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UNDERGROUND PREPARATION FOR WASTE RECEIPT AT THE WASTE ISOLATION PILOT PLANT

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ABSTRACT

Initial disposal of transuranic waste (TRUW or TRU waste) at the Waste Isolation Pilot Plant (WIPP) will take place in rooms that were excavated in bedded salt between 1986 and 1988. Because of various project delays and the creep of the salt, the rooms have deformed sufficiently to impact operating clearances. Creep closure is the mechanism by which the waste will be encapsulated and isolated. In anticipation of waste receipt in June 1998, the first waste disposal room was renovated by removing about 2 ½ feet of salt from the floor and installing a new generation of roof support. The room was then carefully assessed geotechnically and authorized for waste disposal operations.

This work was timed to maximize the benefits and was closely planned and controlled by WIPP Mine Engineering, Geotechnical Engineering, and Underground Operations staff working as a team. The work was completed to exceptionally high standards, with no injuries or accidents to personnel or equipment. The rock mass around the room responded in the anticipated manner. A successful demonstration of waste disposal operations was completed as part of the Operational Readiness Review. The first room is now ready for disposal operations once legal and regulatory challenges are overcome.

INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is located in southeastern New Mexico, about forty kilometers southeast of Carlsbad. The WIPP is intended to receive, handle, and permanently dispose of transuranic waste. The U. S. Department of Energy (DOE) has constructed a full scale facility to demonstrate both technical and operational principles of the permanent isolation of TRU waste.

The underground facility consists of (1) the main shaft area and associated access drifts; (2) a waste emplacement area to the south of the main shaft area that consists of eight panels of seven rooms each to be used for the disposal of TRU waste (only Panel 1 is presently excavated); and (3) an experimental area (now decommissioned) for nonradioactive experiments developed to the north of the main shaft area. A schematic view of the underground facilities at the WIPP site is shown in Figure 1.

GEOLOGY AND STRATIGRAPHY

The underground facility at the WIPP is located 655 meters (m) (2,150 feet [ft.]) below the surface, about 200 m (610 ft.) above the bottom of the 600 m (2,000 ft.) thick bedded salt of the Permian Salado Formation of southeast New Mexico. The facility horizon lies within an evaporite sequence consisting of halite, argillaceous halite, and polyhalite (Figure 2).

Observations indicate that these beds are laterally continuous. A persistent 50 to 80 centimeter (cm) (1 ½ to 2 3/4 ft.) thick bed of anhydrite and polyhalite, identified as Marker Bed

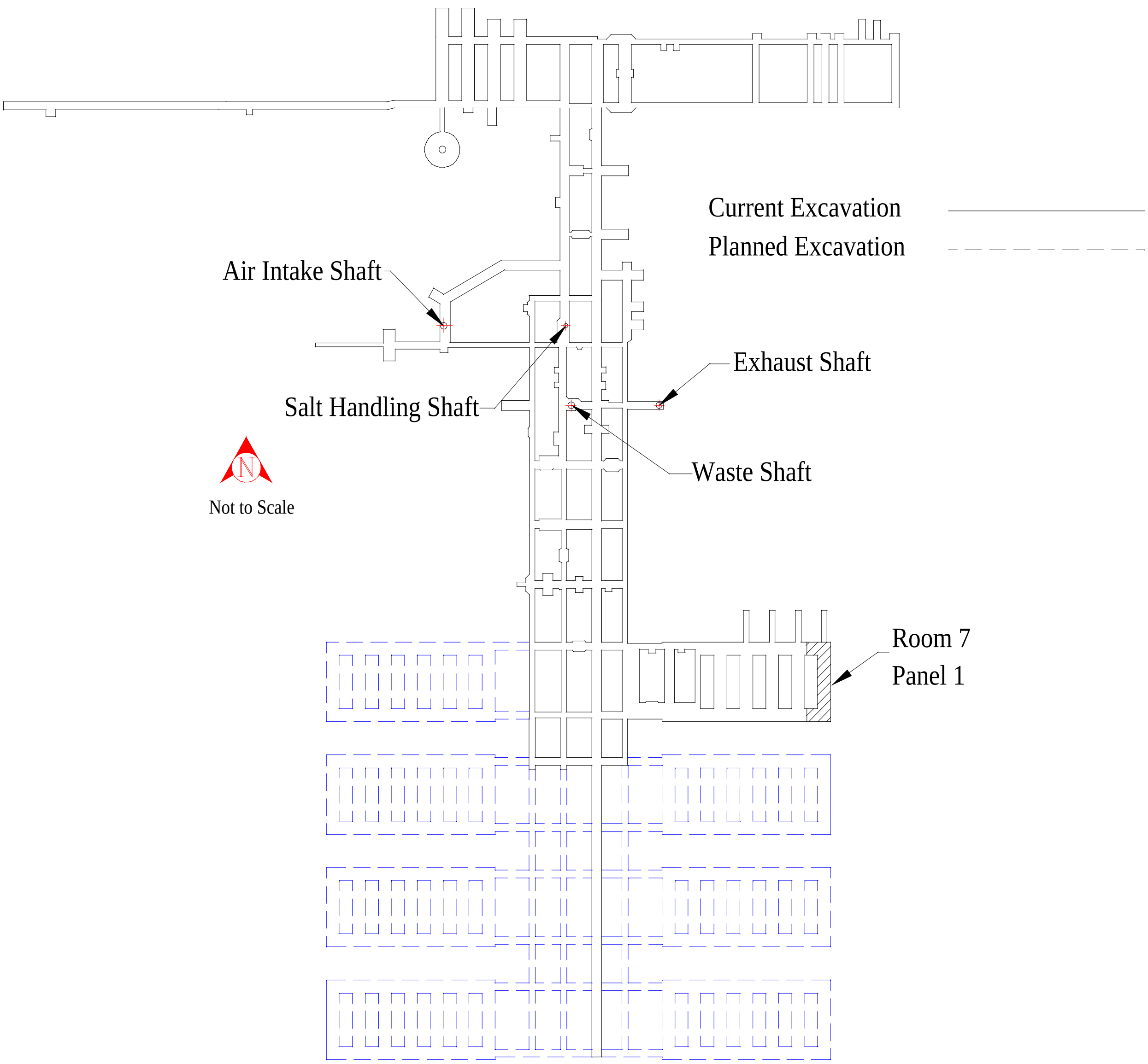


Fig. 1. Plan View of theWIPP Underground Facility

139 (MB139), lies about 1.5 m (5 ft.) below the repository floor. Laterial variability in composition and thickness within this anhydrite bed exists at both the site and the regional scale.

Undulations of up to 15 cm (½ ft.) in the surface of MB139 have been observed in cores taken from the facility horizon. The bottom of MB139 is subhorizontal and underlain by clay E. Anhydrite "b," 5.5 cm (2 1/6 inches) thick, is about 2.0 m (7 ft.) above the roof and underlain by clay G. Clays E and G are less than 2.5 cm (1 inch) thick. A diffused clay, clay F, is exposed in the ribs just below the roof.

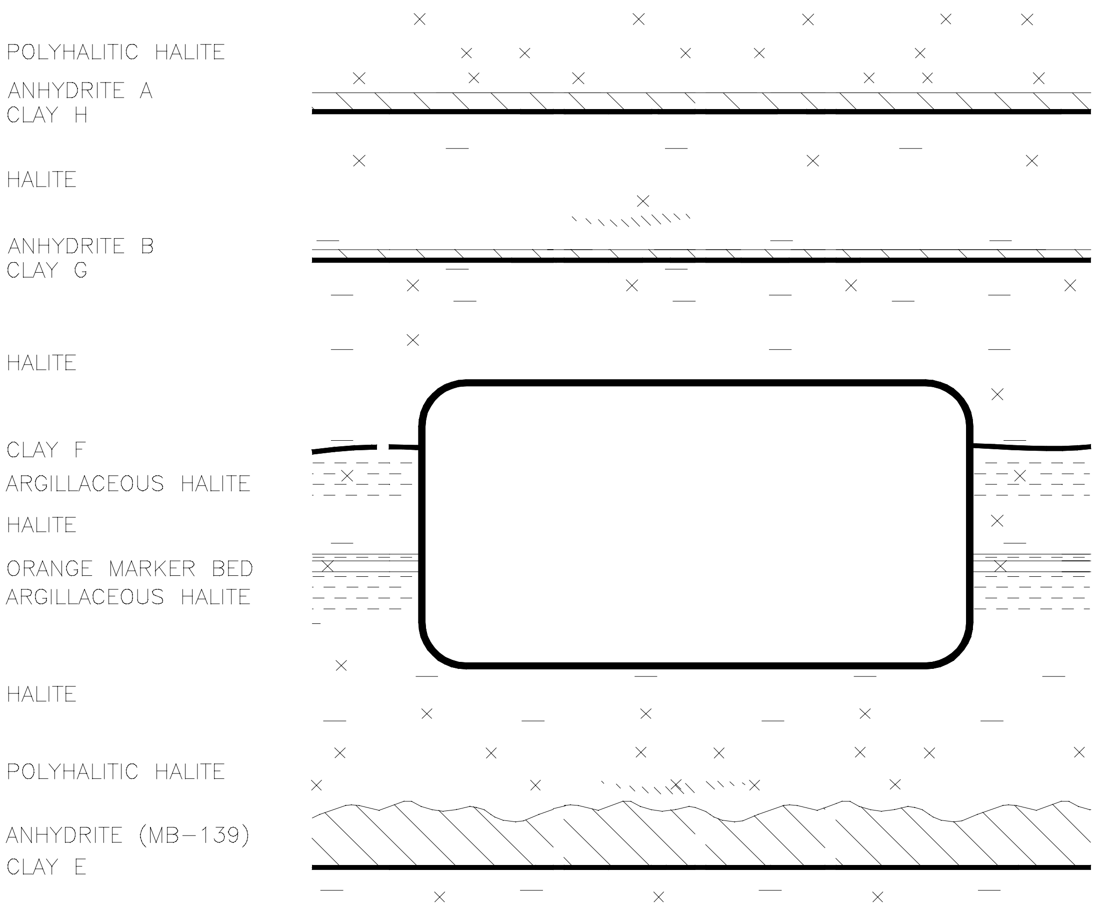


Fig. 2. Typical Geologic Cross-section.

In rock salt, the excavation responds initially by elastic deformation due to stress redistribution, and subsequently by inelastic, time-dependent deformation due to deviatoric stresses. As a result of this time-dependent (rheologic) behavior, which is called creep, the surrounding rock mass tends to slowly move into the opening.

Four major clay seams (E, G, H, and I) are located near the repository horizon. In situ observations show that the clay seams contain moisture. These clay seams are usually less than 2.5 cm (1 inch) thick. Their mechanical properties are drastically different from the surrounding salt. Clay seams have negligible tensile strength and very low shear strength compared to the surrounding rock salt. Therefore, they constitute planes of weakness along which shearing and separation can easily take place. They also strongly influence the magnitude and orientation of the stress distribution around the openings. Compared to the surrounding rock salt, MB139 is a stiff brittle layer. As the salt mass moves towards the opening, stress concentrations develop in MB 139. When these stresses reach a critical level, fractures develop in the marker bed, propagate through the floor salt layer, and eventually may extend to the floor of the room resulting in floor heave.

PANEL 1 UTILIZATION

In 1994, the Panel 1 Utilization Plan was prepared and issued (WIPP/WID-94-2027, Waste Isolation Division, Carlsbad, New Mexico.). This document was reviewed and reassessed in 1996, when it was concluded that the 1994 Plan was still valid and sufficiently flexible and comprehensive to allow use of all or part of Panel 1. Further regular assessments have not brought forward any convincing arguments to prevent Panel 1 from being used for waste emplacement. The concern for, and challenge of, utilizing Panel 1 for waste disposal relate to its age and the uncertainties of when waste disposal will commence and at which rate it will proceed. Since the potential for problems increases with time, it is critical to be able to identify potential problems and to ensure the safe conduct of waste disposal operations. The first is accomplished by a carefully planned geomechanical monitoring program, and the second by an intense, focused ground control program.

Excavation of the waste disposal area began in May 1986 with the mining of entries to Panel 1. The original design for the waste disposal rooms at the WIPP provided a limited period of time during which to mine the openings and to emplace waste. Each panel, consisting of seven disposal rooms, was scheduled to be mined and filled in fewer than 5 years. Panel 1 was developed to receive waste for a demonstration phase that was scheduled to start in October 1988. The demonstration phase was deferred, and the experimental test program was modified to use contact-handled (CH) transuranic waste in bin-scale tests, planned for Room 1, Panel 1. In late 1993, the planned bin-scale test program was relocated off-site, with a new anticipated date for waste receipt in 1998.

With the off-site relocation of the bin-scale test program, a WIPP Disposal Decision Plan (DDP) was formulated by the DOE Carlsbad Area Office (CAO). In accordance with the DDP, waste receipt was scheduled for June 1998. Room 7 was renovated in preparation for that date.

The WIPP had to demonstrate that it has the trained personnel and proper equipment to safely conduct waste emplacement operations. Panel 1 is a waste disposal panel that meets all criteria for the performance of readiness activities. In support of the readiness demonstration, a number of systems development and training activities had to take place. Panel 1 was used for this testing and training because it provides realistic operating conditions. Panel 1 was readily available and met the configuration control requirements.

The engineering approach used in the WIPP underground control program uses the experience gained from observation and analysis of in situ salt behavior. An expert review panel assembled for the review of Panel 1 agreed in 1991 that the engineered monitoring system provides adequate warning of ground stability problems before they pose an imminent hazard.

Because of WIPP’s excellent mine operation and geotechnical monitoring program, coupled with oversight by the Mine, Safety, and Health Administration (MSHA) and periodic inspections by the New Mexico State Mine Inspector, the safety of Panel 1 is well documented. If maintaining safety in Panel 1 requires going beyond the normal WIPP ground control program, the cost effectiveness of doing so will be evaluated.

The Panel 1 operating plan addresses three major elements of waste disposal operations. They include (1) the waste receipt schedule, (2) the location where the waste will be emplaced, and (3) the waste emplacement sequence in the panel. The status of Panel 1 will be regularly reviewed and evaluated. The option always exists to close Panel 1 based on safety or economic considerations. From cost and schedule perspectives, Panel 1 is a cost effective and available resource for the first waste disposal plan that should not be abandoned without the most careful and detailed consideration. The ground stability of the Panel is closely monitored, and all issues associated with the use of Panel 1 are reviewed frequently. If a situation arises that warrants modification to current plans e.g., using only part of the panel for waste emplacement, those issues will be addressed.

The utilization of Panel 1 as the initial waste emplacement panel is critical to the scheduled receipt of waste. With this in mind, the use of Panel 1 for predisposal and initial disposal activities is an appropriate utilization of an available resource.

PANEL MAINTENANCE

Underground maintenance work of all kinds is carefully planned and controlled, based on then-current program plans and assumptions. This allows cost-effective decisions on extent and timing, while maintaining the desired level of operational and safety readiness. For example, floor maintenance was reduced to the minimum level necessary for safe daily operation. This level, however, did not maintain some waste disposal operational clearances, which is of no consequence as long as no waste is being emplaced.

In preparation for the 1998 Operational Readiness Review and for anticipated waste receipt in June 1998, an integrated maintenance plan was prepared. This plan had to coordinate planned waste disposal activities and rates with maintenance work and operational activities. The main activities identified were

- restoration of operational clearance
- ground control
- geomechanical monitoring
- waste handling operations facilities
- backfill facilities
- ventilation

Each of these is discussed below.

Restoration of Operational Clearances

Creep closure of the excavation had significantly reduced room height as well as room width. Two alternatives existed to restore room height; mine out the roof or mine out the floor. In either case a minimum of about 75 to 100 cm (2 ½ to 3 ft.) had to be excavated. If this was done in the roof, it would be necessary in practice to excavate about 1.5 m to 2 m up to clay G, while at the same time doing extensive milling of the floor to provide a flat surface. If the floor was mined, only the minimum quantity would have to be removed, and this would in itself provide an acceptable floor surface.

Re-establishing the nominal room width was considered. Because of ground control installations and the relatively small amount of material to be removed, this appeared to be a relatively cost-ineffective activity. Waste Handling Operations staff reviewed the situation and concluded that with a minor re-arrangement of waste stack configuration they could work within the existing room width.

The decision was therefore made to mine out the floor as required and to leave the ribs (sidewalls) as is, except for normal routine safety scaling. Underground Operations staff determined that the floor mining would best be performed using the Marietta continuous miner. Since this machine had seen only infrequent use, this task presented a cost-effective way to reactivate this machine and its operators in anticipation of other mining activities associated with eventual development of Panel 2.

Geotechnical Engineering staff did not believe that floor milling would cause any significant change in rock mass behavior around the room. This was based on both field observations (which showed the heaved floor to be essentially a large, detached slab) and computer model results. Some outside groups had expressed concern that mining the floor would accelerate room closure. Plans were made therefore to monitor the response of the rock mass to floor mining. The response was as expected, with only skin effects being observed, and these only for a short period.

The floor removal work went as planned. (Figure 3) The continuous miner and essential equipment were serviced. A comprehensive work package for the excavation work was prepared, ensuring that ramps were of suitable gradients and that a smooth flat floor was obtained. The actual excavation required about 2 ½ weeks to complete. All work was completed with no injuries or damage to equipment.

Ground Control

Each year, Westinghouse Waste Isolation Division (WID), produces both an Annual and a Long-term Ground Control Plan. These plans cover the entire underground facility and thus include Room 7. Once specific activities and schedules for waste disposal operations were identified, the ground control plans were adapted to meet the needs of these activities. In particular, the timing of support installations was set to maximize the period when little or no maintenance would be required. Each generation of support is independent of all others, and maintenance of a support system usually involves only rock bolt replacement on a one-for-one basis. With the exception of the supplementary support system in Room 1, support systems do not typically require regular and routine maintenance.

Given the age of Room 7 and the physical condition of its roof, a system of resin-anchored roof bolts with mesh and cable lacing was selected. A work package was prepared and the system was installed and completed shortly before anticipated initial waste receipt. The system was installed in compliance with MSHA and WIPP Quality Assurance requirements. The work package was completed with no injuries or damage to equipment.

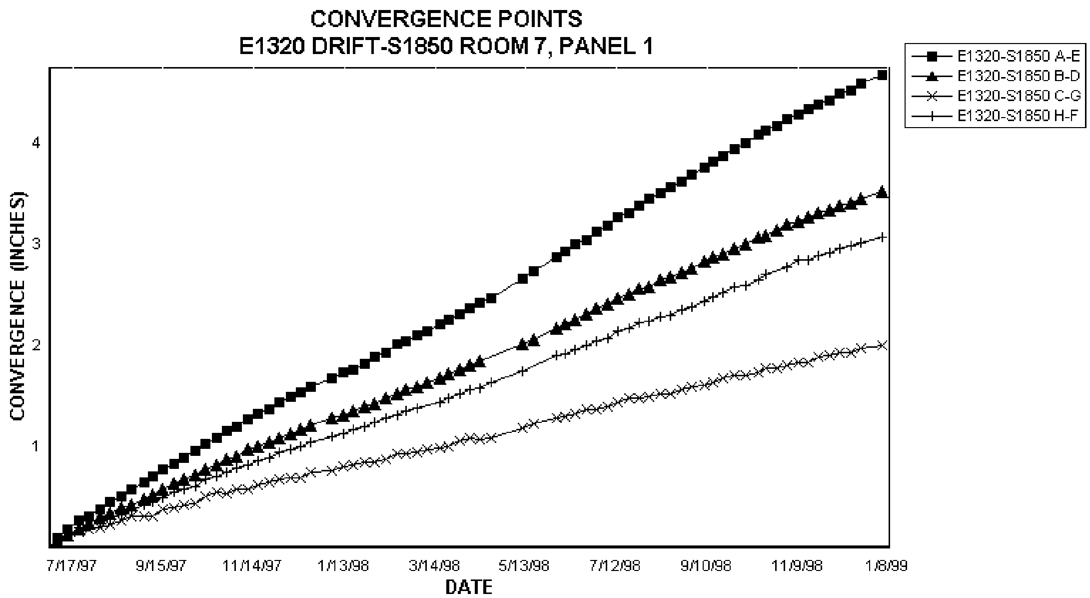
Fig. 3. Room 7, Panel 1 after Floor Excavation.

Upon completion, this system was assumed to be the only support. Previous systems, which remain in place and contribute to support, are no longer considered in stability assessments. Geotechnical Engineering staff believes that the latest system will last about four years before any significant maintenance is required. In the disposal area acceptability determination, the entire room was cleared for waste disposal operations for one year. An external assessment by an independent rock mechanics observer indicated a life of at least two years, and probably much longer.

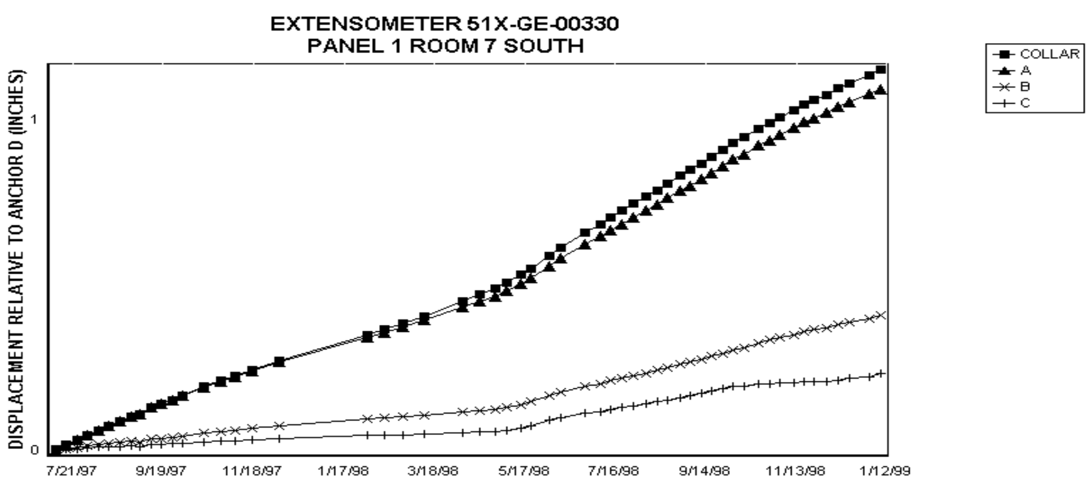
Geomechanical Monitoring

Room 7 is covered by the facility-wide geomechanical monitoring system. The decision to mine the floor and the anticipation of imminent waste receipt presented both the need and opportunity to update the geomechanical instrumentation in the room.

Three multiple point extensometers were installed and connected into the Ground Control Monitoring System. These remotely read extensometers will continue to be read as long as the panel is open. They will give continuous information on roof behavior in waste-filled rooms and will give advance warning of any major roof instability. Experience with roof falls in



NOTES:
1. EXCAVATION DATE: MARCH 10, 1988.



NOTES:
1. INSTRUMENT INSTALLED: JULY 09,1997.

Fig. 4 Typical Convergence and Extensometer Plots of Room 7.

the Site and Preliminary Design Validation Rooms 1 and 2 as well as subsequent analyses give confidence in operational and environmental safety for both the open, operating disposal area, as well as the closed disposal areas. During mining, the behavior of the roof was monitored closely. As can be seen in Figure 4, the mining caused a relatively minor response in the roof. This confirms that the heaved floor is essentially loose and can be removed without adverse consequence.

Waste Handling Operations Facilities

All necessary facilities for waste handling and radiological control were moved into position and commissioned. These are all free-standing, and they required no specific mining-related work. They will be moved in steps as the room is filled.

Backfill Facilities

A magnesium oxide backfill will be used and emplaced in two sizes of sacks. The larger, a so-called super sack, holds about 1,800 kilograms (kg) (4000 pounds [lbs.]) and is placed on top of the waste stack. It is handled using the slip sheet methodology used for waste containers. The smaller sacks are cylindrical, and weigh 25 kg (50 pounds) each, and are placed between and around the waste containers. Both types of sacks are prefilled by the supplier. They are delivered using a just-in-time approach. The smaller sacks are handled in wire mesh containers. Once underground, they are stored on free standing units in an area adjacent to the waste disposal operations. The storage units will be moved in steps as necessary.

Ventilation and Radiation Monitoring

Ventilation controls and radiation monitoring equipment were in place and were validated during the Operational Readiness Review. While the renovation mining activities were being performed, the opportunity was taken to do preventive maintenance and make minor improvements to these items.

GEOTECHNICAL ASSESSMENT AND AREA ACCEPTABILITY

WIPP has developed an internal set of guidance for establishing waste disposal area acceptability. This guidance also covers room closure which will not be considered here. A process is used rather than quantitative criteria, because each excavation performs, to varying degrees, differently than other seemingly similar excavations. This is due to the physical variability inherent in geological materials. Because each excavation and the ground control installed in each excavation is unique, the stability of each excavation must be assessed individually. Therefore, a process is used which employs a variety of factors to make an informed assessment of the conditions of each area.

The process of determining acceptability of an area for waste emplacement operations and disposal involves an evaluation of geotechnical stability in a projected area for a specific period of time. Roof stability is of primary interest, while rib and floor stability are secondary.

Each determination considers the performance of any installed ground support, and physical observations. Expected overhead clearance and floor stability is also documented. Acceptability of an area for waste emplacement is determined upon completion of the evaluation process. If the area is found to be acceptable, a time period is determined during which emplacement operations may proceed before another detailed, specific area acceptability evaluation becomes necessary. It is anticipated that no more than two areas at a time will be declared acceptable, and that the acceptable period will not exceed one year.

Room 7 has been cleared twice. The first time was in September 1997 as part of the Performance Dry Run. The second time on June 3, 1998, was in anticipation of waste receipt in June 1998. Upon completion of the acceptability process, Room 7 was handed over to the Waste Handling Operations staff. The room is ready, and monitoring indicates that it behaves as anticipated. Due to the delay in waste receipt, Room 7 will likely be cleared a third time.

This style of an iterative evaluation process is not new to geotechnical and ground control activities at WIPP. It supports planning and integration of operations processes relating to waste emplacement and room closure.

Re-evaluation of an existing emplacement area and evaluation of new emplacement areas will take place as frequently as necessary, but at a minimum once a year. Typically, it is expected that areas will be made acceptable periodically based on the waste receipt schedule. A re-evaluation of an acceptable area will be performed immediately, should conditions or data show unexpected behavior of the ground.

SUMMARY

WIPP uses an iterative planning and control system to ensure the safe, cost effective use of underground facilities. In accordance with the DDP, Room 7 of Panel 1 was prepared in anticipation of initial waste receipt in June 1998.

Room renovation and preparation mainly consisted of milling about 75 cm (2 ½ ft.) out of the floor and installing another ground support system. Both of these activities were performed as planned, with no injuries or damage to equipment. Room 7 was approved for waste disposal operation in June 1998 and is being maintained in that status.

We conclude that this work was efficient and effective, that Panel 1 is a useable resource, and that WIPP remains in an operational state ready to receive waste at any time. We also know that the WIPP planning and control systems operate correctly and smoothly.