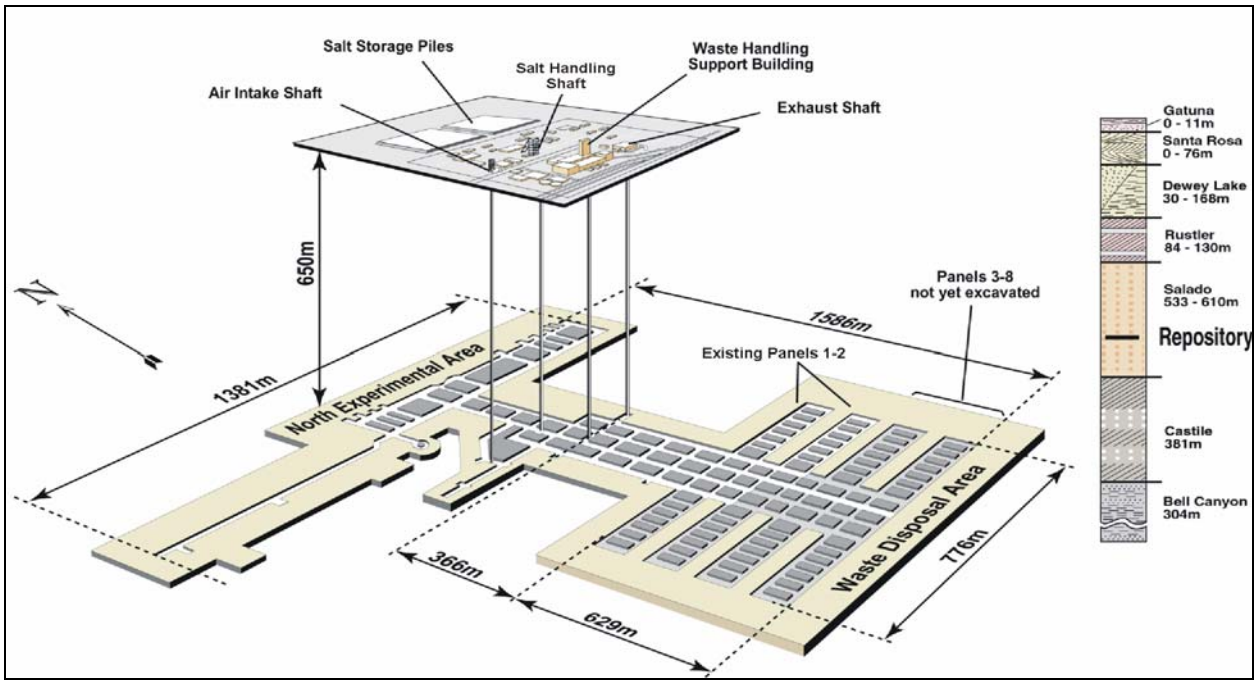

Figure 1. Schematic illustration of the WIPP repository and the geologic stratigraphy at the site.

Surface and subsurface facilities designed to facilitate the safe handling and disposal of TRU waste are located within the WIPP site's 42-km^2 set-aside area (Figure 1). The disposal area is in a bedded salt formation at a depth of 650 meters (m). Approximately 176,000 m^3 of TRU waste containing between 12-17 kilograms of plutonium will be emplaced in disposal rooms 4 m high, 10 m wide, and 91 m long. Properties of the repository horizon have been investigated in an underground test facility excavated north of the waste disposal area, in which seals, rock mechanics, hydrology, and simulated waste emplacement tests were conducted. Geologic and hydrologic characterizations of strata on the site have been conducted by surface-based boreholes and observations from the existing excavation.

THE DISPOSAL SITE AND SYSTEM

The WIPP Land Withdrawal Act of 1992, and amended in 1996, sets aside a 6.4 by 6.4-km surface area in the southeastern portion of New Mexico for the development, operation, and closure of a deep geological repository for long-lived TRU waste. In a separate agreement with the State of New Mexico, the DOE has agreed to limit the depth of the disposal system to 1,828-m and the amount of remote-handled (RH) TRU waste to 7,080 m^3. As illustrated in Fig. 2, both the WIPP underground research laboratory (URL) and repository are situated approximately 650 m below the ground surface in a 600-m-thick, 250-million-year-old, undisturbed, virtually impermeable, bedded salt formation. Compliance with applicable regulations/criteria is measured at the perimeter of the 42 km^2 WIPP Disposal System block.

All TRU waste received at WIPP must be in solid form. However, the TRU waste containers may contain up to one percent, by volume, of free liquid. Furthermore, approximately 60 percent of the existing 106,000 m^3 of TRUW is mixed with regulated hazardous constituents. In order for the CBFO to dispose of this mixed TRU waste at WIPP, it had to obtain a hazardous-waste disposal permit from

the New Mexico Environment Department (NMED). The NMED issued the hazardous-waste disposal permit for the WIPP repository on October 27, 1999. By November 2002, approximately 1370 shipments of non-mixed and mixed contact-handled (CH) TRU waste had been received and safely disposed at the WIPP site.

As shown in Fig. 1, the baseline repository layout/design comprises eight separate panels. Each panel hosts seven disposal rooms. The shortest lateral distance between the repository perimeter and the WIPP Disposal System block boundary (accessible environment) is 2.4 km. Due to the creep nature of the salt, the facility is being mined in stages. Panels 1 and 2 have been mined and utilized at the present time.

The current disposal system involves stacking CH-TRU waste containers or CH-TRU waste standard-waste boxes (SWBs) in the disposal rooms and placing the RH-TRU waste containers in cased, horizontal holes in the walls between the disposal rooms. Bags containing granulated magnesium oxide (MgO) backfill are attached to the CH-TRUW waste containers and SWBs. The main purpose of the MgO backfill is to maintain stable chemical conditions to minimize actinide solubility in the disposal room during the 10,000-year regulatory period. According to the analyses conducted for WIPP, actinide solubility is the key to the safe long-term performance of the WIPP repository because all CH-TRU waste (more than 95 percent of the total TRU waste volume) is contained in short-lived containers. The MgO will also absorb brine and thereby reduce the amount of liquid available for radionuclide transport.

At the beginning of the project, the CBFO had planned to remove all TRU waste from 17 of the 23 sites by the year 2006 and to remove the TRU waste from the remaining six sites by the year 2034. This schedule was based on information on TRU waste for each site, and the availability of an effective and efficient waste-characterization and transportation system that would facilitate up to 17 CH-TRUW shipments per week. However, CH-TRU waste shipments have exceeded this shipment level. As many as 25 shipments per week was achieved, and the eventual goal is 34 shipments per week. Thus, it is felt that the accelerated schedule will enable the cleanup to occur earlier than originally planned. The CBFO continues to pursue all responsible means to (a) modify and/or void some of the permit conditions considered to be unnecessarily burdensome or risky, based on the related safety impacts, and (b) enhance existing waste-characterization and shipment capabilities, also referred to as “filling the pipeline to WIPP”.

THE SITE GEOLOGY

The WIPP site (Fig. 1) is located on an arid, generally flat, plain covered with sand, caliche, and desert bushes in the northern portion of the Delaware Basin. The stratigraphic column at the WIPP site comprises about 4,575 m of Paleozoic sedimentary rocks on top of the Precambrian basement. The formations of interest with respect to the WIPP repository, from the youngest/shallowest to the oldest/deepest, are (Fig. 2):

- The Pleistocene Gatuna Formation;
- The Upper Triassic Santa Rosa Sandstone Formation;
- The Dewey Lake, Rustler, Salado, and Castile formations of the Permian Ochoan Series; and
- The Bell Canyon Formation of the Permian Delaware Mountain Group.

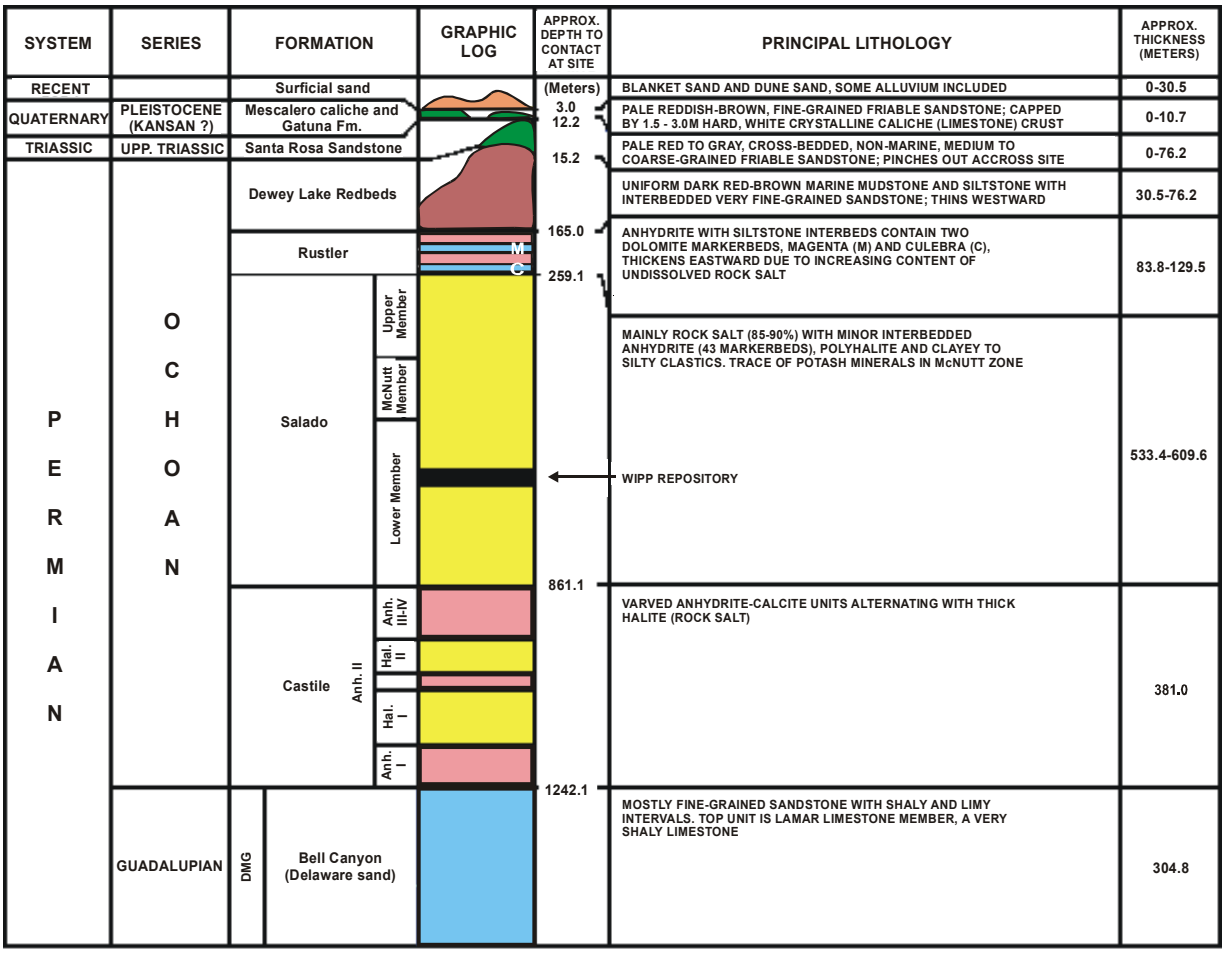

Fig. 2. Generalized stratigraphy at the WIPP site.

The Rustler Formation contains the most important geohydrologic units in the region. The thickness of the Rustler Formation varies between 84 m to 130 m in the northern Delaware Basin and is approximately 95 m thick at the WIPP site. It contains three recognized fluid-bearing zones: the Rustler-Salado Contact Residuum, the Culebra Dolomite, and the Magenta Dolomite (shallowest). Of the three Rustler units, the Magenta Dolomite and the Culebra Dolomite extend across the WIPP site, whereas the Rustler-Salado Contact Residuum mainly produces water west of the WIPP site. Available field data indicate that the transmissivity of the Culebra Dolomite is the highest, followed by the Magenta Dolomite, and the Rustler-Salado Contact Residuum. Results of several single- and multiple-hole flow tests at the site indicate that the transmissivities of the Culebra Formation at and near the WIPP site range between 10^{-3} meter square per second (m^2/s) in the Nash Draw to 10^{-8} m^2/s east of the WIPP site. Generally, the transmissivity increases from east to west across the WIPP site. The highest transmissivity zones occur in the southeastern, north-central, and northwestern portions of the WIPP site.

The chemical composition of the Culebra Formation groundwater varies widely within short distances at and near the WIPP site. The total dissolved solids (TDS) concentration is lowest in the Magenta Dolomite and highest in the Rustler-Salado Contact Residuum. Nearly all the water in the Rustler Formation at the WIPP site has TDS concentrations greater than 10,000 milligrams per liter (mg/l). Five-km south of the WIPP site, the Culebra Formation water typically contains 3,000 mg/l of TDS. At

the site itself, the TDS content varies from 12,500 mg/l to 139,500 mg/l. Extreme variation in the chemistry of the Culebra Formation water within short distances is illustrated by TDS concentrations of 12,500 mg/l, 153,500 mg/l, and 118,000 mg/l within a distance of 3 km.

The underground research laboratory (URL), the North Experimental Facility (NEF), and the repository shown in Fig. 1 are situated approximately 650-m below the ground surface in the lower half of the Salado Formation. This formation underlies the Rustler Formation and overlies the Castile Formation. The Salado Formation is approximately 600-m thick and consists primarily of halite with a zone of potassium- and magnesium-bearing minerals (sylvite, langbeinite) and thin (<1 m) seams of clay, anhydrite, and polyhalite. Before 1986, thick salt beds were considered essentially dry and impermeable. However, observations from the WIPP excavations show that local seeps occur, which indicates that the salt beds may be saturated with brine and may exhibit Darcian flow, albeit at very low permeability.

INTERNATIONAL COOPERATION

Based on 25-years of WIPP repository and TRU waste characterization activities and four years of operating a deep-geological disposal site, the CBFO has developed a leading expertise in radioactive waste management issues. The CBFO is providing the international community convenient access to this information by sponsoring and hosting symposia and workshops on relevant topics and by participation in international waste management organizations and topical meetings.

The three main CBFO International Program objectives are:

1. The timely and cost-effective acquisition of data and information enhancing the assurance and confidence in the CBFO's safe operation, closure, and decommissioning of the WIPP site;
2. The timely and cost-effective sharing of WIPP data and information with other similar programs; and
3. Vigorous, timely, and cost-effective international outreach promoting (a) Carlsbad/WIPP-based multi-national collaborations and partnerships, and (b) the recognition of the CBFO as an international leader, peer, broker, source, and resource in radioactive waste management and disposal.

The CBFO has agreed to exchange scientific information with eight foreign radioactive waste management organizations, and other national radioactive waste management and disposal organizations have expressed interest in similar agreements for technical exchanges with the CBFO. These activities result in the cost-effective acquisition of scientific information in support of increased WIPP facility operational and post-closure assurance and reliability. It also demonstrates the CBFO's intent to honor international commitments and obligations.

The CBFO believes that it is important to maintain current commitments while pursuing new opportunities for collaborations with or under the umbrella of international radioactive waste management organizations. International organizations deemed to be of particular interest to the successful accomplishment of the CBFO mission are the following:

a. Commission for European Communities (CEC),
b. International Atomic Energy Agency (IAEA), and

c. Organization for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA).

Collaborations with these organizations will provide both access to state-of-the-art information and enhance recognition of the CBFO as a leading international radioactive waste management program. CBFO is participating in two CEC projects: (1) the Cluster Repository Project (CROP), which has the mission of developing an international guidance document for the development, design, construction and implementation of deep geological disposal sites and underground research laboratories; and (2) Backfilling and Sealing of Underground Repositories for Radioactive Waste in Salt, Phase II (BAMBUS II). The BAMBUS II is investigating the behavior of the backfill and the disturbed rock zone in a geological repository in rock salt.

The CBFO is also integrally involved in the IAEA`s Network of Centers of Excellence program. The purpose of the Network is to foster cooperative projects in underground research facilities (URFs) and associated facilities. Eight facilities have been designated as part of the Network. They are the surface laboratories at the University of Wales and Lawrence Berkeley Laboratory, and the underground facilities at the underground research laboratory in Canada, the Mol facility in Belgium, Mont Terri in Switzerland, Grimsel Test Site in Switzerland, Yucca Mountain site in Nevada, and WIPP. This is a significant milestone and tremendous achievement for CBFO and WIPP. Increased global recognition is resulting for CBFO from its designation as an International Center of Excellence. As the only deep-geological disposal site for long-lived radioactive waste that is operating in the world today, WIPP`s designation by IAEA as an International Center of Excellence will facilitate cooperative projects. Countries with advanced waste management programs but without an URF and countries with less developed programs and also without an URF will be participants in the activity. The Network has the objective of fostering cooperative projects regarding training in and demonstration of waste disposal technologies in underground research facilities (URFs). The Network will be an effective vehicle to foster collaboration at CBFO. In the immediate future, there will be more focus on training than demonstration projects. For developed programs, both training assignments and joint projects, either under development or planned, will be pursued. We will work with other organizations to develop an accelerated long-term performance demonstration test at WIPP.

A new and important concept is the Salt Club. The CBFO worked closely with German waste management organizations and the NEA to have the NEA establish a Forum for the Development of Repositories in Rock Salt, or Salt Club, similar to the NEA`s Clay Club. The purpose of the new group will be (1) the timely and cost-effective exchange of information on the attributes of rock salt as the host rock for deep geological repositories (and underground research laboratories [URLs]) for long-lived radioactive waste, and (2) the establishment of a international dialogue on rock salt, including the distribution of information to national and international radioactive waste management organizations and institutions. Participants will include waste management nations with adequate rock salt deposits for safe disposal of long-lived radioactive waste as well as any other national and international organizations expressing interest in obtaining/ receiving the information. Membership in the "Salt Club" will be open to representatives from any international or national organization interested in staying abreast on the latest R&D and near-term plans for deep geological disposal of long-lived wastes in rock salt. The “Salt Club” is now beginning its initial work. Other collaborations with NEA have included CBFO membership in the OECD/NEA’s Radioactive Waste Management Committee (RWMC), the Integrated Group for the Safety Case (IGSC), and the Forum on Stakeholder Confidence (FSC).

The CBFO is also hosting scholarships/internships allowing students and scientists to work for a limited time on one or more of the CBFO’s domestic R&D initiatives/activities. These scholarships/internships

will foster greater understanding of the CBFO's mission and capabilities and aid in the sharing of relevant data. The first two examples in this activity occurred in 2002, during which a German graduate student and a Hungarian scientist, under a scholarship from the Fulbright Foundation, were stationed at CBFO to learn more about the successes from the only currently operating deep-geological disposal site for long-lived radioactive waste in the world today.

USA-based collaborations and partnerships with foreign radioactive waste management organizations have included hydrological and chemical laboratory tests, analyses, and modeling, which are principally conducted in Albuquerque, New Mexico, by SNL. A primary goal of future USA-based collaborations and partnerships is, whenever possible, to focus new activities in Carlsbad or at the WIPP site. Four main conditions encumbering increased Carlsbad/WIPP-based activities are:

1. The limited number of nations currently pursuing rock salt as a primary geologic medium for deep geological disposal of long-lived radioactive waste;
2. The limited global knowledge about the experience/knowledge vested in the WIPP-project participants;
3. The limited global knowledge about the CBFO's pending activities; and
4. The limited availability of resources, equipment, and facilities to conduct state-of-the-art earth sciences experiments in Carlsbad and at the WIPP site.

Crystalline rocks are currently the main geological media considered by other national programs for deep geological disposal of long-lived wastes. Another geological medium gaining international interest is clay. However, among the approximately 41 nations with radioactive waste management programs, 22 of these nations may have adequate rock salt formations for a geological repository. There clearly is an abundance of rock salt in many of the nations currently considering and/or actively pursuing deep geological repository programs. Consequently, increased participation in Carlsbad/WIPP-based collaborations could lead to a better understanding of the long-term containment and isolation characteristics of rock salt. In addition, it is important that:

- The CBFO's scientific and operational programs are better understood and appreciated throughout the world; and
- The resources, equipment, and facilities in Carlsbad and at the WIPP site are expanded.

An important step in addressing these challenges has been the development of a concise document outlining the CBFO's future plans, including the resources, equipment, and facilities available in Carlsbad and at the WIPP site. This document is called the "Prospectus on Waste Management and Repository Development Collaborations with the U. S. Department of Energy Carlsbad Field Office". The Prospectus discusses future CBFO activities of potential interest to the international radioactive waste management community. The Prospectus contains concise information on the type, schedule and expected outcomes of the tests, model developments, and safety/performance assessment activities planned by the CBFO to support the recertification of WIPP. It also contains information on planned experiments designed to reduce (a) the conservatism in the current baseline design and (b) construction and operational complexities. The Prospectus has been distributed to radioactive waste management organizations in nations with potentially adequate rock salt deposits, ongoing repository siting efforts, and/or ongoing radioactive waste R&D programs. This document will serve to enhance the CBFO as a leading global source and resource for radioactive waste management and disposal services.

A logical element of collaborations consists of topical meetings and/or workshops. Past topical meetings and workshops have been very conducive to focused and in-depth information exchanges and to the

fostering of lines of communication for future technical exchanges and cooperation. They have also expanded the CBFO's visibility and international network of contacts, and enhanced the CBFO's credibility and standing in the international radioactive waste management community.

The CBFO will continue to sponsor, either singularly or jointly with other organizations, topical meetings/workshops. Whenever appropriate and concurred by the co-sponsor, organizations from other countries will be invited. This initiative/activity and approach will allow CBFO to share its state-of-the-art knowledge with other organizations as well as obtain current information on issues faced by other radioactive waste management organizations and which are of interest to CBFO. The logical evolution of such topical meetings/workshops is the development of joint research activities. In 2001, CBFO sponsored a workshop with 12 waste management organizations from Germany and a workshop with SKB of Sweden, which is the lead waste management organization in Sweden. The German workshop covered six technical areas from flow and transport to sealing and closure systems. It was decided at the workshop that additional cooperative activities would be undertaken between CBFO and the German waste management organizations. The workshop with SKB covered site selection and site investigation. It was also agreed that specific areas of joint research would be performed in the future, and continued discussions are planned. In February 2003, three very important international meetings/workshops are being co-hosted by CBFO and taking place in Carlsbad. The International Association for Safe Environmental Disposal of Radioactive Material (EDRAM) is holding a workshop on repository siting. Waste management organizations from the United States, Germany, France, Sweden, Finland, Belgium, Switzerland, Canada, UK, Japan, and Spain will be represented at the EDRAM workshop. Also in February 2003, CBFO is co-hosting with CROP, in conjunction with the CEC, bi-annual meetings of the CROP and BAMBUS II. As noted earlier, the CROP has the mission of developing an international guidance document for the development, design, construction and implementation of deep geological disposal sites and underground research laboratories; and BAMBUS II is investigating the behavior of the backfill and the disturbed rock zone in a geological repository in rock salt.

The CBFO is engaged in eight foreign-based collaborations and partnerships with mature radioactive waste management organizations in Canada, Germany, Japan, Spain, Sweden, and Switzerland. These collaborations and partnerships are based on the CBFO's monitoring and evaluation of foreign-based radioactive waste management programs and are projected to continue to add value to the International Programs. In particular, the CBFO is currently increasing collaborations with waste management organizations in Germany.

SUMMARY AND CONCLUSIONS

The mission, vision, objectives, goals, strategies, approaches, initiatives, and activities described above comprise the framework for how the CBFO will pursue international collaborations and partnerships. The vigorous implementation of the initiatives and activities defined in this paper will maintain and enhance the DOE's, the CBFO's, and the WIPP project's visibility and credibility in the international radioactive waste management community. It will also provide cost-effective access to state-of-the-art data supporting the recertification of WIPP.

FURTHER READING ON WIPP

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