Progress In Long-Lived Radioactive Waste Management And Disposal At The Waste Isolation Pilot Plant

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ABSTRACT

Approximately 250 million years ago, the area around present-day Carlsbad, New Mexico, United States of America (USA), was a barren salt bed. Dinosaurs had not yet roamed the Earth, and the early humans were in the distant future. Once covered by the Permian Sea, the area underwent cycles of inundation and evaporation, leaving behind a salt bed exceeding 600 meters (m) in thickness, now known as the Salado Formation. Today, the Salado Formation is buried more than 350 m beneath the sands and cacti of the Chihuahuan Desert and hosts the Waste Isolation Pilot Plant (WIPP) deep geological repository at a depth of approximately 650 m (Fig. 1).

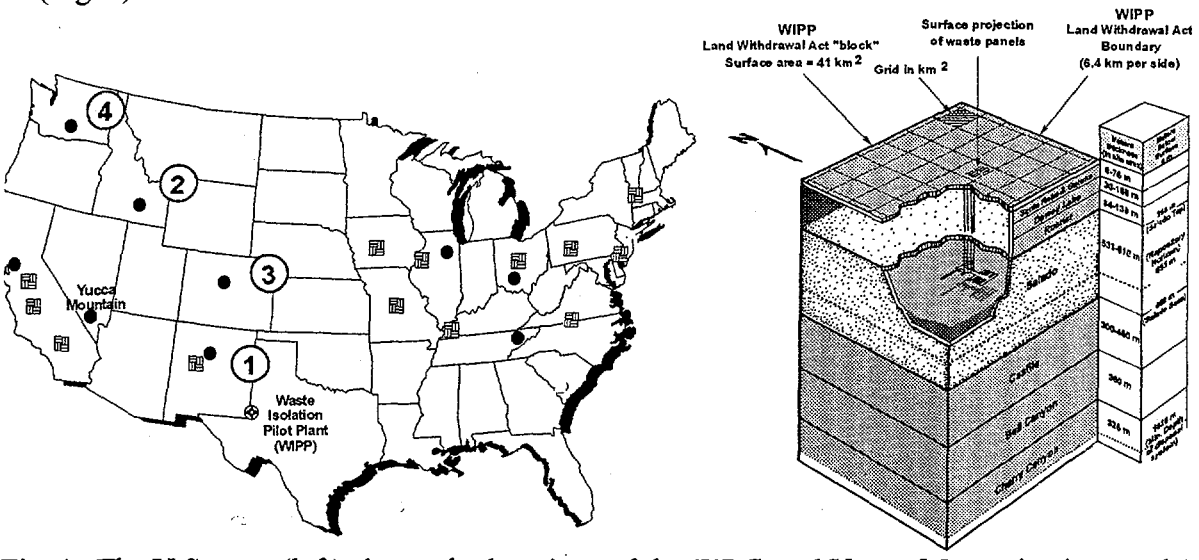

Fig. 1. The U.S. map (left) shows the locations of the WIPP and Yucca Mountain sites, and 10 large-quantity (circles) and 13 small-quantity (squares) TRUW generator and storage sites (sites numbered 1-4 have shipped TRUW to WIPP). The schematic WIPP Land Withdrawal Act (geosphere) block (right) shows the 41.6 square kilometer (km^2), 1,828-m deep, "controlled area" at the WIPP site.

The WIPP opened on 26 March 1999. It is managed and operated by the U.S. Department of Energy (DOE) Carlsbad Field Office (CBFO). At the end of year 2000, WIPP had received 128 shipments of long-lived, defense-related transuranic radioactive waste (TRUW)[(a)]. When filled to its current statutory capacity, WIPP will safely contain and isolate up to 175,584 cubic meters (m^3) of post-1970, defense-related TRUW, including approximately 12 metric tons of plutonium and canisters with surface dose rates of up to 10 sieverts per hour.

(a) TRUW destined for WIPP must contain at least 3,700 becquerels (Bq) of alpha-emitting, transuranic (atomic weight/number greater than ^{92}uranium) isotopes with half-lives greater than 20 years, per gram of waste, but the canister surface dose rate may not exceed 10 sieverts per hour (Sv/h). There are two categories of TRUW: contact handled (CH) that may have a maximum canister surface dose rate of 0.002 Sv/h and remote handled (RH) that may have a canister surface dose rate between 0.002 Sv/h and 10 Sv/h.

WIPP relies on the natural barriers and the shaft seals for post-closure radionuclide containment and isolation. Two different regulators have verified the operational and post-closure safety of WIPP: the U.S. Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED).

The post-closure safety of WIPP is very high. Based on the assumptions that the WIPP repository is (a) filled to its statutory capacity with TRUW and (b) not breached by any inadvertent human intrusion, the projected post-closure radiation exposure to the general public is 32 times lower than the applicable regulatory limit and 768 times lower than the average natural background radiation in the USA. If the filled WIPP repository is breached by multiple, post-closure human intrusions, the conservative projected quantity of radionuclides released outside of the "controlled area" (Fig. 1) is at least 10 times lower, and realistically more than 30 times lower, than the applicable, very stringent regulatory limits. Actually, the applicable federal regulations pertain to the safe management and deep geological disposal of spent nuclear fuel, TRUW, and high-level radioactive wastes (HLW). In fact, the initial 10 years of site characterization included large-scale, *in-situ* tests designed to establish whether the WIPP site could accommodate one TRUW and one HLW repository. The preliminary test results suggested that the Salado Formation could accommodate a TRUW repository at a depth of 650 m and a HLW repository at a depth of 820 m in the Infra-Cowden unit.

The WIPP repository siting, design, construction, certification, and permitting process was not easy (faced and overcame many legal challenges), quick (took 28 years), or cheap (the cost was approximately 2 billion U.S. dollars at opening). The process endured extensive public, interest group, and regulatory oversights. It faced and overcame institutional politics and distant opposition, but also achieved strong local support and favorable domestic and international peer reviews so that when all was said and done, WIPP became the world's first operating deep geological repository for safe disposal of long-lived radionuclides, thereby effectively demonstrating that long-lived radionuclides can be safely disposed.

The WIPP development and certification process serves, and will continue to serve, as a model for citizen involvement, while satisfying all scientific and regulatory requirements, and establishing a facility that has earned several awards for safe operation. The lessons learned during this process will be implemented and enhanced during the 35-year-operation of WIPP. WIPP currently faces the following main challenges:

- Waste characterization, transportation capacity, and efficacy constraints which could be mitigated, at least partially, by resource reallocations; and
- EPA recertification of WIPP at least every fifth year that will be accomplished by focused scientific and engineering programs, including foreign programs' participation.

As follows, other radioactive waste management organizations and institutions may also benefit from past and future lessons learned, available expertise, facilities, and infrastructure during the continued operation of WIPP through strategic partnerships and collaborations with the CBFO. To that end, the CBFO has prepared a Prospectus summarizing past, current, and future CBFO research and development (R&D) activities. To date, the CBFO has established strategic partnerships with eight radioactive waste management organizations in six countries, and is negotiating similar relationships with four more national organizations in four additional countries. The CBFO is also actively involved in joint international R&D at three foreign underground research laboratories (URLs), is supporting the European Union-sponsored

"Cluster Repository Project" and "Backfill and Material Behaviour in Underground Salt Repositories, Phase II", and has offered the WIPP URL to the International Atomic Energy Agency for international repository demonstrations. The main benefits to the CBFO to date from these activities are:

- Maintaining cutting-edge awareness about and cost-effective access to R&D in other countries;
- Improving the ability to explain and justify differences in concepts, models, and data obtained and/or used by others, relative to those espoused by the CBFO; and
- Sharing the immense credibility of being a globally recognized and accepted radioactive waste management organization, project, and resource.

Since the WIPP repository is at least 10 years ahead of any other repository development for long-lived radioactive waste, other radioactive waste management organizations and institutions could benefit both scientifically and politically from sharing the lessons learned at WIPP. Benefits would include using existing expertise and facilities to cost-effectively address and solve program-specific issues and to train staff. The characteristics of the WIPP repository and infrastructure make it uniquely suited for underground research, since it provides ready access to the underground, with ventilation, power, extensive data communications, safety oversight, surface support, emergency services and security all in place. More experiments can be conducted at WIPP for the net research dollar than at other typical choices open to the underground research community, including another set of full-scale removability/retrievability/reversibility/recoverability tests. Such research, which can and will be conducted without compromising the primary disposal mission of WIPP and the priority on safety, will achieve tremendous benefit from the DOE's significant financial and intellectual investment in the WIPP.